Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut

Gjoa Haven, NU

Final Report

September 2023

Prepared for:
Government of Nunavut – Department of Community and Government Services

Prepared by:
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Project No.: 144903260

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Drainage Assessment and Planning

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144903260 Gjoa Haven Drainage Final Report

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Abbreviations

asl	above sea level
bgs	below ground surface
CGS	Department of Community and Government Services
cm	centimetres
CSA	Canadian Standards Association
DEM	Digital Elevation Model
DTM	Digital Terrain Model
GN	Government of Nunavut
IDPA	identified drainage problem area
K	soil erodibility factor
km	kilometres
m	metres
MAAT	mean annual air temperature
MAGT	mean annual ground temperature
mm	millimetres
Nunami Stantec	Nunami Stantec Limited
RFQ	Request for Quote
ROW	right-of-way
USCS	Unified Soil Classification System
VIC	volumetric ice content
yr	year

Definitions and Terminology

Active layer – The top layer of ground that is subject to annual freezing and thawing in areas underlain by permafrost (Canadian Standards Association; CSA, 2014).

Catchment – The area which collectively drains to a specified outlet location.

Channel – A natural or apparently natural drainage feature with defined bed and banks and which conveys perennial, intermittent, or ephemeral flow.

Constraint – Naturally occurring features that have the potential to negatively affect the design, construction and maintenance of infrastructures. Examples of terrain constraints include slope steepness, drainage conditions, snow accumulation areas, steep bedrock ridges and ice-rich permafrost.

Cross Culvert – A culvert which conveys flow beneath a travelled road.

Cryostructure – The structural characteristics of frozen earth materials. Includes the amount, distribution, type and arrangement of ice within the frozen material (National Standard of Canada, 2017).

Culvert Invert – the bottom of the end of a culvert (upstream or downstream).

Culvert Obvert – the top of the end of a culvert (upstream or downstream)

Ditch – A constructed or apparently constructed drainage feature with defined bed and banks and which conveys perennial, intermittent, or ephemeral flow.

Drainage Draw – A natural or constructed drainage feature which collects and conveys semi-concentrated flow, but does not have defined bed and banks.

Drainage Pathway – General term to describe drainage direction; includes overland flow, drainage draws, ditches, and channels.

Entrance culvert – A culvert which conveys flow beneath a driveway.

Existing developed areas – Existing built-up areas of Rankin Inlet.

Geohazard – Features or terrain conditions having the potential to lead to localized or widespread damage to property and threaten personal safety. Examples of geohazards are ground subsidence related to permafrost thaw degradation, landslide, flooding and shoreline erosion.

Ground ice – A general term referring to all types of ice contained in freezing and frozen ground (National Standard of Canada 2017).

Overland Flow – Surface drainage occurring in a non-channelized, mostly evenly distributed manner over the land.

Permafrost - Ground (soil or rock and included ice and organic material) that remains at or below a temperature of 0 °C for at least two consecutive years (CSA 2014).

Permafrost Table – Defined as the upper limit of permafrost, or maximum depth of the active layer.

Planned future subdivisions – Phase 1, Phase 2, Phase 3, Phase 4a, Phase 5, Phase 6, and Phase 7, as outlined in Figure 1-1.

Watershed – Analogous to a catchment but often used for larger scale applications and/or referring to a large river or lake (e.g., the Swan Lake watershed).

1 INTRODUCTION

1.1 General

Nunami Stantec Limited (Nunami Stantec) was contracted by the Government of Nunavut (GN) – Department of Community and Government Services (CGS) to complete a geotechnical evaluation, drainage assessment and planning for the community of Gjoa Haven. As outlined in the Request for Quote (RFQ) developed by CGS and subsequent proposal prepared by Nunami Stantec, the scope of work includes the following key objectives:

Geotechnical evaluation component:

- Complete a desktop terrain analysis with focus on surficial geology, topography, drainage conditions, permafrost, and periglacial features,
- Conduct a geotechnical investigation within the existing townsite and planned future subdivision areas through visual observations and shallow borehole investigations,
- Identify terrain constraints and landscape hazards within the existing townsite and future development areas, and of interest, assess the area subject to gullying and erosion that separates the old townsite and the northern subdivision,
- Develop construction suitability (or development suitability) map categorizing the study area as generally suitable for development, conditionally suitable for development or unsuitable for development.
- Provide recommendations regarding site works and/or preparations required for future developments, especially for areas identified as conditionally suitable for development.

Drainage assessment and planning component:

- Evaluate the existing community drainage infrastructure and make community wide recommendations regarding how local drainage can be improved,
- At identified drainage problem areas (IDPAs) noted by the community, develop specific recommendations for drainage improvements,
- Develop a master drainage plan that will:
  - Describe practices for site and community planning that help to maintain the service life of community infrastructure, as well as the natural landscape processes through avoidance, mitigation and drainage system management practices, and
  - Suggest solutions that can be adapted and implemented given local constraints on capacity and resources.

Community consultation component:

- Stage 1: meet with available member of the community representatives to explain and discuss the geotechnical evaluation and drainage planning work, as well as getting inputs on potential problem areas,

- Stage 2: following the completion of the geotechnical evaluation and drainage planning, this component will focus on a workshop with the community and updating / educating staff on the recommendations and implementation measures.

As part of this report, only the geotechnical evaluation and drainage assessment and planning components are presented. The community consultation component will be delivered as a separate report.

1.2 Study Area

Gjoa Haven is in the Petersen Bay, on the southeastern coast of King William Island (68°37’ N, 95°52’ W), in the Kitikmeot region of Nunavut. The community has an estimated population of 1,197 (2016 census, Government of Nunavut).

As detailed in the RFQ, the study area includes the existing townsite (old townsite and northern subdivision), immediate surroundings including planned future subdivisions and future growth areas, as well as the area subject to gullying and erosion that separates the old townsite and the northern subdivision (hereafter referred to as the Gullied Area). Airport lands, quarries, wastewater, and solid waste facilities are excluded from the study area.

The overall study area and conceptual layouts for the 2021-2041 Gjoa Haven Community Plan & Zoning By-Law are presented on Figure 1-1 and in Appendix B

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- Watercourse
- Waterbody
- Planned Future Subdivision
- Planned Parcel
- Parcel
- Runway
- Gjoa Haven Airport
- Gullied Area
- Completed Borehole

N

0 200 400 m

(At original document size of 11x17)
1:10,000

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Source: Government of Nunavut
3. Background: World Imagery: Earthstar Geographics
Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NRCan, Parks Canada
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

Prepared by WW on 2023-03-15
TR by MV on 2023-03-16

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
1-1

Title
Study Area

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2 METHODOLOGY

2.1 Desktop Terrain Assessment

Conducting a desktop terrain assessment provides key insights regarding overall site conditions, distribution of landforms and surficial materials, as well as natural processes operating a landscape. This assessment was initiated prior to the execution of the field program, which informed the planning and execution of the field activities. The information summarized below was then reviewed using field data.

2.1.1 Background Data Review

Key background data used to support the assessment included:

- Satellite Imagery (2021)
- 2022 DTM data and orthophoto acquired from Arctic UAV drone survey
- Historical air photos (1956, 1975, 1987, and 1996) (Appendix E)
- Satellite-derived 1m Digital Elevation Model (DEM)
- Building footprint, infrastructure, and transportation vector datasets
- Hydrology and watershed vector datasets
- Contours and cadastral vector datasets

Reports from previous geological and geotechnical assessments included:

- Watershed study (Sani-International Technology Advisors Inc. 2009)
- Bedrock geology (Trettin 1991)
- Surficial geology and aggregate resource assessment (Helie 1984; Stantec 2010; Nunami Stantec Limited 2011)
- Geotechnical investigations (Nunami Stantec Limited 2017; Englobe Corp. 2021)

Additional reference and guideline documents from Canadian Standards Association (CSA) and National Standard of Canada were also accounted for as part of the geotechnical evaluation and drainage planning work.

2.2 Geotechnical Investigation

2.2.1 Field Program

The field program was completed between June 15 and 20, 2022 and consisted of advancing shallow boreholes within the footprint of the future subdivisions. The field program also included a visual assessment of the terrain conditions within the study area.

The boreholes were drilled using a two-person auger operated by Nunami Stantec. The boreholes were advanced by coring 0.3 m length cores, with an approximate 82.5 mm outside diameter core barrel which

allows for the retrieval of undisturbed cores of frozen soils. The boreholes were backfilled with drill cuttings.

Drilling locations were distributed across the footprint of the future subdivisions. Areas suspected of containing ice-rich permafrost (e.g., at suspected ice wedge locations) were also targeted. A total of nine (9) boreholes (BH22-01 to BH22-09) were drilled to depths ranging from 0.65 to 2.95 m below the ground surface (bgs).

Borehole coordinates, approximate elevations, and drilling depths are provided in Table 2-1. Borehole locations are displayed in Appendix C.

Table 2-1 Summary of Borehole Location, Elevation, and Drilling Depth

Borehole no.	Planned Future Subdivision Targeted	Coordinates (UTM NAD83 Zone 15N)		Ground Surface Elevation (m asl) [1]	Drilling depth (m bgs)
		Northing (m)	Easting (m)		
BH22-01	Phase 7	7615250	383974	25.7	2.95
BH22-02	Phase 6	7615398	383960	26.2	1.55
BH22-03	Commercial district near Phase 4a	7616081	383867	35.3	2.30
BH22-04	Phase 5	7615584	384161	31.5	0.90
BH22-05	Phase 7	7615234	383958	24.4	1.30
BH22-06	Phase 4a	7616318	383839	39.0	2.00
BH22-07	Phase 7	7615077	383955	24.9	2.35
BH22-08	Phase 3	7615953	383292	21.7	0.65
BH22-09	Phase 3	7615873	383394	18.7	2.40

NOTES:
[1] Ground surface elevation obtained from Arctic UAV drone survey

Soils were described and logged in accordance with the Unified Soil Classification System (USCS). Whenever observed in the core samples, the cryostructures were described using nomenclature and classification derived from ASTM D4083 (Standard Practice for Description of Frozen Soils, Visual-Manual Procedure).

2.2.2 Laboratory Testing

Samples recovered from the site were sealed in moisture tight bags and returned to the Stantec geotechnical laboratory in Laval (Quebec) for detailed classification and testing. Laboratory testing was completed on selected samples and consisted of the following:

- Particle size analysis (sieve; ASTM C136)
- Moisture content (or gravimetric water content) (ASTM D2216)
- Volumetric ice content (VIC) of selected samples using:

$$\mathbf{VIC}\ (\%) = \frac{\mathbf{V_i}}{\mathbf{V_t}}$$

where V_t is the total volume of the frozen sample (cm^3) and V_i is the volume of ice (cm^3) estimated from weight loss after drying, using the theoretical density of ice (0.9175 g cm^{-3}).

The results of the laboratory testing are shown on the borehole records in Appendix F and in the laboratory testing results provided in Appendix G.

2.3 Qualitative Construction Suitability Assessment

The culmination of the geotechnical evaluation consists of a development suitability map, which assigns suitability classes to site-specific conditions. The development suitability classification used for the assessment is based on the recently published *Risk-Based Approach for Community Planning in Northern Regions* (National Standard of Canada 2023), then was adapted to the overall site conditions encountered within the study area. A summary of criteria used for assessing development suitability through the hamlet is presented in Table 2-2. Results of the assessment are summarized in Section 4, with figures presented in Appendix C.

Table 2-2 Criteria Used for Estimating Development Suitability

Classes Conditions[1]
Terrain generally suitable for development (green areas[2]) • Permafrost with low to moderate ground ice content (ice wedges that developed in coarse material deposits and that present no sign of thaw degradation may be present). • Well to imperfectly drained soils[3]. • Flat to gently undulating topography (slopes under 20%). • Inactive or limited periglacial processes. No observed evidence of mass movement, or major ground settlement.
Terrain conditionally suitable for development (yellow areas[2]) • Permafrost with moderate ground ice content may include areas of high ice content. • Permafrost features such as ice wedges may be present. • Imperfectly drained to poorly drained soils[3]. • Overland flow path may occur. • Gently to moderately sloping topography (slopes between 20% and 40%). • Site is adjacent to an area presenting unsuitable conditions. • Site is adjacent to a slope where erosion and material loss is likely to occur (a buffer of 2 times the slope height was considered).
Terrain unsuitable for development (red areas[2]) • Permafrost with elevated ground ice content. • Confirmed presence of massive ice. • Observed indicators of unstable terrain (e.g., ground settlement, thermokarst development, thermo-erosion, gully erosion, landslide). • Poorly drained to very poorly drained[3]. • Slopes > 40%. • Thick organic soils. • Snow drifting and/or snow accumulation areas. • Site showing active evidence of mass movement. • Areas susceptible to flooding. • Site is adjacent to steep slope with potential stability issue (a buffer of 2 times the slope height was considered).
NOTES: [1] What is considered “generally suitable” for one type of infrastructure or land may be “conditionally suitable” for a different type of infrastructure or land use. The same is applicable to “conditionally suitable” or “unsuitable” classes. [2] Refers to color-coded units displayed on the development suitability map located in Appendix C-2. [3] Drainage classes derived from the Canadian Soil Information System (Expert Committee on Soils Survey 1982).

2.4 Drainage Assessment and Planning

In northern communities, surface drainage issues during the short summers and spring/fall shoulder seasons are often a challenge. Typical drainage issues include road washouts after extreme rainfall events, water ponding, culverts with reduced capacity, and obstruction/overflow of ditches with poor definition and/or insufficient depth. The CSA, through the *Community Drainage System Planning, Design, and Maintenance in Northern Communities* (CSA 2020), indicates that a drainage analysis should have due regard for a number of interconnected factors, including existing surface drainage infrastructure, climate data, site inspection data, bedrock and surficial geology maps, topographic data, permafrost features, hydrologic data (e.g., catchment area and drainage patterns), geotechnical investigation and available plans for future development. The activities and expectations of the local community, as well as

overall public safety, should also be taken into account when performing drainage assessment and planning.

The drainage assessment and planning component of this project generally followed the guidance and protocols from Clause 4 of CSA (2020). As stated in CSA (2020), under ideal circumstances, drainage system planning and design using the CSA (2020) standard is completed in advance of development. With the exception of the planned future subdivisions (Phase 1 through to 7), the drainage infrastructure for Gjoa Haven has already been constructed. Drainage assessment and planning are therefore discussed separately for the existing developed areas (Section 4.3.1) and the planned future subdivisions (Section 4.3.2).

Within each of these two sections, drainage assessment (characterization of existing conditions) and drainage planning (alterations and improvements) are discussed in sequence. The drainage assessment and drainage planning tasks were based on the results of the desktop terrain assessment (Section 2.1) and the field assessment.

As noted in CSA (2020), field assessments of drainage are best performed during spring melt conditions, to observe the drainage system under peak stress due to (for example) seasonally high runoff volumes, potential culvert and ditch icing, and slope destabilization due to freeze/thaw cycles. This is why Stantec's field assessment took place between June 13 and 14, 2022 during spring melt.

2.4.1 Existing Developed Areas

The existing developed areas are illustrated on Figures 1, 2 and 3 in Appendix D-1.

2.4.1.1 Drainage Assessment

The following activities were completed during the field assessment:

- Meeting with Council to identify locations and details of areas which have demonstrated notable drainage issues in the past, and where the Council would like specific recommendations for improvement. These areas were referred to as identified drainage problem areas, or IDPAs.
- Performed assessment of cause of drainage issues at IDPAs.
- Determined finalized catchment boundaries by ground truthing the preliminary catchment boundaries (from Section 3.5). Catchment delineation for Gjoa Haven was completed at a scale which functionally informed, or could inform, the drainage infrastructure. For example, two separate roadside ditches (each with a series of culverts) would have their own catchments. The point where these two ditches confluence would represent the downstream end of their respective catchments, and the upstream end of a third catchment for the downstream ditch.
- Ditch (constructed) and channel (natural) networks were delineated in the field using ESRI ArcGIS Collector with aerial imagery. For the purposes of this project, ditches and channels had defined bed and banks whereas overland flow paths (which convey semi-concentrated surface water flow) were low-lying areas without bed and bank definition. Drainage draws are defined as low-lying areas that

many ditches and/or channels funnel into. Ditch measurement (geometry, slope) was considered beyond the scope of this project and was not performed in 2022.

- Completed a detailed inventory of culverts in Gjoa Haven, obtaining the following information:
  - Street that the culvert crosses under (street name, or driveway)
  - Location (northing/easting, referenced to NAD83 UTM Zone 15 CSRS)
  - Type (entrance or cross culvert)
  - Shape (circular, box, arch, other)
  - Material (corrugated metal, metal, plastic, other)
  - Diameter or dimensions (in mm)
  - Crushing of culverts ends (yes/no)
  - Infilling of culvert barrel with sediment (depth of sediment in mm)
  - Five photographs: upstream end of the culvert facing upstream, upstream end of the culvert facing downstream, downstream end of the culvert facing upstream, downstream end of the culvert facing downstream and view of the crossing road or entrance.
  - General observations regarding upstream and downstream ditch and embankment conditions
- Using the data collected during the field inspection, the following were measured, calculated, or determined:
  - Culvert condition ratings for five different categories (Table 2-3), based on general assessment methods from CSA (2020) and a modified version of MTO (2013) to suit the project objectives and infrastructure types found in Gjoa Haven
  - Priority levels for remediation (high, medium, low as outlined in Table 2-3) for each of the five culvert condition ratings

Table 2-3 Culvert Rating Methodology (modified from MTO 2013)

Category	Rating Methodology
Material - Metal Culverts	0 - New condition, may also exhibit slight discolouration of surface, galvanizing partially gone along invert. 1 - Discolouration of surface, galvanizing completely gone along invert but no layers of rust. Minor pinholes in pipe material located at end of pipe but not located beneath roadway. 2 - Layers of rust forming. Sporadic pitting of invert, minor pinholes forming throughout pipe. 3 - Heavy rust, thick scaling throughout pipe. Deep pitting, perforations throughout invert. 4 - Extensive heavy rust, extensive perforations throughout pipe. End sections corroded away. Bottom portion completely corroded exposing underlying granular. Partially to fully collapsed. Priority levels for remediation: High: 3-4 Medium: None Low: 0-2
Shape	0 - Smooth curvature in barrel. Span dimensions within 3% of design. 1 - Smooth curvature in top half of barrel with flattening on bottom portion. Span dimensions up to 5% greater than design. 2 - Slight distortion in one location on the top portion. Bottom has slight reverse curvature in one location. Span dimension up to 10% greater than design. Nonsymmetrical shape. 3 - Significant distortion throughout length. Lower 1/3 may be kinked. Span dimensions up to 15% greater than design. 4 - Extreme deflection at isolated locations. Flattening at top of arch or crown. Bottom has reverse curvature throughout. Span dimensions greater than 15% of design. Extremely non-symmetrical Priority levels for remediation: High: 3-4 Medium: 2 Low: 0-1
Capacity	0 - Little to no sediment build-up in pipe. Culvert ends are undamaged. Little to no debris blocking flow. 1 - Minor debris and sediment, less than 30% blockage. Possible infiltration of fine roots. No evidence of flooding of roadway or adjacent land. 2 - Major debris and sediment more than 30% blockage, flooding of roadway and/or adjacent properties. Possible infiltration of tap roots causing major flow restriction. Priority levels for remediation: High: 2 Medium: 1 Low: 0
Erosion and Scour	0 - Embankment, slopes, and at culvert outlets are intact and stable. 1 - Minor erosion of embankment, slope, or at culvert outlet less than 100 mm around ends. Still protected or well vegetated. 2 - Major erosion of slope, embankment, or at culvert outlet greater than 200 mm around culvert ends, guardrail displaced / settled, posts loosened / separated from soil. Priority levels for remediation: High: 2 Medium: None Low: 0-1
Upstream and Downstream Channel	0 - No evidence of channel bed or bank erosion. Intermittent patches of grass and exposed earth. 1 - Minor channel erosion. Minor damage to channel protection. 2 - Bank protection eroded. Bank protection debris causing blockage and more significant channel erosion. Deposition within channel impeding flow. Channel alignment causing scour holes, bank erosion, and is threatening end treatment. Major erosion of channel. Priority levels for remediation: High: 2 Medium: None Low: 0-1

Integration of observations in ESRI ArcGIS produced an existing condition drainage map consisting of catchment boundaries, overland drainage pathways, drainage channels/ditches, and culverts. The map was accompanied by a detailed culvert inventory and by text summarizing the general drainage conditions in the developed areas of Gjoa Haven. Collectively, the existing conditions drainage map, detailed culvert inventory, and general summary of drainage conditions represented the drainage assessment. The drainage assessment provided the basis for drainage planning of the Gjoa Haven developed areas.

The results of the drainage assessment were compared to established industry standards and guidelines for northern communities and for local roads from CSA (2020) and MTO (2013):

- Sufficient ROW width of 16 m to accommodate for travelled road surface, shoulders, walkway, snow storage and drainage ditches (CSA 2020)
- Positive drainage across roads to roadside ditches, ideally from the centreline road crown (CSA 2020)
- Roadside ditches have positive drainage and capacity to accommodate piling of snow, in accordance with typical dimensions provided in CSA (2020)
- Adequate culvert conditions (priority levels for remediation provided in Table 2-3)
- Presence of marker post (CSA 2020)

2.4.1.2 Drainage Planning

The planning task for existing developed areas adopted separate approaches for i) general drainage conditions and ii) the IDPAs:

For General Drainage Conditions:

Based on the general drainage conditions and comparisons to established industry standards outlined in Section 2.4.1.1, a series of community-wide recommendations were developed to improve the existing drainage system. The recommendations for culverts were more specific owing to the level of detail of the culvert inventory. The recommendations took into consideration the following:

- Qualitative assessment of cost efficiency for drainage improvements.
- The expectations and typical activities of the residents of Gjoa Haven should be, to the degree practicable, preserved.
- Construction equipment, materials, or windows may impact the plausibility or timeframe for implementation of drainage improvements.
- Gjoa Haven is a mid-sized community in Nunavut. The scale and level of entrenchment of the existing drainage infrastructure into the community is considerable. Therefore, large-scale changes to the drainage network could not be made without significant disruption to the existing community or prohibitive capital costs and were therefore not considered for the developed areas of Gjoa Haven (unless at an IDPA; see description below).

At IDPAs: Specific, site-scale recommendations were provided for each of the IDPAs. The recommendations were developed to address the specific cause of the drainage issue at the IDPA. Recommendations for each IDPA were illustrated on a map of the IDPA and described in text.

2.4.2 Planned Future Subdivisions

The planned future subdivisions (Phase 1, 2, 3, 4a, 5, 6 and 7) are illustrated on Figure 1-1 and Appendix B.

2.4.2.1 Drainage Assessment

During the field assessment, the preliminary catchments identified from the desktop terrain assessment (Section 0) were ground-truthed to confirm their locations. Overland drainage flow paths and drainage channels/ditches were documented, and culverts were identified and characterized using the protocol outlined in Section 2.4.1.1. Surrounding drainage infrastructure and potentially sensitive environmental features were identified to inform inflows to the development block(s), and potential outfall locations from the development block(s). Low-lying areas prone to seepage and ponding were noted to supplement the geotechnical investigation and development suitability assessment.

Integration of observations in ESRI ArcGIS produced an existing condition drainage map consisting of catchment boundaries, overland drainage pathways, drainage channels/ditches, and culverts. The existing conditions drainage map provided the basis for drainage planning of the planned development areas.

2.4.2.2 Drainage Planning

A proposed conditions drainage plan (map with text description) was developed consisting of general development block grading and overland flow direction, constructed channels/ditches, culverts, and outfall locations. The development of the proposed conditions drainage plan considered existing drainage patterns and infrastructure, the inflows to the development block, the downstream receiving systems, any nearby sensitive environmental features, the conceptual road and lot layout in the development blocks, the standards in CSA (2020), and other northern drainage best-management practices.

2.5 Community Consultation

Stage 1 of the community consultation task was conducted on June 13 and 14, 2022 and consisted of a meeting with the community representatives and Council to explain and discuss the details of the geotechnical evaluation and drainage assessment and planning work to be completed. A special attention was brought to identifying drainage-related problem areas (or IDPAs) as well as other geotechnical-related problem areas (e.g., including stability issues) occurring within the community. The Council pointed out the IDPAs and other problem areas of concern on a map. IDPAs and other problem areas were then visited and assessed as part of the geotechnical and drainage work field investigation.

The stage 2 task of the community consultation will be conducted following the completion of the present report.

3 SUMMARY OF SITE CONDITIONS

The following sections summarize general site conditions based on a desktop review.

3.1 Bedrock Geology

The bedrock in the study area is composed of Lower Paleozoic sedimentary rocks of the Arctic Platform (Trettin 1991). These rocks are mostly flat-lying to gently dipping, forming beds that are approximately 100 m thick (Blackadar and Christie 1963, 1967). This bedrock assemblage is predominantly Ordovician to Silurian in age and comprises dolostone and dolomitic sandstone, with lesser amounts of Cambrian sandstone, sandy dolostone, dolostone, shaley dolostone and conglomerate (Blackadar and Christie 1967).

3.2 Surficial Geology

King William Island was covered by the Keewatin sector of the Laurentide Ice Sheet during the last glaciation, with ice retreating from the area between 9,000 and 8,400 years ago (Dyke and Dredge 1989). The maximum postglacial sea level was about 150 m above sea level (asl) in the area (Dyke and Dredge 1989).

Surficial geology mapping is available for the King William Island region (Helie 1984). Additional mapping conducted by Stantec (2010) is also available for the area surrounding Gjoa Haven (presented in Figure 3-1).

The surficial geology mapped near Gjoa Haven generally comprises ice contact glaciofluvial deposits overlain with thin beach ridges (consisting of sand with gravel), and coarse glaciomarine deposits (consisting mainly of cobbly sand and gravel) forming flights of raised beaches. Coarse glaciomarine deposits are generally thin and assumed to overly thick ice contact deltaic deposits. Marine and colluvial deposits, and in lesser extent, organic and fluvial deposits, were also mapped near the community (Nunami Stantec Limited 2011). Geotechnical investigations conducted confirmed that sand to silty sand with traces of gravel extend down to at least 10 to 12 m bgs within Gjoa Haven (Nunami Stantec Limited 2017; Englobe corp. 2021).

Few bedrock outcrops occur near Gjoa Haven.

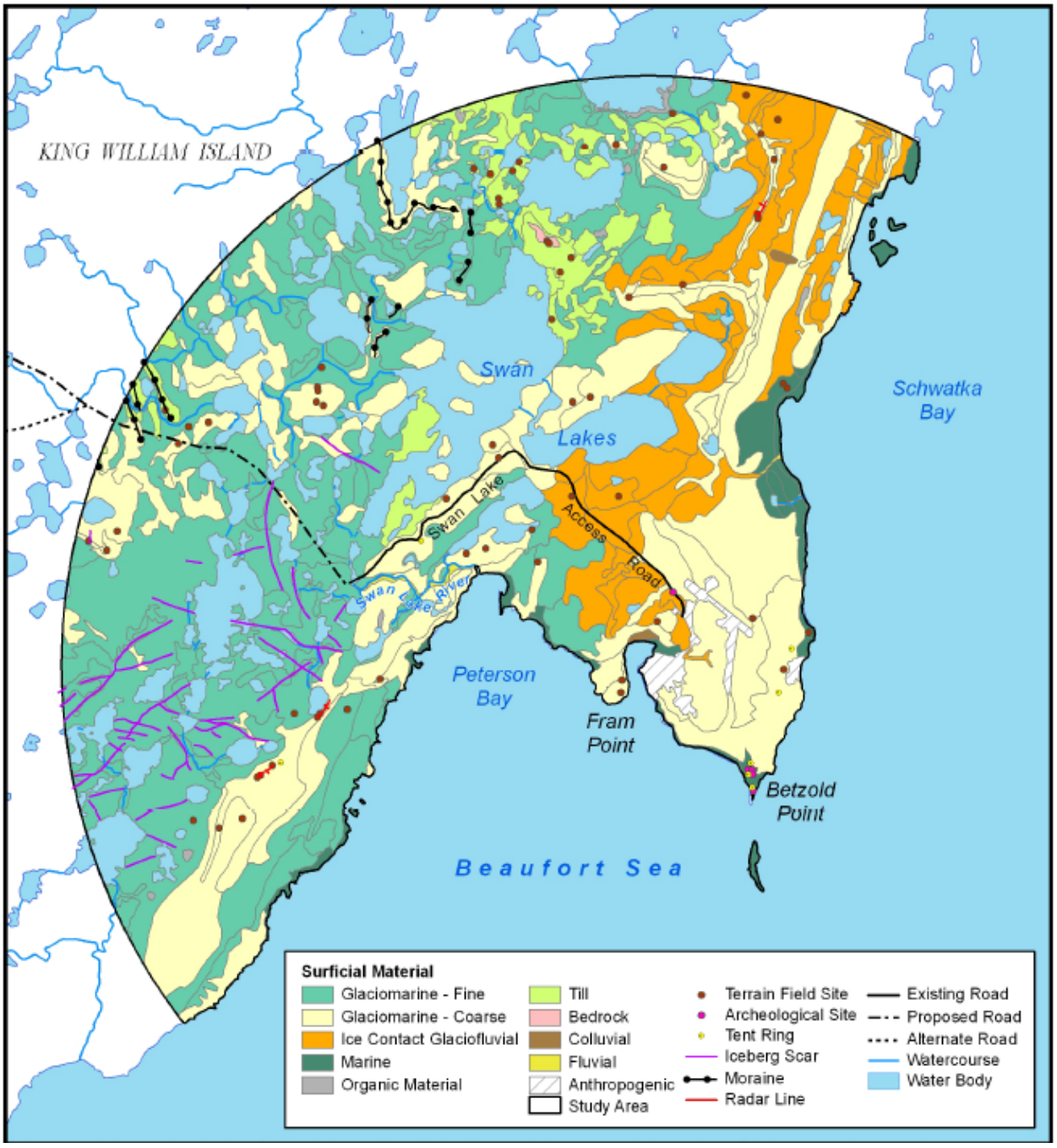

Figure 3-1 Surficial Geology Map, Gjoa Haven (from Stantec 2010)[1]

[1] Refer to the Stantec (2010) report for the detailed surficial geology map of Gjoa Haven.

3.3 Topography

Within the developed portion of the community, ground elevations range from sea level along the shoreline, to a maximum of approximately 20 m asl in the old townsite, and 35 m asl in the northern subdivision. The terrain gradually climbs towards the northeast, until reaching the airport located on a raised beach ridge at approximately 45 m asl.

Most of the community was developed on flat to gently undulating terrain which is dissected by two large gully systems. Slopes are generally under 5%, and steeper gradients in the order of 10-50% are found locally throughout the community (e.g., along ridges in the old townsite and south from the northern subdivision, near the shoreline, and along the various gullies). Short steep slopes over 70% are present along the Gullied Area.

A map presenting slope classes and contour data is presented in Figure C-1 (Appendix C).

3.4 Climate

Gjoa Haven has a high arctic ecoclimate. Warming air temperatures during summer trigger ice melt and breakup with open water areas developing around the community. The addition of moisture to the lowest levels of the atmosphere over the open water can be substantial creating areas of low clouds and fog (Nav Canada 2010). During the winter, local weather is often subject to winds from the northwest which typically causing blowing snow.

Climate Normals (1981 to 2010) including precipitation (snowfall and rainfall) and temperature are presented in Figure 3-2 (GoC 2021). The total annual precipitation is 209 mm, of which 62% falls as snow. Mean daily air temperatures vary from 8°C in July to -33.8°C in January, and mean annual air temperature (MAAT) is -14.4°C.

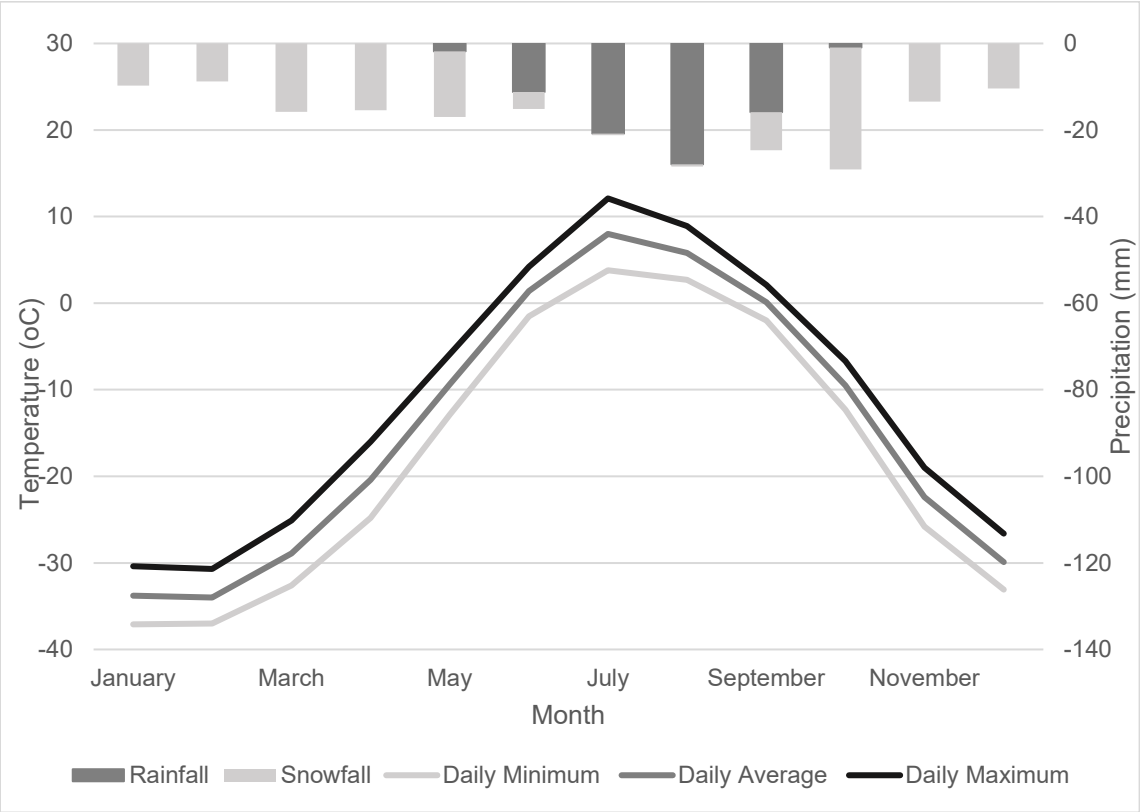

Figure 3-2 Temperature and Precipitation at Gjoa Haven A (1981 – 2010 Climate Normals)

Degree days for a given day are the number of degrees Celsius that the mean temperature is above or below a specified temperature. Degree days for a given period of time is the sum of those daily degrees Celsius values, across the given period of time. Heating degree days provide an estimate of the heating requirements for buildings, and consider temperatures below 18°C. Growing degree days provide an index of vegetation growth, and consider temperatures above 5°C. Figure 3-3 illustrates the heating degree days and growing degree days (based on 1981 – 2010 climate normals) at Gjoa Haven A (GoC 2022). Figure 3-3 indicates that heating of homes is required for much of the year, and vegetation growth is limited to the summer months (predominantly in July and August).

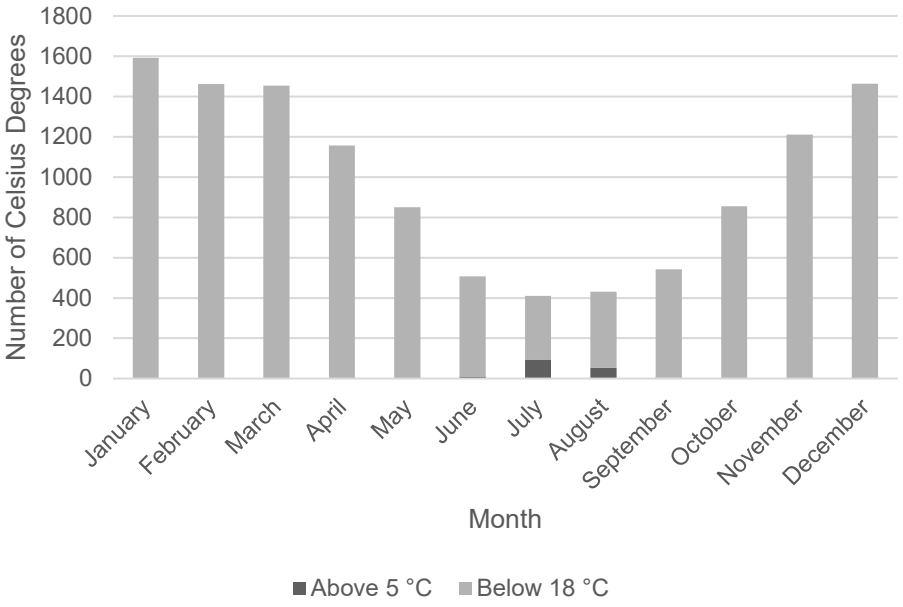

Figure 3-3 Degree Days at Gjoa Haven A (1981 – 2010 Climate Normals)

3.5 Hydrology

The hydrology in Gjoa Haven is largely snowmelt driven although notable precipitation and runoff events can occur in the summer months. The spatial redistribution of snowpack over the winter (e.g., wind drifts, snow clearing) is likely to result in increased runoff rates and volumes in catchments with snow accumulation. Ditch and culvert icing during spring melt is a common occurrence in northern communities, and may inhibit drainage in affected areas (CSA 2020).

Background information on watersheds is available from data developed by Sani-International Technology Advisors Inc. (2009). Catchment delineation polygons were reviewed using satellite imagery and topographic data received from CGS. Minor adjustments were made along some of the watershed boundaries. The delineation of waterbodies, watercourses and apparent overland flow paths was further refined based on field observations.

A review of historical air photos indicated that development in the old townsite (at the school) and in the northern subdivision, was conducted on historical lakes and within poorly drained areas. Drainage-related problems now occur at these locations (Figure 3-4) and are discussed further in Section 4.3.1.2.

1. Ponding occurs in the school's playground located over an historical lake (refer to IDPA #7).
2. Ponding occurs in and adjacent to new development area located over an historical lake (Refer to IDPA #3).
3. Ponding occurs in a subdivision built over poorly drained area (Refer to IDPA #2).

Figure 3-4 Development Occurring Over Historical Lakes and poorly drained areas. A) 1975 Historical Air Photo; B) 2022 Orthophoto.

3.6 Permafrost

Gjoa Haven is located within the continuous permafrost zone (Brown et al. 2002) in an area where permafrost likely extends several hundred metres below the ground surface. Mean annual ground temperature (MAGT) is often used to characterize permafrost temperature. MAGT in Gjoa Haven was reported to vary from -8°C to -9°C at 15 m bgs in 2012 (Ednie and Smith 2015).

Active Layer

The maximum active layer depth (permafrost table) near Gjoa Haven was reported to range between 0.75 and 1.80 m bgs in gravel ridges (Nuna Burnside Engineering and Environmental Ltd. 2007), between 1.25 and 1.50 m bgs on a beach ridge that served as local aggregate located west from the community (Stantec 2010), and at 2.25 m bgs within sandy deposits south from the old townsite (Englobe corp. 2021).

Ground Ice

Based on permafrost and ground ice conditions mapping from Brown et al. (1997), medium to high ground ice content is generally expected in the area (i.e., >10% per volume in the first 10 to 20 m bgs), including ice wedges and massive ice bodies. Papadimitriou and Catto (2008) reported that, in Gjoa Haven, coarse-grained material associated with the ice contact and raised beach deposits are not ice rich, however, that areas of fine sand and silt are. Englobe corp. (2021) reported ice-poor permafrost with moisture content varying between 7% and 19% in sandy deposits.

Ice wedges are ground ice features that result from the thermal contraction of permafrost soils, creating cracks that fill with ice formed from snowmelt water (Mackay 1990). The yearly repetition of this process facilitates the creation of ice wedges that form huge polygonal networks across the landscape. Polygonal networks of ice wedges were identified from desktop assessment throughout the study area; however, they appear predominant in planned future subdivisions Phase 2, Phase 4a, Phase 5, Phase 6 and Phase 7.

The presence of ground ice in permafrost contributes significantly to a site's sensitivity to disturbance. Melting of ground ice associated with permafrost thaw can lead to subsidence on flat terrain or landslides on slopes, which can represent a threat to infrastructure (CSA 2014).

Pore Water Salinity

Permafrost in the area is assumed to be saline, as the area was submerged by sea water following the last glacial maximum.

Hivon and Sego (1993) reported that pore water salinity in Gjoa Haven was measured to be approximately 0.2 PPT, which is considered low. However, other reports by other consultants have reported pore water salinities as being much higher, in one case over 82 PPT (typical sea water is approximately 32 PPT) (Nunami Stantec Limited 2017).

The presence of pore water salinity induces freeze point depression. The freezing point depresses approximately 0.28°C for every 5 ppt of salinity. Hence, soils with a pore water salinity of 32 ppt will have an actual freeze/thaw temperature of about -2°C.

3.7 Climate Change

Air temperatures in the Arctic have warmed at approximately twice the global rate for several decades (Anisimov et al. 2007). During the 1976-2005 period, MAAT in Gjoa Haven rose 1.3°C[2].

CSA provides guidance for screening the vulnerability of a development to climate change (CSA 2019). Based on future projections of air temperatures derived from climate models under a “high” greenhouse gas scenario, Gjoa Haven may experience an increase in MAAT of 1.7°C by 2040, and up to 4.4°C by 2070. Acknowledging that observed permafrost warming in communities of the eastern and high Arctic appears consistent with the changes in regional air temperature (Ednie and Smith 2015), it seems

[2] https://climateatlas.ca/

reasonable taking the conservative assumption that near-surface ground temperature increases will match MAAT increases (i.e., 1.7°C warmer by 2040) (Table 3-1).

Table 3-1 Projected Seasonal Mean Air Temperature Change Under a "High" Greenhouse Gas Emission Scenario

Year	Winter	Spring	Summer	Autumn	Annual
2011–2040	2.1	1.5	1.0	2.0	1.7
2041–2070	6.1	3.8	2.7	5.1	4.4
2071–2100	11.1	6.7	4.7	8.2	7.7

NOTE: The value displayed in each cell represents the average change in mean seasonal or annual temperature for the specified 30-year period when compared to the average mean seasonal temperature from 1986 to 2015 (Arctic Sector C2).
SOURCE: modified from CSA (2019).

The overall sensitivity of permafrost can be classified based upon ground material, ice content, and an estimate of the ground temperature (CSA 2019). For the purpose of climate change screening, the CSA developed a permafrost sensitivity ranking based on the following three main factors:

- the likelihood of thaw settlement due to active layer deepening
- the potential for a reduction in bearing strength and creep resistance due to warming of the frozen ground
- the potential for accentuated frost heaving.

Because soils in Gjoa Haven are predominantly composed of coarse-grained material and of potentially saline marine deposits, and also because of the occurrence of soils potentially containing massive ice (ice wedge) at shallow depth, the overall sensitivity of permafrost to climate change within the study area is anticipated to range from low to medium (CSA 2019).

Another important factor to consider is the intensification of the hydrological cycle triggered by the rise in temperatures. The amount, type, and patterns of rainfall and snow precipitation are expected to change, further contributing to permafrost degradation, and adding stress to local drainage infrastructure. The Nunavut Climate Change Secretariat (2021) reports that precipitation in the Arctic has increased by approximately 8 % in the last 100 years, with additional increases predicted for the future. It is reasonable to expect that the permafrost degradation and precipitation changes caused by climate change will lead to increased risk of ground instability, local flooding, erosion, and washouts along roads, access trails, and other infrastructure.

4 RESULTS

4.1 Geotechnical Evaluation

4.1.1 General Field Observations

The following observations were made from field investigation and supported from desktop analysis.

4.1.1.1 Planned Future Subdivisions

Phase 1 is adjacent to the northern subdivision and consist of an elevated ridge sitting approximately 5 m above surrounding terrain. Slope gradients along the ridge are generally under 10%. Local soils consist of well-drained sand and gravel with cobbles and boulders.

Along the eastern portion of the subdivision (below from the ridge) are soils covered with a thin organic layer (<10 cm). Drainage conditions were observed to be poor, with occasional ponding water taking place (see IDPA#3 in Section 4.3.1.2). A review of aerial imagery suggests that sparse ice wedges are present in the area.

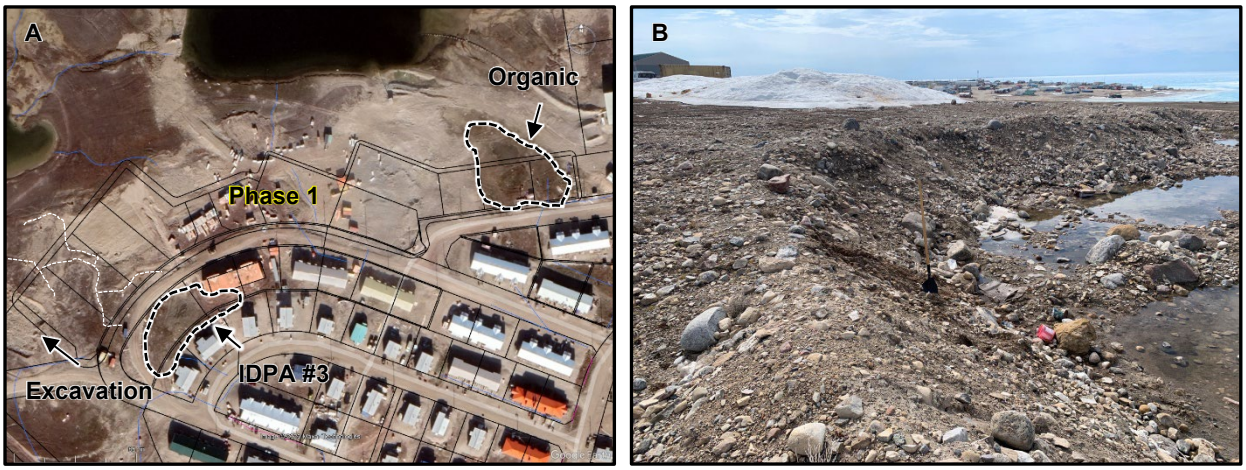

Figure 4-1 Site Conditions Within Phase 1. A) Subdivision Overview (blue lines represent drainage flow path; white dash lines represent examples of ice wedge within Phase 1); B) Exposed Sand and Gravel from Excavation.

Phase 2 is located near the school and adjacent to the old townsite. The terrain in the area is mainly flat (< 5%), except for a short steep slope (~50%) present alongside a stream channel. The channel, which profile was straightened in the past, is showing signs of lateral erosion.

A network of ice wedges is present within this proposed subdivision. Similar polygonal networks are present in other planned future subdivisions (e.g., within Phases 4a, 5, 6, and 7).

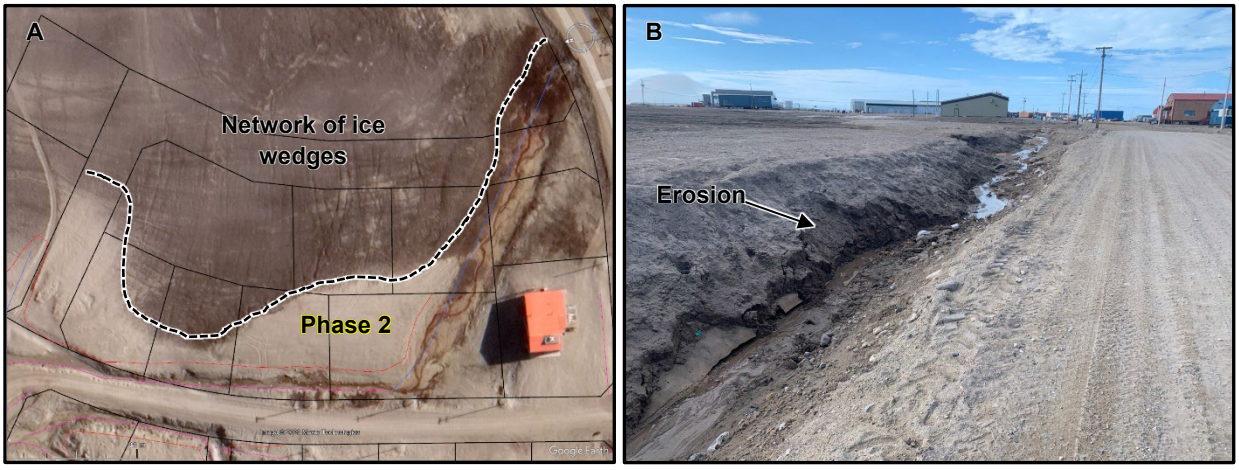

Figure 4-2 Site Conditions Within Phase 2. A) Subdivision Overview (blue line represents drainage channel; purple line represents drainage ditch; red line represents surface erosion and gullying); B) Lateral Erosion Along the Stream.

Phase 3 is located south of the northern subdivision and is facing the Peterson Bay. Slope gradients are generally under 10%. Cobbles and few boulders were observed at the ground surface. Overland flow paths initiating from the northern subdivision were observed crossing the Phase 3. Sparsely distributed ice wedges were observed within the subdivision. Surface erosion and gullying occur to the south.

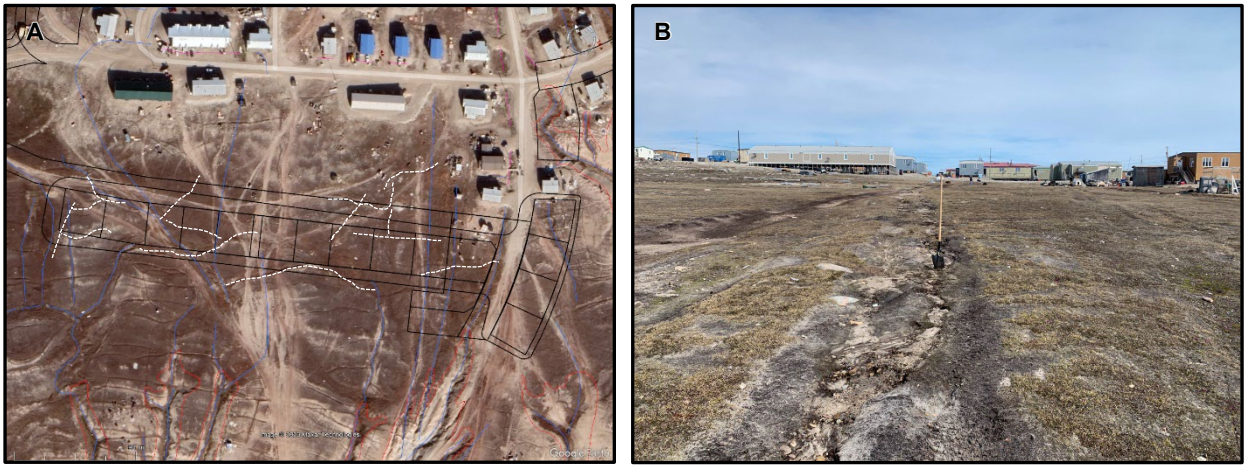

Figure 4-3 Site Conditions Within Phase 2. A) Subdivision Overview (red lines represent surface erosion and gullying; blue lines represent drainage flow path; white dash lines represent examples of ice wedges); B) Overland Flow Path.

Phase 4a and Adjacent Commercial Development Area are accessible via an existing road connecting the community to the airport. The terrain is mainly flat in the area (< 5%). A well-defined network of ice wedges was observed throughout the subdivisions and thermal-contraction cracks sometimes occurred alongside the wedges. Overland flow paths occurring within ice wedges as well as two shallow lakes were

observed within the commercial development area. Vehicle ruts were observed; however, apparently not causing permafrost degradation.

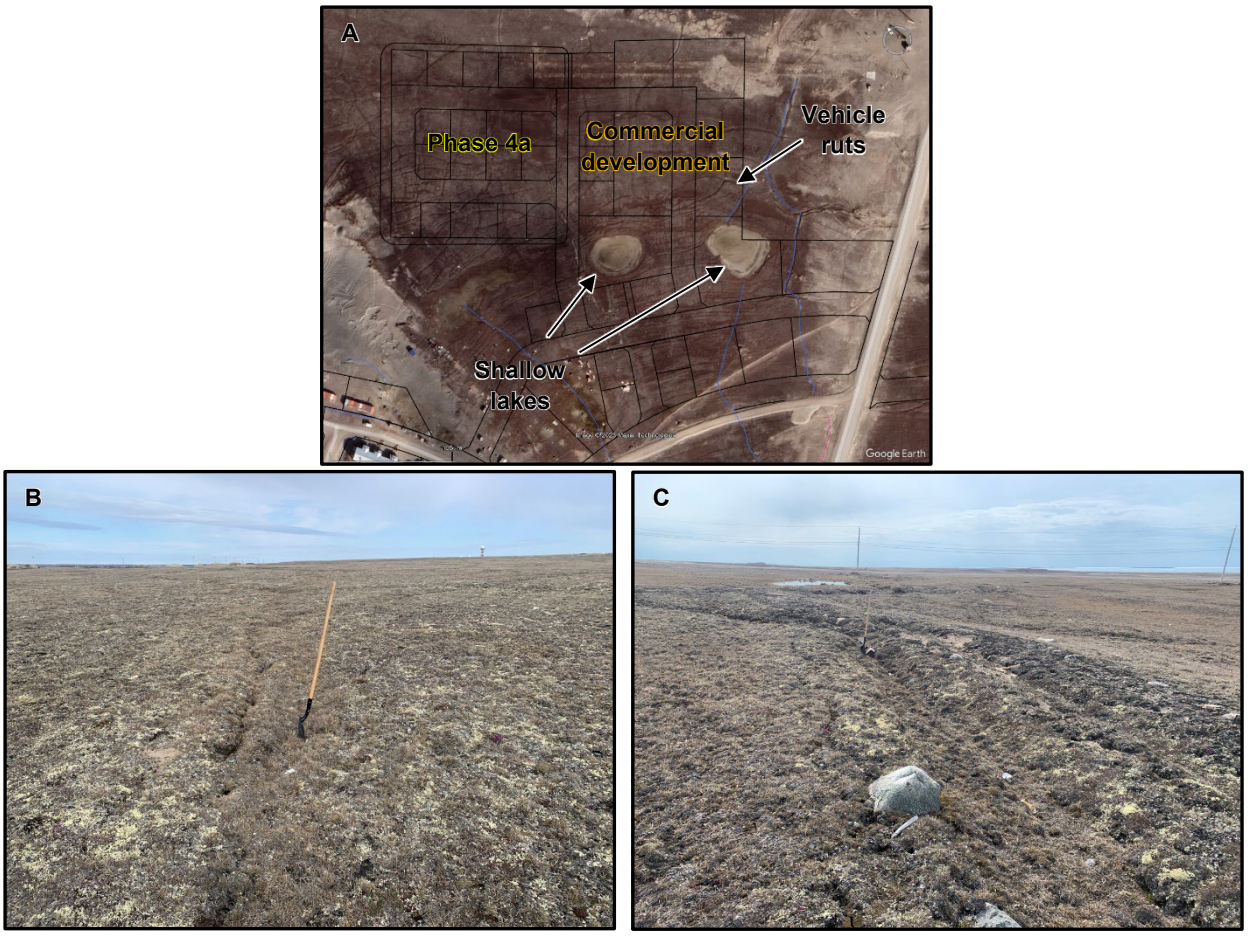

Figure 4-4 Site Conditions Within Phase 4a and Adjacent Commercial Development Area. A) Overview of the Subdivisions (blue lines represent overland flow paths); C) Thermal-Contraction Crack Along an Ice Wedge; D) Ground Surface Disturbance from Vehicle Ruts.

Phase 5, Phase 6 and Phase 7 are accessible via an existing road connecting the community to the airport, sewage lagoon, and cemetery. Slope gradients are generally under 5 % and sometimes up to 30% along the gullies and the ridge within the northeast portion of Phase 5. Steeper slope gradients up to 60% are present along the gully dissecting terrain between Phase 5 and Phase 6; soil surface erosion occurs along this gully section.

A well-defined network of ice wedges was observed throughout the Phase 5, Phase 6 and Phase 7 subdivisions. Based on desktop analysis and field observation, it was interpreted that drainage generally concentrates along the ice wedge's troughs, sometimes leading to erosion and gullying. Many thermal-contraction cracks were observed, some located along and beside the ice wedges. Cracks observed beside the ice wedges generally showed a preferential north-south orientation, were up to 8 cm wide and

300 m long (and could be longer), and were interpreted as relatively fresh (i.e., likely occurred within the last years).

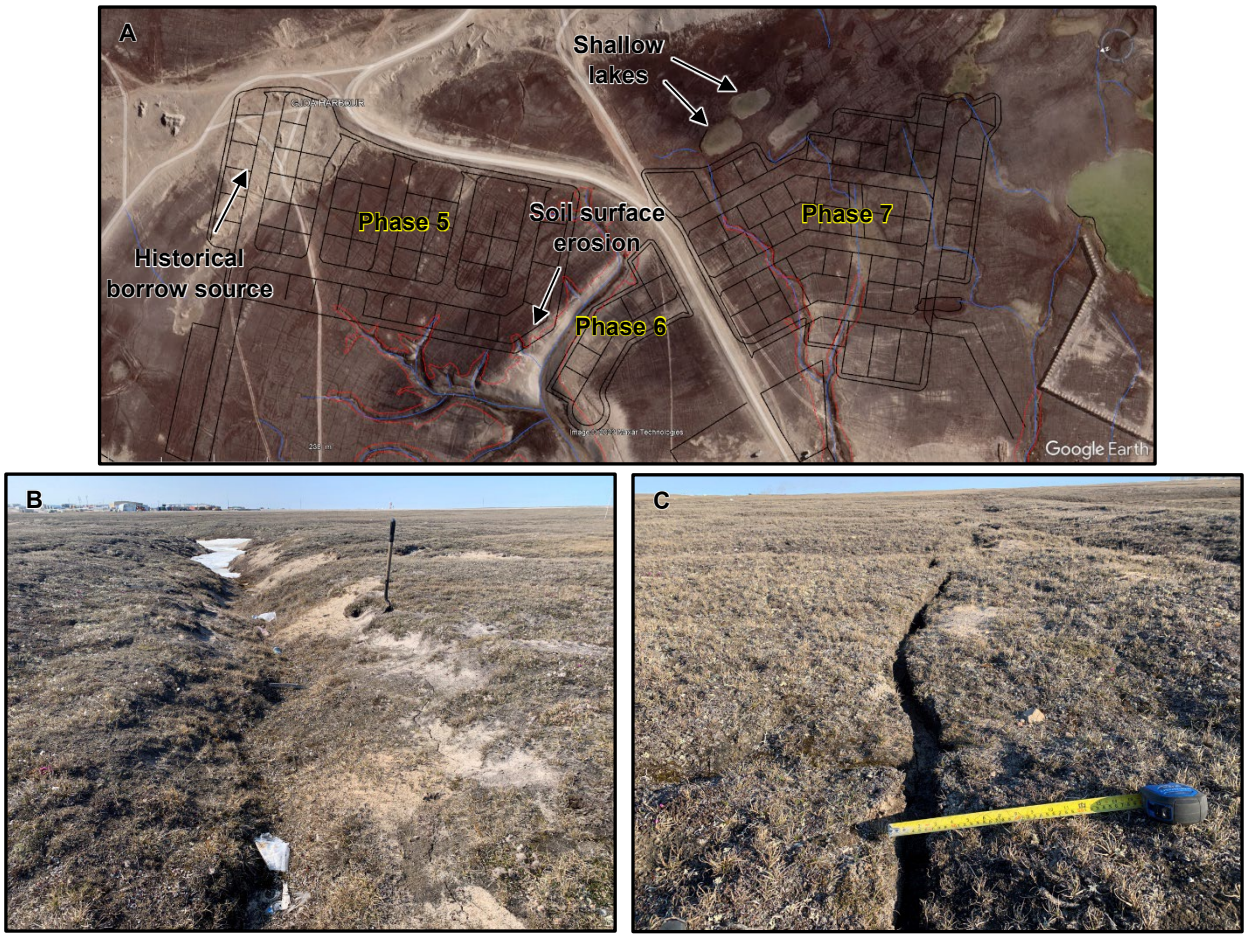

Figure 4-5 Site Conditions Within Phase 5, Phase 6 and Phase 7. A) Overview of the Subdivisions (red lines represent gully erosion; blue lines represent drainage channels and overland flow paths); B) Soil Surface Erosion and Gullying Along an Ice Wedge in Phase 5. C) 8 cm Wide Thermal-Contraction Crack in Phase 7.

4.1.1.2 Existing Townsite

Geotechnical constraints and hazards identified within the existing townsite included soil surface erosion (Figure 4-6). Erosion scars were observed within the gully crossing the old townsite and within the Gullied Area. Embankment erosion associated with drainage issues was also identified at various locations (see IDPA discussion in Section 4.3.1.2).

No sign of ground settlements related to permafrost thaw degradation could be identified within the existing townsite.

Figure 4-6 Examples of Soil Surface Erosion Observed Within the Existing Townsite. A) Erosion Scars Along the Gully that Crosses the Old Townsite (identified as white dash lines). B) Embankment Rill Erosion (IDPA #5).

Aside from the IDPAs, the Council also identified the following problem areas within the existing townsite (Figure 4-7):

- Slope instabilities were reported along the Gullied Area in the section adjacent to the old townsite. The Gullied Area is discussed in the following Section 4.1.1.3.
- House shifting was reported south from the community. No visible sign of house shifting could be identified during field investigation. Ground settlement could be related to permafrost thaw degradation; however, other mechanisms such as improper construction and poor drainage could have caused the distress.

Figure 4-7 Other Problem Areas Identified by the Council.

4.1.1.3 Gullied Area

The Gullied Area consists of an east/west oriented gully system that dissects the sandy to gravelly terrain and separates the old townsite from the northern subdivision. The gully side slopes are up to 9 m high,

and their gradients generally range between 20% and 40%. Near vertical slopes are present at some locations. Most of the gully is free of vegetation, which makes the area susceptible to soil surface erosion.

The gully was likely formed from the incision of running water (mainly following spring freshets and intense rainfall events), which eroded the soils and transported sediment downslope. Intermittent flow paths running through secondary gullies and runoff waters along the slopes drain into the gully, which conveys the aggregated flow to the Bay.

Historical air photos (1956, 1975, 1987, 1997) and 2022 orthophoto and DTM data (Arctic UAV drone survey), were used to delineate the gully and identify areas of slope regression. The gully erosion system is presented in Figure 4-8 along with examples of surface erosion observed during field investigation. The findings are summarized below:

- Available data suggest that the gully did not expand in length across the landscape.
- A few localized areas; however, are impacted by erosion and slope regression. They were generally characterized by the presence of overland flow path, erosion at the slope toe and/or by the absence of a vegetation cover.
- The comparison between the 1987 air photos and 2022 drone survey data suggested that, where present, slope regressions were generally under 5 m (averaging less than 15 cm/yr) since 1987.
- Three locations of interest with higher slope regressions were identified adjacent to the old townsite, near the sealift area, and south from the northern subdivision (Figure 4-8 and Figure 4-9).
- The slope located adjacent to the old townsite (Figure 4-9a) regressed up to 25 m (70 cm/yr) and included the development of three gullies since 1987. Review of historical air photos suggests this slope was partially levelled and graded between the years 1975 and 1987. Since then, this slope section served as an access trail for vehicular transit between the old townsite and the northern subdivision (Figure 4-8d), which is believed to have accentuated the erosion process.

  Note that a 5 m deep gully with near-vertical side slopes and signs of active erosion, occurs adjacent to this section (Figure 4-8f); however, it presented limited regression (<5 m) since 1987. This gully is located within 20 m from two houses.
- The slope located near the sealift area (Figure 4-9b) initially consisted of two gullies that developed into one larger gully. The overall slope regression observed was up to 60 m (170 cm/yr) since 1987. The gully formed following the development of the northern subdivision, which allowed for additional water to transit within the gullies and soils to be eroded. This slope section also served as an access trail for vehicular transit between the old townsite and northern subdivision, which is believed to have accentuated the erosion process.
- The slope located south from the northern subdivision (Figure 4-9Figure 4-9c) showed a regression up to 10 m (30 cm/yr) since 1987. The erosion occurred following the development of the northern subdivision, likely due to the increased amount of water transiting within the gully channel.

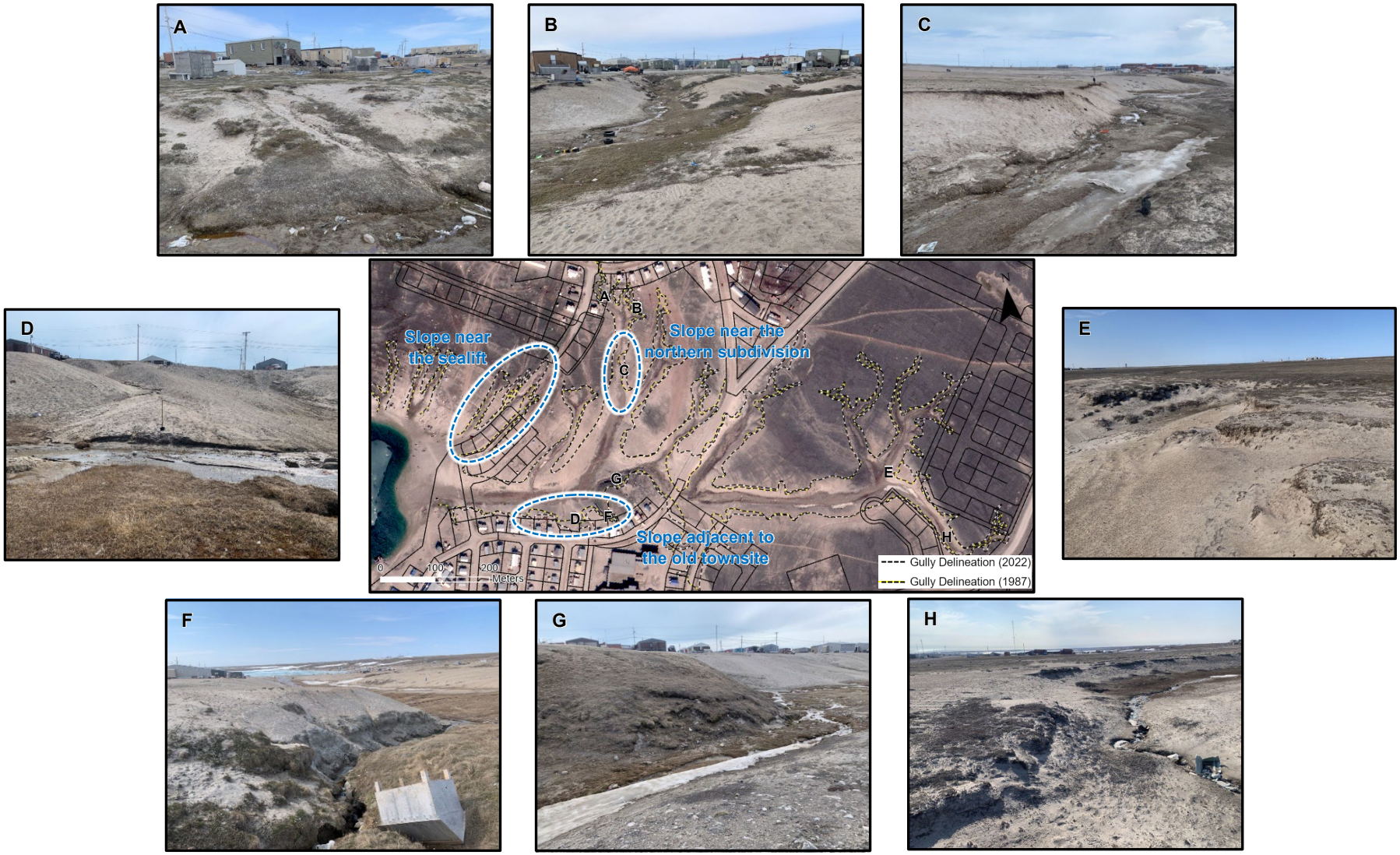

Figure 4-8 **Soil Surface Erosion Observed Along the Gullied Area. Black Dash Lines Represent Areas Characterized with Higher Slope Regression Since 1987.**

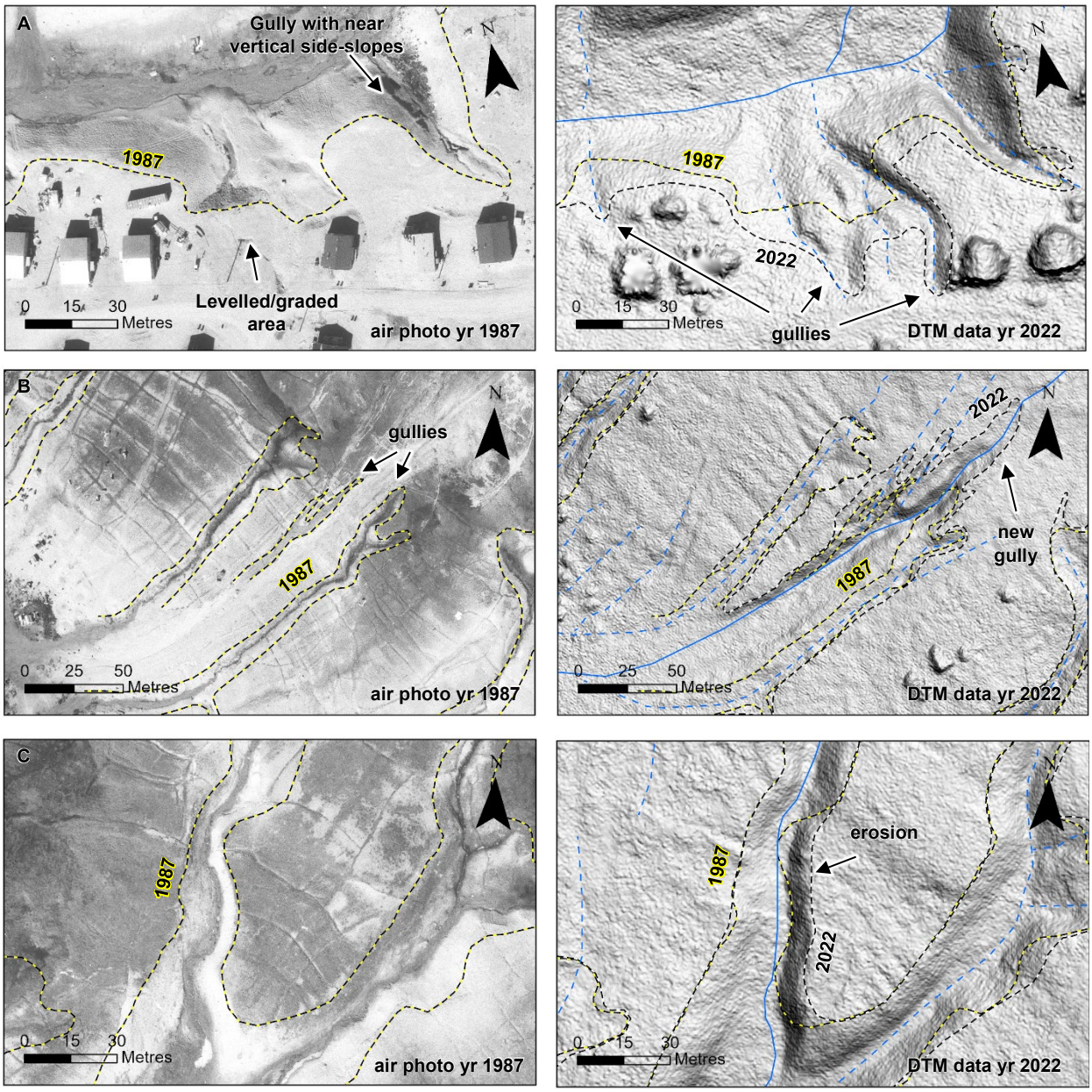

Figure 4-9 **Delineation of the Gully System for the Years 1987 and 2022 (blue lines represent overland flow paths and drainage channels). A) Slope Adjacent to the Old Townsite; B) Slope Near the Sealift Area; C) Slope South From the Northern Subdivision.**

4.1.2 Subsurface Conditions

Subsurface conditions are summarized based on the results from the field investigation. Geotechnical observations and data are presented in detail on the borehole records provided in Appendix F. The laboratory testing results are presented in the attached gradation curves and summary tables in Appendix G and are summarized in Table 4-1.

Table 4-1 Particle Size, Moisture Content, Volumetric Ice Content, and Cryostructure

Sample No.	Depth (m)	Sediment fraction (%)			Moisture Content (%)	Volumetric Ice Content (%)	Cryostructure[1]
		Fine particles	Sand	Gravel			
BH22-01 DC-06	1.10 – 1.26 m	0.4	97.2	2.4	21.3	-	Nbn, Vx
BH22-01 DC-09	1.83 – 2.03 m	-	-	-	22.0	44.4	Nbn, Vx
BH22-02 DC-04	1.05 – 1.30 m	-	-	-	21.4	43.7	Nbn
BH22-03 DC-07	1.46 – 1.65 m	0.1	99.9	0	14.2	-	Nbn
BH22-06 DC-05-B	1.19 – 1.30 m	-	-	-	40.5	58.8	Nbn, I+S
BH22-06 DC-08	1.70 – 1.90 m	0.5	77.3	22.2	19.5	-	Nbe, Vc
BH22-07 DC-06	1.20 – 1.35 m	-	-	-	24.8	-	Nbn, Vs
BH22-07 DC-07	1.35 – 1.50 m	-	-	-	49.9	78.5	Vs, I+S
BH22-07 DC-08	1.50 – 1.65 m	0.7	96.1	3.2	46.1	64.2	Vs, I+S
BH22-07 DC-11	2.20 – 2.35 m	-	-	-	19.9	40.0	Nbn, Vx
BH22-09 DC-10	1.92 – 2.05 m	4.2	95.7	0.1	21.6	-	Nbn

NOTES:
[1] Poorly-bonded (Nf), Well-bonded no excess ice (Nbn), Well-bonded excess ice (Nbe), Individual ice (Vx), Ice coating (Vc), Random ice (Vr), Stratified ice (Vs), Ice with soil inclusions (I+S), Ice with soil <25 mm thick (Ice).

4.1.2.1 Organics

At all the borehole locations, surficial organics were encountered overlying granular soils. They consisted of a thin cover of mosses and sod overlying a thin topsoil (< 5 cm thick).

4.1.2.2 Overburden

The dominant stratigraphy encountered at the boreholes consisted of poorly graded fine and medium sand to sand and gravel soils with traces of silt. Cobbles and boulders were observed at the ground surface near borehole BH22-08. Seashells were encountered at borehole BH22-01 between 2.25 and 2.60 m bgs.

Boreholes BH22-02, BH22-04, BH22-06, and BH22-08 generally contained a greater proportion of gravel. These boreholes were all terminated due to refusal on inferred coarse material between 0.65 and 2.00 m bgs. Boreholes BH22-01, BH22-03, BH22-05, BH22-07, and BH22-09 were all terminated in sand.

Particle size analysis conducted on sandy deposits was used to estimate the soil erodibility factor (K), which quantifies the soil's susceptibility/resistance to erosion and the soil's influence on runoff amount and rate (RUSLEFAC 1997). The very fine fraction of sand encountered (< 0.1 mm) represented generally less than 2%, which corresponds to a K-factors of approximately 0.006 and soils very slightly susceptible to water erosion. In sample BH22-09-DC-10, located near the Gullied Area south from the northern subdivision, the very fine fraction was up to approximately 13% indicating a K-factor of approximately 0.011 and soils slightly susceptible to water erosion. During periods of freeze-thaw, the K-factor is considered to increase by a factor of 2, which means during thaw the susceptibility to erosion increases.

4.1.2.3 Bedrock

Bedrock was not encountered within the limits of the boreholes.

4.1.2.4 Groundwater

The groundwater level was observed at only one borehole (BH22-05) at 0.15 m bgs, the remaining boreholes were dry at the time of backfilling. The remaining boreholes were dry at the time of backfilling. This borehole was advanced in a low-lying area adjacent to a drainage channel located in a low-relief gully depression.

In continuous permafrost terrain, groundwater levels will typically be perched within the active layer. These levels are expected to fluctuate seasonally and in response to precipitation events, surface drainage or ground disturbances.

4.1.2.5 Permafrost

Active Layer Measurement and Interpretation

Active layer measurements were taken at the borehole locations while conducting the drilling on June 15 to 17, 2022. Findings are summarized below:

- Active layer depths ranged between 0.24 and 0.54 m bgs.
- Based on cryostructure interpretation, it was expected that the depth of the permafrost table (maximum depth of the active layer) ranged between approximately 1.2 and 1.3 m bgs at boreholes BH22-01, BH22-06 and BH22-07.
- At boreholes BH22-02, BH22-03, BH22-04, BH22-05, BH22-08, and BH22-09, the depth of the permafrost table would be expected to be at least 1.3 m bgs, and could extend deeper.

Note that lower ice content permafrost is likely to have a deeper active layer depth, considering the higher amount of latent heat required to melt the ice in ice-rich permafrost profiles.

Ground ice

Moisture content testing conducted on recovered samples was used to estimate the potential ice content within the frozen active layer and first metre of permafrost. Findings are summarized below:

- Measured moisture contents varied between 14.2% and 49.9%.
- Measured VIC varied between 40.0% and 78.5%.
- Frozen soils with low ice content (estimated from cryostructure interpretation and moisture content < 25%) were encountered within all boreholes. Low ice content profiles included poorly-bonded (Nf), well bonded with no excess ice (Nbn), individual ice (Vx), stratified ice (Vs) and ice coating (Vc) cryostructures.
- Frozen soils with moderate ice content (estimated from cryostructure interpretation and moisture content 25% to 50%) were encountered within boreholes BH22-06 and BH22-07. Moderate ice content profiles included well bonded with excess ice (NBe), ice coating (Vc), stratified ice (Vs), and ice with soil inclusion (I+S) cryostructures.
- Boreholes BH22-01, BH22-02, BH22-03 and BH22-06 were advanced along apparent ice wedges troughs. No massive ice was observed in obtained core samples within these boreholes; however, the ice with soil inclusion (I+S) cryostructures observed within borehole BH22-06 were 2 cm wide and occurred on the side of the cores (along the length), which could represent the edge of an ice wedge.
- The ice with soil inclusion (I+S) cryostructures observed within borehole BH22-07 were approximately 1 cm wide, and as for BH22-06, they occurred on the side of the core (along the length). No apparent ice wedge trough was identified at the ground surface at this location.

Examples of cryostructures observed are presented in Figure 4-10.

Figure 4-10 Examples of Cryostructures Observed. A) 1 cm-Thick Ice Vein (Vs) at BH22-01-DC-09 (1.9 – 2.0 m bgs); B) Ice with Soil Inclusions (I+S) at BH22-06-DC-05 (1.0 – 1.3 m bgs) Showing the Permafrost Table at 1.2 m bgs; C, D) Ice with Soil Inclusions (I+S) and 1 cm-Thick Ice Vein (Vs) at BH22-07-DC-08 (1.5 – 1.7 m bgs).

4.2 Development Suitability Assessment

The qualitative development suitability assessment conducted as part of the project focused on terrain and geotechnical site conditions that could adversely affect land development. Through the assessment, adverse conditions were observed to be associated with the following two main categories:

Terrain and/or geotechnical constraints consisting of naturally occurring features having the potential to negatively affect the design, construction and maintenance of infrastructure. Local examples of terrain or geotechnical constraints may include slope steepness, drainage conditions, and the occurrence of ice-rich permafrost.

Landscape hazards consisting of features or conditions having the potential to lead to localized or widespread damage to property and threaten personal safety. Local examples of landscape hazards may include mass movements, gully erosion, thermokarst and ground subsidence, flooding or shoreline erosion.

Results of the development suitability assessment are presented in Figures C-2a to C-2c in Appendix C along with the constraints and hazards identified. Key findings include the following:

- **Terrain Generally Suitable for Development:**

  Based on the findings of the development suitability assessment, short to medium-term development strategies should focus on terrain identified as generally suitable for development.

  Terrain generally suitable for development was mapped in all planned future subdivisions (Phase 1 to Phase 7), and mainly consisted of lots located on flat to gently sloping terrain (< 20%), where no drainage anomaly or apparent landscape hazard was observed.

  Although terrain generally suitable for development includes areas of suspected ice wedges, most of these features appeared stable, without sign of degradation. The localized presence of ice wedges should still be accounted for as part of future design and/or maintenance.

- **Terrain conditionally suitable for development:**

  Terrain conditionally suitable for development consists predominantly of areas associated to the presence of poor drainage anomalies, of areas located near a gully system, and where slope gradients range between 20% and 40%. Levelling and grading may be required to develop in areas with steeper slope sections.

- **Terrain unsuitable for development:**

  Terrain unsuitable for development consists predominantly of a combination of moderately steep to steep topography (i.e., slopes > 40%), of poorly to very poorly drained terrain, of ponding areas, and of hazards such as soil surface erosion. Although engineering measures and construction techniques could be applied to address the above-listed conditions, avoiding these locations is preferred.

  Note that an extra buffer (2 times the slope height) for terrain unsuitable for development was added surrounding areas with near-vertical slopes presenting potential for slope failure (i.e., at few locations within the Gullied Area).

Where development is to occur in areas presenting constraints and hazards, then appropriate design, construction and maintenance guidelines should be applied (see Section 5: Summary of Key Findings and Recommendations).

4.3 Drainage Assessment and Mapping

4.3.1 Existing Developed Areas

Drainage catchment boundaries, drainage pathways, and drainage infrastructure are illustrated on Figures 1, 2 and 3 in Appendix D-1. Culvert characteristics are provided in Appendix H.

4.3.1.1 General Drainage Conditions

Drainage Assessment

Catchments. The drainage assessment resulted in a total of 27 catchments within the Gjoa Haven developed and surrounding areas. The catchment delineation method resulted in smaller catchments within the developed community center, owing to the density of drainage infrastructure of interest (i.e., desired outfall points).

ROW Widths. Figure 4 from CSA (2020) recommends a 16 m wide ROW width for local roads. Desktop analysis indicated that the majority of ROW widths are greater than 16 m, although the road footprint is often offset to one side of the ROW.

Ditches and Channels. A total of 1,873 m of ditches and channel were delineated within the 27 catchments. Figure 5 from CSA (2020) recommends that ditches should be present on both sides of roads to convey roadway drainage coming from the road crest. In some cases, ditching on both sides of the road is not required due to the overall drainage patterns in the catchment or on the road. This is reflected in Figure 4 of CSA (2020). In the developed core of Gjoa Haven, 1,873 m of the ditches/channels are within 5 m of the road ROW and may be considered roadside drainage ditches. The total road network within the development core of Gjoa Haven is approximately 16,751 m; therefore, approximately 11% of the road network within Gjoa Haven's developed core has roadside ditches. CSA (2020) generally recommends that roadside ditches be provided on at least one side of each road for snow accumulation and conveyance of runoff.

- Drainage deficiency: spatial coverage of the ditch network is insufficient for the road network.

The distinction between a ditch and channel (as defined in the Definitions and Terminology section) can be subjective. This was especially true for the Gjoa Haven drainage infrastructure because many of the roadside drainage features are informal (i.e., not intentionally constructed), or have little to no bed or bank definition putting them on the threshold of a ditch/channel/flow path. This wide, shallow drainage ditch design can be important in northern communities to allow for flexible vehicle access to buildings for servicing (e.g., septic pumpouts, fuel tank filling, water tank filing) (CSA 2020). However, the shallow ditch geometry in Gjoa Haven comes at the expense of reduced capacity for snow clearing in the winter and flow conveyance during runoff events in the spring, summer, and fall, as well as increased risk of ditch and culvert icing during the winter and during spring melt periods. In addition, the shallow ditch geometry

facilitates the driving of vehicles, ATV's and snowmobiles in the ditch which can a) alter the geometry (impairing conveyance) b) compact snow piled in the ditch (increasing risk of ditch and culvert icing/blockages) and c) crushing of culvert ends (impairing conveyance). Depending on the road crest elevation and overall drainage patterns, the impaired spilling or ponding of water on the road may also result from the shallow ditch geometry.

Minimum ditch dimensions provided by CSA (2020) include 2-4 m width and 0.75 m depth, although ditches should be sized as required to adequately convey the flows they are receiving. Ditch dimensions were not obtained in 2022, however depths of less than 0.75 m were frequently observed both in ditches/channels, and in roadside drainage features not formally categorized as ditches/channels. Future detailed design of ditches should consider hydrologic and hydraulic modelling.

- Drainage deficiency: variable and often insufficient ditch depths and widths (qualitative observation).

Culverts. A total of 64 culverts were inventoried in Gjoa Haven in the 2022 field program, consisting of 40 cross culverts and 24 entrance culverts. The location, IDs and drainage direction of each culvert are illustrated on Figure 1 and Figure 2 in Appendix D-1. The detailed database of culvert characteristics, along with datasheets for each culvert, are provided in Appendix H.

A breakdown of culvert type, material, and size are provided in Table 4-2. All culverts are circular in shape.

Table 4-2 Summary Characteristics of Culverts in Gjoa Haven

Culvert Type	Culvert Material	Culvert Diameter (mm)												Totals	
		250	280	300	400	500	600	800	900	1100	1120	250/600[1]	Unknown		
Cross	CSP			4	2	11	2	3	3	1		1	2	29	40
	PVC	10									1			11	
Entrance	CSP		1	1	7	3	2		1					15	24
	PVC	9												9	
Totals		19	1	5	9	14	4	3	4	1	1	1	2	64	64

NOTES:
[1] Culvert location had a 250 mm and 600 mm culvert installed.

Culvert Condition Ratings: Barrel Material, Shape, Capacity, Erosion and Scour.

Table 4-3 provides a summary of culvert condition ratings for the 64 culverts inventoried in Gjoa Haven. The priority level for remediation, as defined in Table 2-3, is also indicated in Table 4-3.

Table 4-3 Summary of Culvert Condition Ratings

Condition Rating	Barrel Material (0-4)		Shape (0-4)		Capacity (0-2)		Erosion and Scour (0-2)		US/DS Channel (0-2)	
0	64	100.0%	26	40.6%	14	21.9%	45	70.3%	28	43.8%
1		0.0%	15	23.4%	17	26.6%	18	28.1%	15	23.4%
2		0.0%	13	20.3%	33	51.6%	1	1.6%	21	32.8%
3		0.0%	4	6.3%						
4		0.0%	6	9.4%						
NOTES Priority for remediation (based on Table 3-3):					High	Medium	Low (no highlight)			

Based on the results in Table 4-3, the following drainage deficiencies are noted:

- Drainage deficiency: 10 of the 64 culverts (15.7 %) have damaged ends with a high priority for remediation; an additional 13 culverts have damaged ends with a medium priority for remediation.
- Drainage deficiency: 33 of the 64 culverts (51.6%) are infilled with a high priority for remediation.
- Drainage deficiency: 1 of the 64 culverts (1.6%) have erosion and scour in the vicinity of the culverts ends with a high priority for remediation.
- Drainage deficiency: 21 of the 64 culverts (32.8%) have channel erosion, scour, sedimentation, or other instability upstream or downstream of the culvert that threatens the culvert or prevents flow from reaching the culvert such that there is a high priority for remediation.

Culvert Marker Pole. None of the evaluated culverts had functional marker poles at both ends of the culvert. The purpose of the marker poles is to identify culvert ends so that drivers and snowplows can avoid the culvert ends, therefore minimizing damage. The absence of culvert marker poles is likely a contributing factor to the high rate of culvert end damage (Table 4-3, Shape condition).

Other. Other general drainage problems that were observed during the drainage assessment or otherwise expressed to Stantec included:

- Drainage deficiency: backyard or front yard ponding is a frequent occurrence.
- Drainage deficiency: several driveways are missing entrance culverts; this results in a blockage of the existing ditch, creating conveyance issues.
- Drainage deficiency: full complement of emergency flooding equipment and supplies is not held in reserve for emergency use.
- Drainage deficiency: drainage monitoring and maintenance is completed on a response- or incident-basis; a formal drainage monitoring and maintenance program is not currently in place.

Drainage Planning

As discussed in Section 4.3.1, there is an extensive amount of existing drainage infrastructure within Gjoa Haven which is well entrenched into the overall community infrastructure. Based on drainage deficiencies noted in the drainage assessment above, 10 community-wide drainage recommendations were developed for Gjoa Haven (Table 4-4). It is Stantec's opinion that implementation of these drainage recommendations is likely to improve drainage conditions within the existing community.

CSA (2020) recommends Smooth Wall Steel Pipe (SWSP) culverts as the preferred material where depth of cover or culvert icing issues are present. The structural strength and longer lifespan of SWSP culverts are advantageous for the long-term resiliency of the drainage plan, however SWSP is considerably more expensive than CSP. Depending on the drainage conditions and challenges at a given site and material availability, the increased cost of SWSP may be warranted.

Table 4-4 Community-Wide Drainage Recommendations

Drainage Deficiency	Recommended Action(s)
Ditch network coverage insufficient for road network	Increase the density of drainage ditches alongside the road network in Gjoa Haven. The existing conditions drainage map delineates the existing ditch network relative to the road network and provides the foundation for Gjoa Haven to identify areas requiring additional roadside ditches. New ditches should meet the ditch geometry standards outlined in CSA (2020); that is, width of 4 m and depth of 0.75 m. These dimensions result in side slopes of approximately 2.7:1 (H:V) which should be reasonable for occasional servicing access by vehicles if required, but will also discourage everyday driving over the ditches which should preserve ditch geometry, conveyance capacity, and snow-clearing capacity. If the ditching area has space constraints, the width of the ditch may be narrowed to a minimum of 2 m. Larger ditches may be required if inflows require increased conveyance capacity or if ditch or culvert icing is common in the area. As ditch construction may restrict access to properties, designated site access (driveways) and entrance culverts may need to be provided for private properties. Entrance culverts should have the required depth of cover, have marker posts installed, and have culvert end treatments applied to protect the ends from damage. Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). The culvert diameter for entrance culverts should be at least 300 mm. If the culvert is located within a culvert chain, the culvert should be equal to or larger than the upstream culverts. Culvert invert elevations should be such that they connect directly to upstream and downstream ditch elevations and provide positive drainage through the culvert and through the overall drainage network. Verifying elevations for positive drainage conditions during installation may be completed by manual surveys using a level and stadia rod or other comparable survey equipment.
Qualitative variable and often insufficient ditch depths and widths	Improve the geometry of existing drainage ditches. Where permafrost and soil conditions permit, existing ditches should be improved to meet, at a minimum, CSA (2020) guidelines. Recommended actions for ditch design detailed above in “ditch network coverage insufficient for road network drainage deficiency”.
10 culverts have damaged ends with a high priority for remediation; an additional 13 culverts have damaged ends with a medium priority for remediation	Repair the damaged/crushed culvert ends to re-establish hydraulic conveyance capacity of the culvert. The 10 culverts requiring remediation are identified in the detailed culvert database in Appendix H. The severity of the damage will determine the required work at each culvert: i. Culverts with minor deformation at the ends may be bent back to the intended shape with appropriate tools ii. Where i) is not possible, culverts may be repaired by cutting off the damaged portion and either leaving it square (if remaining culvert projects from embankment) or adding a short section of new culvert with an appropriate coupling. Culverts with more substantial end damage may require a portion of the road to be dug up to reach a section of non-crushed culvert prior to coupling with the culvert extension. iii. For severely damaged culverts where crushing extends through substantial portions of the barrel, complete culvert replacement may be required. If the culvert is to be replaced, efforts should be made to install SWSP culverts (CSA 2020). For CSP culverts, the repaired culvert ends should be reinforced with a steel end stiffener (e.g., Figure 4-11 as extracted from CSA 2020) or comparable stiff steel collar. This end treatment will make the culvert ends more resistant to damage in the future. As the hardened end treatments will not deform in the same way as CSP culverts, they pose a potential safety hazard to vehicles or humans who are accustomed to driving over the culvert ends (before or after deformation). The installation of the hardened end treatments should be communicated to the local community in advance of implementation.

Drainage Deficiency	Recommended Action(s)
	Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). SWSP culverts are also more resistant to end deformation and do not require end treatments.
33 culverts are infilled with a high priority for remediation	Clean out the sediment inside the culverts to re-establish culvert conveyance capacity. The 33 culverts requiring cleanouts are identified in the detailed culvert database in Appendix H. Cleaning out of the culverts can be completed hydraulically with a flusher truck, or potentially with a hose from a fire truck. Manual agitation of the sediment in the culvert with a shovel or pole can help loosen sediment and promote hydraulic flushing. If sediment accumulation is too substantial to flush using these methods, culvert replacement may be considered. Infilled culverts are often connected to ditches that have also been infilled. It is recommended that improvements to the ditch geometry (to match CSA 2020 standards and connecting to the culvert inverts) upstream and downstream of the culvert be completed in tandem with the culvert cleanout. Multi-level culvert arrangements, as illustrated in Figure 9 of CSA (2020), can be considered if culvert icing is an issue. Culvert diameter should be equal to or larger than the upstream culverts.
1 culvert had erosion and scour in the vicinity of the culvert ends with a high priority for remediation	The culvert requiring repairs to the embankment or scour/erosion at culvert ends is identified in the detailed culvert database in Appendix H. It is worth investigating the cause of embankment or outlet erosion/scour prior to implementing a solution. For example, an embankment could be eroding due to flows entering the ditch from road spillage caused by nearby culverts being crushed or infilled. In this case, improving the conveyance of the crushed or infilled culverts may re-establish normal drainage patterns and alleviate the embankment erosion, and simple re-grading/re-dressing of the embankment slope is sufficient. In other cases, the embankment or outfall erosion/scour may be due to the quantity of water, slope of the culvert, or slope of the receiving system. In these scenarios, bank stabilization techniques such as angular riprap, erosion matting or re-vegetation are well suited for stabilization.
21 culverts have channel erosion, scour, deposition or other instability upstream or downstream of the culvert that threatens the culvert such that there is a high priority for remediation	The 21 culverts requiring improvements to the channels upstream or downstream of the culvert are identified in the detailed culvert database in Appendix H. If erosion is the issue in the upstream or downstream channel(s), available angular rock or riprap are well suited to reduce erosion. A suitable filter layer of substrate or a layer of non-woven geotextile fabric should be installed beneath the angular rock and keyed into the existing ground at the ends to reduce the winnowing of fines and undermining of the substrate. Well-graded substrate gradations (i.e., a range of diameters) should be used where possible to improve stability. The substrate should be graded to match the culvert invert of the affected end, and should slope gradually to the receiving system avoiding abrupt changes in ditch/channel gradient. If sedimentation is the issue in the upstream or downstream channel(s), excavation of the ditch geometry should be performed and ditch dimensions in accordance with upstream or downstream dimensions should be re-established. Sediment should be removed until ditch grade matches the culvert invert of the affected end, and should slope gradually to the receiving system avoiding abrupt changes in ditch/channel gradient.
Culvert marker poles not present	Culvert marker poles should be installed at the upstream and downstream ends of each culvert in Gjoa Haven. Given the snow ploughing and build up over the winter in Gjoa Haven, it is likely that marker posts may be damaged over the winter each year. The annual inspection, re-securing, or reinstalling of marker posts should be incorporated into the drainage monitoring program (last item in this table).

Drainage Deficiency	Recommended Action(s)
Driveways are missing entrance culverts	Install entrance culverts at all driveways. Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020). Culvert diameter should be equal to or larger than the upstream culverts.
Emergency flooding equipment and supplies not in reserve	To enable emergency flooding response actions, Gjoa Haven should retain the following supplies in reserve for emergency use: • 600 mm CSP culverts • Sandbags • Rolls of 6 mil plastic sheeting (for use in sandbag berms) • Typical details for sandbag berms (e.g., *Sandbag Dike Construction* from Manitoba (undated), provided in Appendix H) • Gas-powered pumps and hoses for pumps • Erosion protection material (i.e., riprap, erosion matting, etc.) • List of competent individuals and contractors in drainage and civil engineering who can be contacted for emergency technical and construction assistance
Drainage Monitoring and Maintenance Program not in place	A drainage monitoring and maintenance program should be developed and implemented. The existing drainage maps and culvert inventory provide the foundation for such a program. The components of a drainage monitoring program are outlined in CSA (2020) Clause 6 and include the following considerations/components: • Able to be executed by local competent individuals (e.g., town foreman or equipment and utility operators familiar with or trained in drainage systems) • Should incorporate risk of failure into project prioritization • Spring inspection and maintenance involving culvert inspections (following a similar method to that applied in this report) and any urgent actions, ditch and culvert blockage identification and removal, culvert marker post inventory and repair, litter and debris removal, and identification/documentation of ditch and culvert icing issues for future planning purposes • Summer inspection and maintenance following a similar approach to the spring inspection, but with snow-free conditions for better observation • Fall construction and repairs when water levels in northern communities are typically the lowest • Drainage monitoring in the winter consists mainly of snow management considerations and planning for the spring melt

Figure 4-11 Culvert End Treatment – Culvert End Stiffener (Figure 17 from CSA 2020)

Figure 17
Example of culvert end treatment
(See Clause 5.6.4.8.)

Note: *This culvert end stiffener detail was developed by the Ministry of Transportation in Saskatchewan (2018). Originally intended for large diameter culverts (1.8 to 2.4 m diameter), a similar detail would also be useful for the smaller diameter culverts commonly seen in the communities. A wider stiffener band could be considered for culvert sections more prone to damage from maintenance equipment or crushing from traffic.*

4.3.1.2 Identified Drainage Problem Areas

Drainage Assessment

A total of 12 IDPA's were identified by the Council. The location of each IDPA is illustrated in Figure 1 through to Figure 12 in Appendix D-2. IDPA numbering was assigned geographically (west to east) and is not indicative of priority level. The drainage issue(s) at each IDPA is/are discussed below and are illustrated on Figure 1 to Figure 12 in Appendix D-2. Recommended actions are provided in Table 4-4.

IDPA #1: Ponding Cutting Across Road: IDPA #1 is located between catchment 103 and catchment 102. Catchment 103 has no upstream contributing catchments, however, it has no defined outlet with the

exception of culvert 103-01. Culvert 103-01 is crushed at the upstream end therefore there the culvert is not functioning at full capacity. Runoff is ponding at the downstream end of catchment 103 and cutting across the road.

IDPA #2: Rear Lot Ponding: IDPA #2 is located within the upstream end of catchment 108, adjacent to catchment 102. Runoff from catchment 102 cuts across the road and ponds in catchment 108. Catchment 105 also shares a border with catchment 108 and culvert 105-01 at the downstream end of catchment 105 outlets into catchment 108.

IDPA #3: Low-Lying Area That Consistently Ponds: IDPA #3 is located at the upstream end of catchment 107. Since ditching within the community is poor it is possible that runoff from adjacent catchments 101 and 102 may cut across the road to pond in the existing low-lying area. IDPA #3 is located over an historical lake as shown as point 2 in Figure 3-4.

IDPA #4: Runoff Cutting Across Road: IDPA #4 is located within catchment 110. It is located at the downstream end of a drainage draw that starts at the top of catchment 110 and passes through culvert 110-01. The existing culvert 110-04 is poorly located as a result it does not drain the ponded area that occurs within IDPA #4.

IDPA #5: Runoff Cutting Across Road: IDPA #5 is located near the border of catchment 110 and 106. Runoff from catchment 106 cuts across the road to catchment 110 where it is causing rilling within the road embankment.

IDPA #6: Improper Culvert Placement: IDPA #6 is located within catchment 115. Ponding was observed at the downstream end of catchment 115. The invert of culvert 115-01 and culvert 115-02 are not located at the correct elevation to drain the ponded water within catchment 115.

IDPA #7: Low-Lying Area That Consistently Ponds: IDPA #7 is located within catchment 113 and 119 and it is a low-lying area that consistently ponds. As shown in Figure 25, IDPA #7 was historically a lake prior to being developed.

IDPA #8: Erosion within Channel Embankment: IDPA #8 is located within catchment 118 on the downstream embankment of culvert 118-04. The embankment around the culvert at 118-04 is unstable and is showing signs of rill erosion.

IDPA #9: Runoff Cutting Across Road: IDPA #9 is located at the downstream end of catchment 117. Runoff is cutting across Kudlik Crescent from Tatqut Street. No culvert present in existing condition.

IDPA #10: Ponding During Spring Melt: IDPA #10 is located within catchment 118. Ponding is occurring on Sinktaquik Street during spring melt. No existing ditches are present on Sinktaquik Street.

IDPA #11: Ponding Cutting Across Road: IDPA #11 is located within catchment 120 and 123. There is an existing low-lying area that ponds and cuts across Tulaktarvik Way.

IDPA #12: Runoff Cutting Across Road: IDPA #12 is located within catchment 122. Runoff is unable to be conveyed through culvert 122-02 due to inadequate conveyance capacity. Therefore, runoff from Pirraaq Road cuts across Hinaaq Street.

Drainage Planning

Specific recommendations for each of the 12 IDPAs are summarized in Table 4-5, including the corresponding figure reference. Depending on the level of complexity of the recommended action, detailed engineering design may be required. Drainage conditions should be monitored following design and implementation of any of the drainage planning recommendations to detect any undesirable by-product impacts of the drainage improvement and inform adaptive or corrective action.

Table 4-5 IDPA Drainage Recommendations

Identified Drainage Problem Area (IDPA)	Figure	Summary of Drainage Issue	Recommended Action(s)
IDPA #1	1, D-2	Ponding cutting across road	Replace culvert 103-01 to convey drainage from the upstream area. Install a new culvert and ditch that drains to culvert 102-02. Reinstall culverts 102-02 and 102-03 at a lower invert elevation. Construct a ditch upstream of culvert 103-01 to convey flow to the culvert.
IDPA #2	2, D-2	Rear lot ponding	Unblock culvert 108-01 and survey the invert. If the invert is not lower than IDPA #2 add fill to IDPA #2 and/or reinstall culvert 108-01 at a lower elevation to improve drainage. Construct a ditch from IDPA #2 to culvert 108-01 to improve conveyance.
IDPA #3	3, D-2	Low-lying area the consistently ponds	Install a culvert at the southwestern corner of IDPA #3. Construct a ditch from the proposed culvert to convey flows. If unable to install culvert at a low enough invert for positive drainage, add fill to IDPA #3.
IDPA #4	4, D-2	Ponding cutting across road	Reinstall culvert 110-04 within the low point in IDPA #4 to allow the ponded area to drain beneath Nattiaq Street.
IDPA #5	5, D-2	Runoff cutting across road	Construct ditch on the east side of Imiqtarvik Road to help minimize the potential of upstream runoff cutting across the road. Install a culvert to convey flows under unnamed road perpendicular to Imiqtarvik Road.
IDPA #6	6, D-2	Improper culvert placement	Replace and install culverts 115-01 and 115-02 with larger capacity structures at a lower invert elevation to help drain the upstream ponded area.
IDPA #7	7, D-2	Low-lying area that consistently ponds	Add fill within the low points of IDPA #7 to help minimize the potential of ponding and provide positive drainage to ditches. Verify the existing ditch on the north end IDPA #7 to culvert 113-02 has sufficient grade to convey flow. Add ditches along Recreation Drive to help convey flow from IDPA #7 towards existing culvert 119-03.
IDPA #8	8, D-2	Erosion within channel embankment	Re-grade embankment to stable slope and stabilize with large angular rock underlain by suitable filter layer or keyed-in non-woven geotextile.
IDPA #9	9, D-2	Runoff cutting across road	Construct ditches on either side of Tatgut Street to convey flow to the proposed culverts under Kudlik Crescent to ultimately discharge to the ocean.
IDPA #10	10, D-2	Ponding during spring melt	Add fill within the low point in IDPA #10 to mitigate ponding and provide positive drainage. Construct ditches on either side of Siniktaquik Street to convey flow to the proposed culvert at the west end of catchment 118.
IDPA #11	11, D-2	Ponding cutting across road	Improve and/or replace existing culverts 123-01 and 123-02. Construct a ditch to convey flow out of IDPA #11 along Tulaktarvik Way.
IDPA #12	12, D-2	Runoff cutting across road	Improve and/or replace culvert 122-02. Construct a ditch along Pirraaq Road and Hinaaq Street to convey flow to culvert 122-02.

4.3.2 Future Development Areas

4.3.2.1 Drainage Assessment

Existing drainage conditions in each of the planned future development areas are briefly summarized below.

Phase 1

Phase 1 is an approximately 2.2 ha area located at the north end of the Gjoa Haven urban area within catchment 101, 102, 107 and 108. Existing drainage in this area is illustrated in Figure 1 in Appendix D-1. Phase 1 is located upstream of the waterbodies in catchment 101 and 102. No drainage infrastructure currently exists within Phase 1.

Phase 2

Phase 2 is an approximately 1.4 ha area located mostly in catchment 114. Existing drainage is shown in Figure 2 in Appendix D-1. Phase 2 is located directly upstream of one of the main drainage draws within the urban development area of Gjoa Haven. In existing conditions there is culvert 114-01 at the north end of Phase 2 and a watercourse that cuts through the southeast corner of Phase 2.

Phase 3

Phase 3 is approximately 2.0 ha area located down gradient from Apumiuk Way within catchment 107, 108 and 109 as shown on Figure 1 in Appendix D-1. There is no drainage infrastructure in existing condition, however, there are multiple drainage channels and overland flow paths within the Phase 3 footprint.

Phase 4a

Phase 4a is approximately 2.6 ha in area and is located within catchment 104 and 106 at the north end of the existing Gjoa Haven development as shown on Figure 1 in Appendix D-1. Currently there is no drainage infrastructure in existing condition within the Phase 4a footprint. South of Phase 4a there is a low-lying area that consistently ponds under existing conditions.

Phase 5

Phase 5 is approximately 8.2 ha in area and is located within catchment 115 directly upstream of one of the main drainage draws within the urban Gjoa Haven area. Existing drainage conditions are shown on Figure 3 in Appendix D-1. No drainage infrastructure currently exists within Phase 5.

Phase 6

Phase 6 is approximately 1.4 ha in area located within catchment 104 directly west of Phase 5. Phase 6 drains to the same drainage draw as Phase 5 located northeast of the Phase 6 development footprint. Existing drainage is shown on Figure 3 in Appendix D-1. No drainage infrastructure currently exists within Phase 6.

Phase 7

Phase 7 is approximately 8.1 ha in area located within catchment 121 and 126 directly south of Phase 6. In existing condition serval drainage paths and channels cut through Phase 7 and serval small waterbodies are located directly upstream of the proposed development. Most of the area within Phase 7 drains to existing culvert 121-01. Existing drainage is shown on Figure 3 in Appendix D-1. No drainage infrastructure currently exists within the Phase 7 footprint.

4.3.2.2 Drainage Planning

The drainage plan for each of the seven development blocks are discussed below. The drainage plans are provided at the conceptual planning level; detailed engineering design has not been completed. Development of the drainage plans assumed that site grading could be completed in a way which resulted in the preferred drainage plan. Future engineering and site development works may require amendments to the conceptual drainage plan presented here. Detailed engineering of the site drainage infrastructure, incorporating quantitative analysis of runoff rates, volumes, and conveyance capacities of infrastructure (existing vs. proposed conditions), should be completed alongside the detailed engineering phases of the overall site development.

The conceptual drainage plans for the planned future subdivisions incorporated the following principles in accordance with CSA (2020) and general best management practices for drainage in developed areas:

- Existing drainage directions and boundaries should be preserved as much as practical.
- Road crown should occur in the centre; roadside ditches should be provided on both sides of the road where necessary.
- Entrance culverts should be located at the driveway entrance of each lot.
- Where warranted and/or practicable, efforts should be made to install SWSP culverts (CSA 2020).
- Drainage from upstream areas between lots should be avoided where practical.
- All culverts should meet minimum depth of cover requirements.
- Culvert marker poles should be installed on both ends of each culvert.
- Ditch outfalls should be located at an existing drainage feature; stable outlets and tie-ins should be provided.
- Drainage monitoring should be completed to detect drainage issues and inform corrective or adaptive action.

Phase 1

Figure 1 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 1. The existing drainage boundaries will be generally preserved with the exception of slight alterations to the boundary between catchment 107 and 101 to accommodate the proposed ditch.

IDPA #3 is located directly downstream of Phase 1. It is anticipated that the construction of the proposed ditch within Phase 1 will reduce the amount of runoff that reaches IDPA #3.

In total, the proposed drainage plan for Phase 1 includes 1 cross culvert, 11 entrance culverts and approximately 550 m of proposed ditching.

Phase 2

Figure 2 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 2. The existing drainage boundaries will be generally preserved with the exception of the eastern corner of catchment 119 which will become smaller once the proposed ditches are constructed. Existing culvert 114-01 is the proposed outlet for Phase 2.

Construction should be avoided on top of the existing channel alignment the southeastern lots within Phase 2.

In total, the proposed drainage plan for Phase 2 includes 1 cross culvert, 8 entrance culverts and approximately 525 m of proposed ditches.

Phase 3

Figure 3 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 3. The existing drainage boundaries will be generally preserved. Four outlets are proposed within Phase 3. Two in catchment 107, 1 in catchment 108 and 1 in catchment 109.

Given the steepness of the receiving ditches/channels, there is an above-average risk of increased flow rates or duration (from the development) may increase downstream erosion risks. This should be specifically investigated prior to installation of the drainage plan for Phase 3.

In total, the proposed drainage plan for Phase 3 includes, 2 cross culverts, 15 entrance culverts and approximately 840 m of proposed ditches.

Phase 4a

Figure 4 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 4a. The existing drainage boundaries will be generally preserved with the exceptions to some changes to the catchment 104 and 106 due to the proposed ditches.

The low point with catchment 106 will serve as the outlet to Phase 4a with overflows to culvert 106-02.

In total, the proposed drainage plan for Phase 4a includes, 2 cross culverts, 18 entrance culverts and approximately 885 m of proposed ditches.

Phase 5

Figure 5 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 5. The existing drainage boundaries will be preserved in proposed condition. The drainage draw located to the southwest of Phase 5 will be the main outlet for Phase 5 in existing and proposed condition.

Five lots at the north end of Phase 5 are proposed to outlet directly to the drainage channel to the north. The rest of the development is proposed to outlet at the existing drainage channel at the south end of the development.

In total, the proposed drainage plan for Phase 5 includes, 8 cross culverts, 51 entrance culverts and approximately 2,500 m of proposed ditches.

Phase 6

Figure 6 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 6. The existing drainage boundaries will be preserved in proposed conditions. In proposed conditions, runoff will be collected by the proposed ditch that runs through Phase 6 to the proposed ditch that runs along Recreation Drive. This differs from existing conditions where flows runoff toward the nearby drainage channel. Flows from Phase 6 will ultimately be conveyed to culvert 115-01 and 115-02 in existing and proposed conditions.

In total, the proposed drainage plan for Phase 6 includes, 1 cross culvert, 7 entrance culverts and approximately 475 m of proposed ditches.

Phase 7

Figure 7 in Appendix D-3 illustrates the proposed conditions drainage plan for Phase 7. The existing drainage boundaries will generally be maintained in proposed conditions. Consideration has been given for the existing watercourses that run through the Phase 7 footprint by constructing ditching along the existing drainage paths. The southern portion of Phase 7 is designed to outlet to culvert 120-01. The rest of the proposed development is designed to outlet to culvert 121-01.

In total, the proposed drainage plan for Phase 7 includes, 8 cross culverts, 35 entrance culverts and approximately 2,260 m of proposed ditches.

5 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

Summary of key findings and recommendations of the geotechnical evaluation and drainage assessment and planning are presented below.

5.1 Summary of Key Findings

5.1.1 Geotechnical Evaluation

5.1.1.1 Overburden Soils

The surficial geology surrounding Gjoa Haven consists mainly of ice contact glaciofluvial deposits overlain with thin beach ridges (consisting of sand with gravel), and coarse glaciomarine deposits (consisting mainly of cobbly sand and gravel) forming flights of raised beaches.

Subsurface conditions at the borehole locations generally consisted of a thin layer of organics underlain by poorly graded fine and medium sand to sand and gravel soils with traces of silt. Sandy soils with up to 13% of very fine fraction (< 0.1 mm) were observed near the Gullied Area south from the northern subdivision. These soils are considered slightly susceptible to water erosion according to soil erodibility K-factor (RUSLEFAC 1997). Soil's erodibility increases with finer grained particle size and during periods of freeze-thaw, which may partly explain erosion issues at some locations along the Gullied Area.

Bedrock was not encountered within the boreholes.

5.1.1.2 Groundwater

Groundwater level was observed at 0.15 m bgs in BH22-05, which was located adjacent to a drainage channel.

5.1.1.3 Permafrost

Gjoa Haven is located within the continuous permafrost zone. The maximum active layer depth in the area was reported to range between approximately 0.75 and 2.25 m bgs, and was measured between 1.2 and 1.3 m bgs as part of the present study. Polygonal networks of ice wedges were identified throughout the study area; however, they appear predominant in the planned future subdivisions Phase 2, Phase 4a, Phase 5, Phase 6 and Phase 7.

Based on the geotechnical evaluation, it is expected that an overall low to moderate ice content permafrost generally occurs within the planned future subdivisions (with recorded moisture contents varying between 14.2% and 49.9%, and VIC varying between 40.0% and 78.5%). No massive ice was observed within the boreholes advanced along apparent ice wedges droughts; however, borehole BH22-06 was potentially advanced along the edge of an ice wedge, as suggested by the occurrence of

ice with soil inclusion (I+S) cryostructures along the length of the cores. It is interpreted that ice wedges are likely to be thin in the area.

Most of the apparent ice wedges observed appeared stable, without sign of thaw degradation. Localized settlement should still be expected if permafrost were to thaw along ice wedges, where massive ice is the most likely to occur. Infrastructure design should be planned accordingly.

5.1.1.4 Slope Stability

Features indicative of slope instabilities are present within the study area. They include soil surface erosion and occur within the Gullied Area and the gully that crosses the old townsite. Available data suggest that recently, the Gullied Area did not expand in length across the landscape. Localized areas are, however, impacted by erosion and slope regression. Areas affected by slope regression are generally characterized with the presence of overland flow path, erosion at the slope toe and/or by the absence of a vegetation cover. Poorly graded sand with a higher fine fraction is another factor contributing to soil erosion and slope regression along the Gullied Area.

The comparison between the 1987 air photos and 2022 drone survey data suggested that, where present, slope regressions along the Gullied Area were generally under 5 m (averaging less than 15 cm/yr) and up to 60 m (170 cm/yr) since 1987. Anthropogenic activities, including the development of the northern subdivision and additional water flow, contributed to slope regression within the Gullied Area. A 5 m deep gully with near-vertical side slopes and signs of active erosion occurs adjacent to the old townsite (Figure 4-8f); however, it presented limited regression (<5 m) since 1987. This gully is located within 20 m from two houses.

A preliminary slope stability assessment of the slope to the Gullied Area was completed, the assessment indicated that the slopes are generally stable, the factor of safety against slope failure was greater than 1.5. Continued erosion of the slope and slope toe could cause the slope to become unstable.

Based on available data it is interpreted that erosion is one of the leading causes impacting stability and contributing to slope regression along the Gullied Area. Rapid snowmelt and extreme rain events have the potential to overwhelm local drainage infrastructures, causing localized flooding, surface erosion, washouts, and landslides. Anthropogenic activities and the development of new subdivisions also has the potential to modify the drainage conditions and might trigger additional erosion downstream. Accordingly, the planned future subdivisions Phase 2, Phase 3, Phase 5 and Phase 6, being located adjacent to the Gullied Area, are the most likely to be impacted by accentuated erosion following their development.

Erosion control and adequate drainage management is required to mitigate instabilities along the gully system.

5.1.2 Development Suitability Assessment

The development suitability assessment conducted focused primarily on terrain and geotechnical site conditions (e.g., topography, drainage, slope stability, permafrost) that could adversely affect the design, construction and maintenance of future developments within the community.

Terrain generally suitable for development consisted of areas located on < 20% slope where no drainage anomaly or apparent landscape hazard was observed, and included polygonal networks of ice wedges that developed in sandy deposits and appeared stable without signs of thaw degradation. Terrain conditionally suitable for development consisted of areas associated to the presence of drainage anomalies, of areas located near a gully, and where slope gradients range between 20% and 40%. Terrain unsuitable for development consists predominantly of a combination of moderately steep to steep topography (i.e., slopes > 40%), of poorly to very poorly drained terrain, of ponding areas, and of hazards such as soil surface erosion.

Short to medium-term development strategies should focus on terrain identified as generally suitable for development. Wherever development is to occur in areas presenting constraints and hazards, then appropriate design, construction and maintenance guidelines should be applied.

5.1.3 Drainage Assessment and Planning

The drainage component of this project was split into two parts:

1. Drainage assessment. The characterization and evaluation of the existing conditions relative to applicable standards and recommended best management practices.
2. Drainage planning. Actions which may be taken to address existing drainage deficiencies and improve overall drainage conditions, as well as drainage infrastructure that should be implemented in areas of new development.

Drainage assessment and planning was completed for three different areas in Gjoa Haven:

- Entirety of the developed area
- Identified Drainage Problem Areas (IDPAs)
- Planned Future Subdivisions

5.1.3.1 Developed Area

Following desktop review of the general hydrology and climate in Rankin Inlet, a field assessment of the existing drainage system was completed. The field assessment included:

- Meeting with Council to identify locations and details of areas which have demonstrated notable drainage issues in the past, and where the Council would like specific recommendations for improvement. These areas were referred to as Identified Drainage Problem Areas (IDPAs) and are discussed further in Section 4.3.1.2.
- Refinement of catchment boundaries by ground-truthing drainage splits
- Delineation of ditch and channel network
- Completion of a detailed inventory of culverts in Gjoa Haven
- Documentation of other relevant components of the general drainage conditions in Gjoa Haven

The collected field data provided the information required to create a drainage map of the existing drainage system consisting of catchments, ditches/channels, culverts, and overland flow paths. The collected field data also provided the basis for evaluation of the drainage system against the drainage requirements outlined in CSA (2020), MTO (2013), and other relevant drainage best management practices. A total of 10 deficiencies for the overall drainage network in Gjoa Haven were identified; recommendations to address each of the 10 deficiencies were developed (Table 5-1).

Table 5-1 Summary of Drainage Assessment and Planning for Developed Area

Drainage Deficiency	Recommended Action(s) [1,2]
Spatial coverage of the ditch network is insufficient for road network	Increase density of drainage ditches alongside the road network
Variable and often insufficient ditch depths and widths	Improve the geometry of existing drainage ditches
10 culverts have damaged ends with a high priority for remediation; 13 culverts have damaged ends with a medium priority for remediation	Repair the damaged/crushed culvert ends and affix steel end stiffener for protection; if culvert beyond repair, replace culvert
33 culverts are infilled with a high priority for remediation	Clean out the sediment inside the culverts to re-establish culvert conveyance capacity
1 culvert has erosion and scour in the vicinity of the culvert ends with a high priority for remediation	Understand cause of outlet erosion or scour; address root cause and/or stabilize outlet with riprap
21 culverts have channel erosion, scour, sedimentation, or other instability upstream or downstream of the culvert that threatens the culvert such that there is a high priority for remediation	Understand cause of channel/ditch scour; address root cause and/or stabilize with riprap
Culvert marker poles not present	Install culvert marker poles
Several driveways are missing entrance culverts	Install entrance culverts at all driveways
Emergency flooding equipment and supplies	Acquire and maintain flood emergency response supplies and equipment
Formal drainage monitoring program	Establish standardized drainage monitoring program building off the drainage inventory completed in this report
NOTES: [1] Drainage issues and recommended actions are discussed in detail in Section 4.3 [2] Where new culverts are being installed (replacement or additional), the culvert material should be smooth walled steel pipe (SWSP), if possible	

5.1.3.2 Identified Drainage Problem Areas (IDPAs)

At each of the 12 IDPAs identified by the Council, Stantec completed an assessment as to the cause of the drainage issue, and developed recommended actions to mitigate the drainage issue (Table 5-2).

Table 5-2 Summary of Drainage Assessment and Planning for IDPAs

IDPA Number	Drainage Issue [1]	Recommended Action(s) [1,2]
IDPA #1	Ponding, poor drainage	Culvert replacement, additional culvert installation, ditching
IDPA #2	Ponding, poor drainage	Unblock culvert, ditching, fill ponded area

IDPA Number	Drainage Issue [1]	Recommended Action(s) [1,2]
IDPA #3	Ponding, poor drainage	Additional culvert installation, ditching
IDPA #4	Ponding, poor drainage	Reinstallation of culvert
IDPA #5	Ponding, poor drainage	Additional culvert installation, ditching
IDPA #6	Ponding, poor drainage	Additional culvert installation
IDPA #7	Ponding, poor drainage	Ditching, fill ponded area
IDPA #8	Erosion within channel embankment	Stabilize bank
IDPA #9	Missing culvert	Additional culvert installation, ditching
IDPA #10	Ponding, poor drainage	Additional culvert installation, ditching, fill ponded area
IDPA #11	Ponding, poor drainage	Additional culvert installation, ditching
IDPA #12	Ineffective culvert	Additional culvert installation, ditching

NOTES:
[1] Drainage issues and recommended actions are discussed in detail in Section 4.3
[2] Where new culverts are being installed (replacement or additional), the culvert material should be smooth walled steel pipe (SWSP) if possible

5.1.3.3 Planned Future Subdivisions

There were seven planned future subdivisions considered in this project: Phase 1, Phase 2, Phase 3, Phase 4a, Phase 5, Phase 6 and Phase 7. For each of the planned future subdivisions, the existing conditions drainage was characterized to inform inflows to the development block, potential outfall locations, existing infrastructure to incorporate/adjust, sensitive environmental features, and other considerations for proposed conditions drainage planning. Using the collected field data and conceptual road and lot layout for the planned future subdivisions, conceptual proposed conditions drainage plans were completed for each Phase (Figures 1, 2, 3, 4, 5, 6 and 7 in Appendix D-3 respectively) consisting of ditch and culvert networks, outfall locations, and (where required) alterations to drainage boundaries.

5.2 Recommendations for Planned Future Subdivisions and Gullied Area

Permafrost ground conditions present unique but solvable challenges with regard to land development in Nunavut. Site specific conditions, exacerbated by impacts of changing temperatures and precipitation patterns require adequate planning, design, and maintenance of infrastructures to reduce negative impacts and disruption.

The following sections highlight key recommendations related to the development of new subdivision components in the community of Gjoa Haven (i.e., road access, building pads and drainage infrastructure) as well as the area subject to gullying and erosion that separates the old townsite and the northern subdivision (referred to as the Gullied Area in the report).

5.2.1 Appropriate Level of Geotechnical Investigation

Geotechnical site investigations are essential to ensure that a sufficient level of site-specific information is available to support appropriate design, construction, and maintenance of existing and future

infrastructures. The current evaluation should be considered a high-level evaluation to support construction suitability from a geotechnical point of view. As the planning of future developments advances, additional site-specific geotechnical investigations should be conducted as they relate to the various stages of land development.

Conducting the following investigations prior to developing infrastructures within areas identified as conditionally suitable for development, and within the Gullied Area near existing infrastructures is recommended:

- Site-specific geotechnical investigations should be conducted once more specific development plans are available. The investigation program should be based on CAN/BNQ 2501-500/2017 *Geotechnical Site Investigations for Buildings Foundations in Permafrost Zones* (National Standard of Canada 2017).
- Borehole drilling and slope stability analysis should be performed to assess site conditions along the northern portion of Phase 6, and along the western portion of Phase 5. A geotechnical set-back from the crest of the slope should be assessed for development. The geotechnical set-back will typically vary from approximately 1 to 4 times the slope height. Additional consideration should be given to placing an erosion protection system on the slopes adjacent to the developments.
- The characteristics of readily available fill materials may impact the design and planning of future infrastructures. Proper assessment of the overall suitability of local borrow materials should be conducted.
- Slope monitoring where soil surface erosion is occurring between Phase 5 and Phase 6, west from Phase 2, south from Phase 3 and within the Gullied area adjacent to the old townsite, near the sealift and south from the northern subdivision. An erosion protection system should be placed on these slopes adjacent to existing or planned infrastructures.

5.2.2 Building Pads and Road Embankments

Structural fill used for building pads should consist of non-frost susceptible granular fill such as well-graded sand and gravel containing less than 5 to 8 percent fines. If such material is not readily available, special attention should be given to ensure that an appropriate building foundation system is selected. Borrow materials (class B and C) appear readily available from sand and gravel sources located east, west and north from the community; refer to *Surficial Geology and Aggregate Resource Analysis* report by Nunami Stantec Limited (2011) for details on the potential borrow sources available.

Findings of the geotechnical evaluation indicated that the sandy soils encountered are generally classified as having a low to moderate sensitivity to thaw degradation (with low to moderate ice content). Although ice wedges generally appeared stable with no massive ice identified as part of the field investigation, infrastructure design and/or maintenance should account for the potential presence of massive ice along apparent ice wedges drought where they occur. Soils containing ice wedges should generally be considered thaw sensitive as they could exhibit settlement upon thawing.

The thickness of the pads and road embankments should be designed to reduce permafrost degradation, especially in terrain identified as conditionally suitable for development and where ice wedges occur

(even if identified as terrain generally suitable for development). Generally, pad/embankments approximately 1.2 to 1.8 m thick placed above grade will reduce permafrost degradation. Thicker pads composed of coarser materials will reduce the potential for permafrost degradation and will drain water more effectively. Side slopes covered with coarse gravel or riprap will reduce erosion and localized sloughing; if riprap material is not available, another material such as a liner, or geotextile should be applied.

Pads and road embankments should be constructed during the summer months when the native subgrades are thawed. The fill should be placed in controlled lifts not exceeding 300 mm in thickness and compacted using suitable compaction equipment such as a vibratory roller.

5.2.3 Site Grading and Drainage

Ground disturbance should be limited to the footprint of the proposed infrastructure as stripping and grading can trigger localized thaw degradation and surface subsidence due to the melting of ground ice. Stripping of the surficial topsoil/organic layer should be avoided. The organic topsoil reduces heat flow into the ground and helps preserve the subgrade in a frozen state.

Proper surface water drainage will be essential to avoid surface erosion and preserve the permafrost during construction. If construction occurs during the thawing season, appropriate drainage management techniques should be in place before spring runoff. The construction of temporary berms is generally preferred over the excavation of drainage ditches or swales.

Building pads should be graded a 2% or more so that water drains away from the lots. Coarse-textured granular fill should be placed on lots and roads characterized by imperfect or poor drainage. Wherever required, slope cuts and/or excavations should be limited to reduce permafrost degradation.

Suspected ice wedges were observed in all future subdivisions. They occurred as large polygonal networks in Phase 2, Phase 4a (and adjacent commercial development), Phase 5, Phase 6, and Phase 7, and were sparse in Phase 1 and Phase 3. Grading and fill placement should be designed to drain water away from any ice wedge, so that the ice wedge depression doesn't trigger preferential flow path and subsequent thaw degradation. Development should be avoided within areas presenting signs of thaw degradation.

5.2.4 Conceptual Drainage Plan

Proper surface water drainage is essential for preserving the protection of infrastructure, private property, and the natural environment.

The conceptual drainage plans for Phase 1, Phase 2, Phase 3, Phase 4a, Phase 5, Phase 6 and Phase 7 are provided at the conceptual planning level in Appendix D-3 in Figure 1-7 (respectively). The conceptual drainage plans for the planned future subdivisions incorporated the following principles in accordance with CSA (2020) and general best management practices for drainage in developed areas:

- Existing drainage directions and boundaries should be preserved as much as practical.
- Road crown should occur in the centre; roadside ditches should be provided on both sides of the road.

- Entrance culverts should be located at the driveway entrance of each lot.
- Culverts should be SWSP.
- Drainage from upstream areas between lots should be avoided where practical.
- All culverts should meet minimum depth of cover requirements.
- Culvert marker poles should be installed on both ends of each culvert.
- Ditch outfalls should be located at an existing drainage feature; stable outlets and tie-ins should be provided.
- Drainage monitoring should be completed to detect drainage issues and inform corrective or adaptive action.

Detailed engineering design has not been completed for the drainage plan. Development of the drainage plans assumed that site grading could be completed in a way which resulted in the preferred drainage plan. Future engineering and site development works may require amendments to the conceptual drainage plan presented here. Detailed engineering of the site drainage infrastructure, incorporating quantitative analysis of runoff rates, volumes, and conveyance capacities of infrastructure, should be completed alongside the detailed engineering phases of the overall site development.

5.2.5 Erosion Control

Erosion control measures should be included in the design of pads and embankments, especially in terrain where proposed developments might cross natural drainage features such as overland flow paths, as well as in areas where soil surface erosion occurs near existing and projected infrastructures (i.e., between Phase 5 and Phase 6, west from Phase 2, south from Phase 3 and within the Gullied area adjacent to the old townsite, near the sealift and south from the northern subdivision). Materials to consider for erosion controls include geotextiles and riprap. More specifically:

- Riprap or other erosion protection materials should be used to armor segments of embankment located alongside culvert inlets/outlets, and to mitigate potential slope erosion near existing and projected infrastructures. This material will limit potential erosion of fine fill material. Riprap aprons should also be used to mitigate potential erosion at culvert outlets. Use of geotextiles or an appropriate filter design is also recommended and may be used if riprap is not available in Gjoa Haven.
- Limiting ground disturbance and potential damage to the native vegetation will minimize soil surface erosion. Maintaining the natural vegetative cover facilitates ground retention and prevents surface erosion.
- Sediment controls should be used to prevent siltation of the culverts, which can cause the drainage system to function poorly. The installation of silt traps, re-vegetation (may be inappropriate for this environment), straw mulching and implementation of other erosion control measures are essential.

5.2.6 Inspection and Maintenance

A properly maintained and monitored drainage system will ensure a high level of efficiency and durability. To do so:

- Inspection and maintenance personnel should be responsible for maintaining the drainage system.
- The drainage infrastructures should be inspected on a weekly basis during melting season and/or after major rain events.
- Damaged culverts should be immediately repaired or replaced.
- Erosion control measures should be implemented as soon as visible signs of surface erosion are identified.
- The cause of any malfunction of the drainage system should be identified and addressed immediately.
- Blocked culverts should be cleared immediately to restore surface water flow through the culvert.
- During winter, carry out frequent inspections to ensure that the drainage system is not damaged by snow removal or completely blocked by ice. Snow removal personnel should be aware of the location of the drainage infrastructure. Marker poles may be placed to warn operators of the presence of the culvert outlets.

6 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of the Client within the Statement of General Conditions, and its agents to review the conditions and to notify Nunami Stantec should any of these not be satisfied. The statement of general conditions addresses the following:

- use of the report
- basis of the report
- standard of care
- interpretation of site conditions
- varying or unexpected site conditions
- planning, design, or construction

We trust that the information contained in this report is adequate for your present purposes. If you have any questions about the contents of the report, or if we can be of any other assistance, please do not hesitate to contact us at your convenience.

Yours very truly,

NUNAMI STANTEC LIMITED

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APPENDIX A Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client and may not be used by any third party without the express written consent of Stantec, which may be withheld at Stantec's discretion. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec's present understanding of the specific site and project scope as described by the Client. The contents of this report are applicable only to the site conditions encountered at the time of the investigation or study. If the proposed project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec is engaged by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the reasonable skill and diligence required by customarily accepted professional practices and procedures normally provided in the performance of such services at the time when and the location in which the services were performed. No other warranty is made.

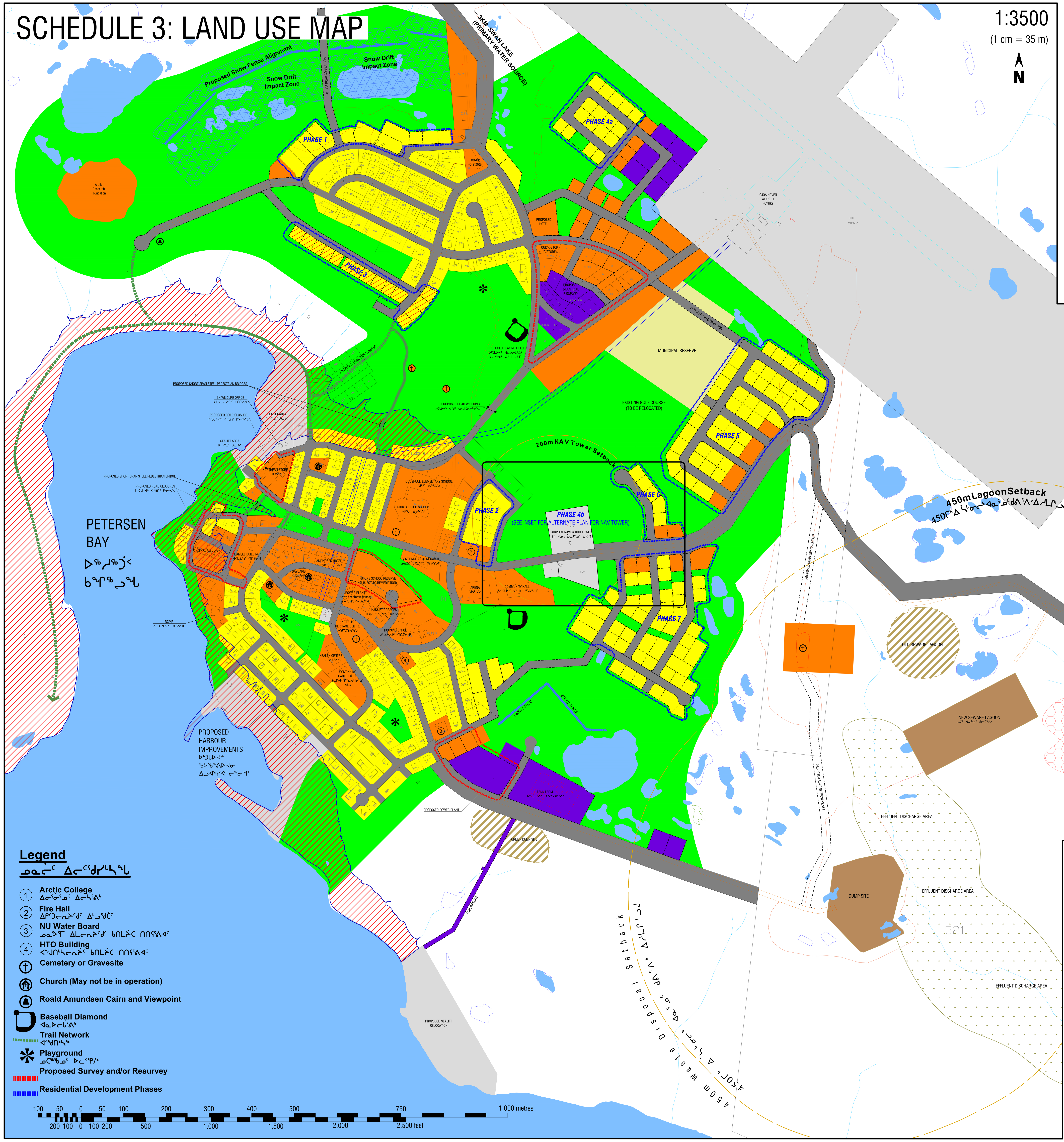
INTERPRETATION OF SITE CONDITIONS: Soil, rock, and/or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec at the time of the work at specific field observation locations and/or through interpretation of both digital imagery and/or LiDAR data. Classifications and statements of condition have been made based on anticipated behavior of the materials or geomorphic processes and are interpretive in nature; no specific description should be considered exact, but rather should be considered reflective of the anticipated behaviour of materials or geomorphic processes. Extrapolation of in situ conditions can only be made to some limited extent beyond the observed locations. The extent depends on variability of the soil, superficial materials, bedrock, soil moisture and groundwater conditions as influenced by geological processes, construction activity, and land use.

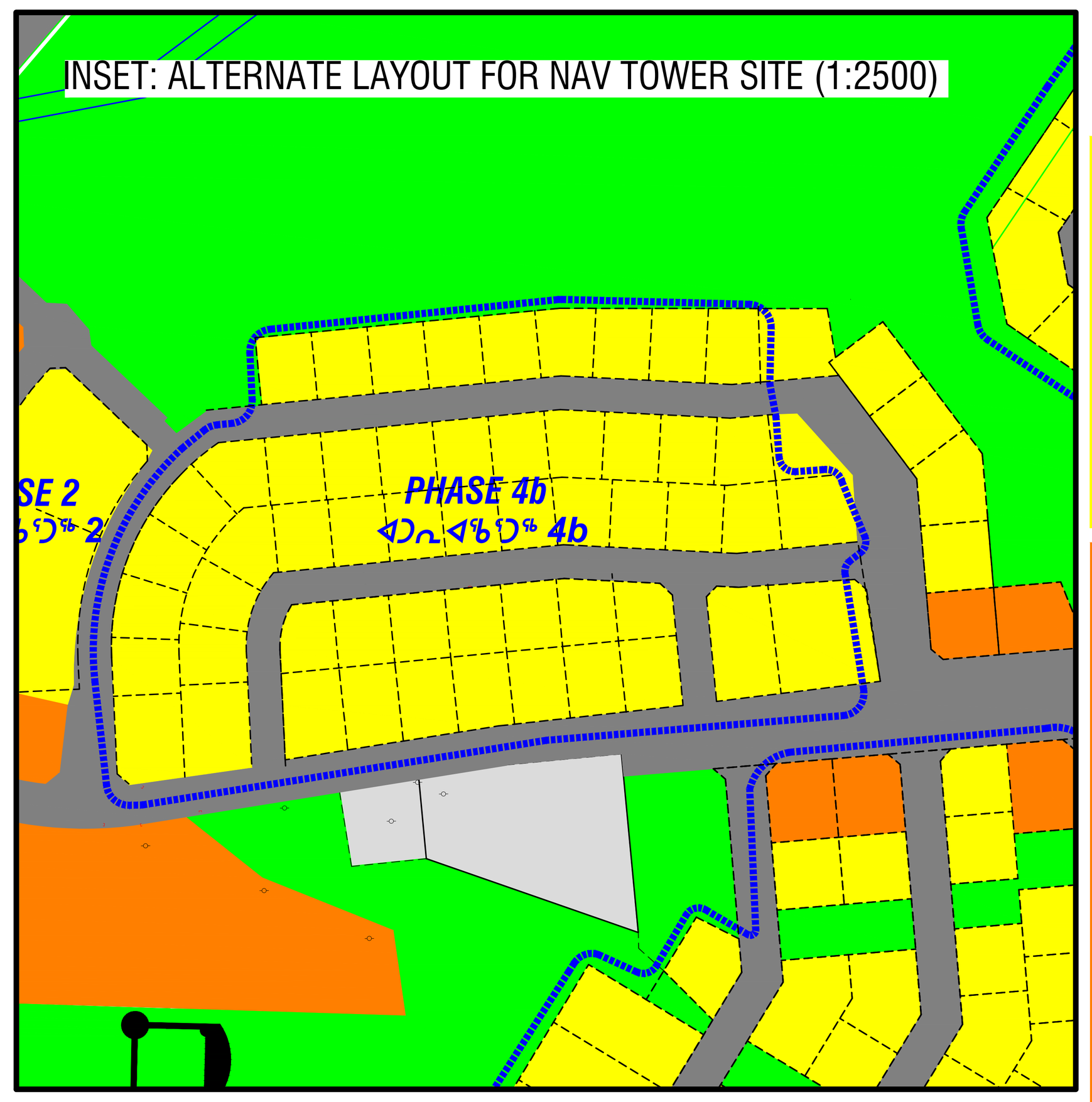
VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report, Stantec must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec will not be responsible to any party for damages incurred as a result of failing to notify Stantec that differing site or sub-surface conditions are present.

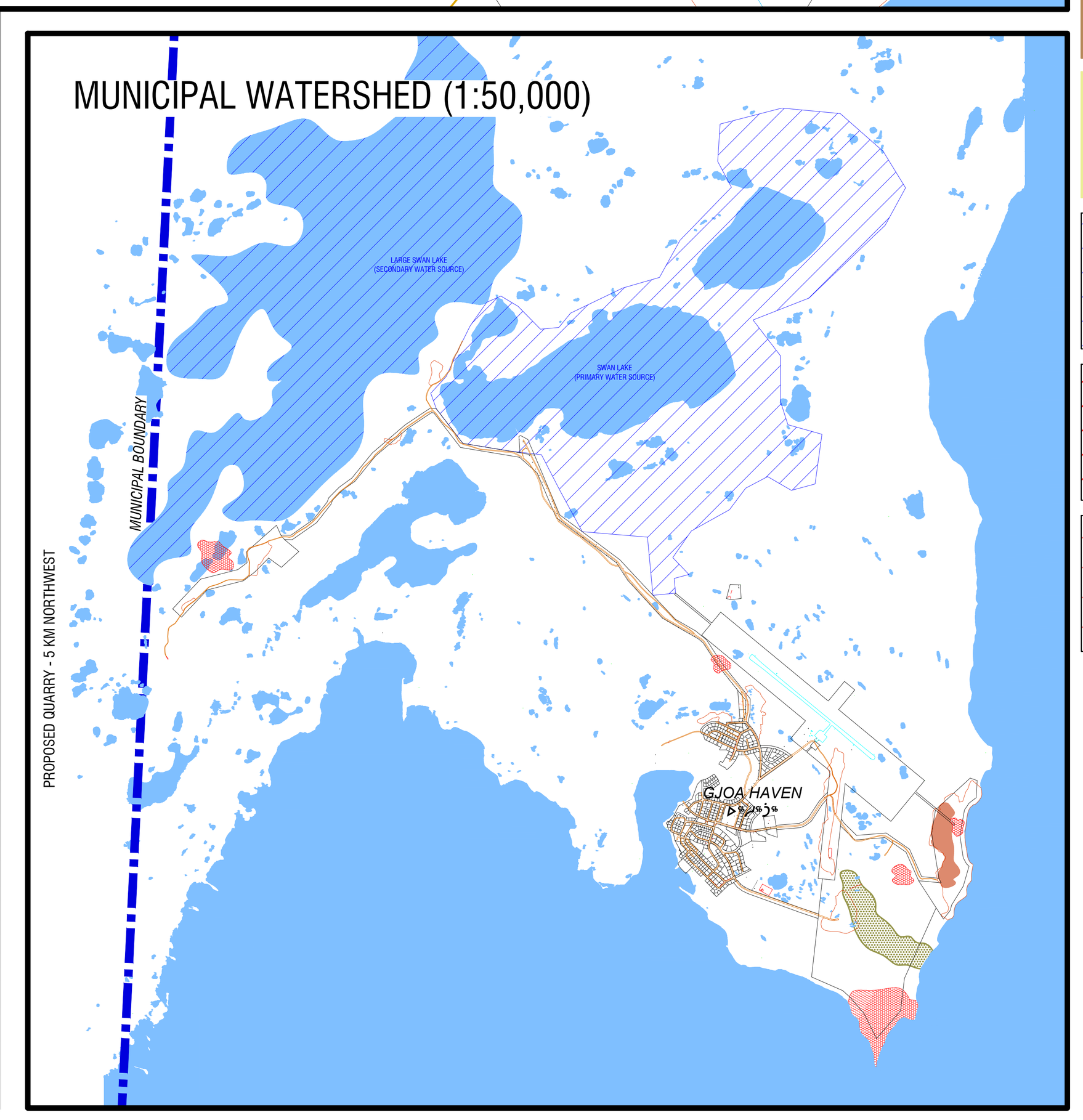
PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec, sufficiently in advance initiating the next project stage (property acquisition, tender, construction, etc.), to confirm that this report adequately addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site

APPENDIX B Community Plan

GJOA HAVEN COMMUNITY PLAN & ZONING BY-LAW ᐅᖅᓱᖅᑑᖅ ᓄᓇᖓᑕ ᐸᕐᓇᐅᑎᖓ + ᓄᓇᓕᐅᑉ ᑭᒡᓕᓕᐅᓯᓂᖓᓄᑦ 2021 - 2041







ZONING SUMMARY ᐊᓯᖏᑦ ᐊᑐᕐᑕᐅᔪᓐᓇᕐᑐᑦ

RESIDENTIAL (R)
ᐃᒡᓗᕐᔪᐊᒃᓴᖃᕐᕕᒃ ᐃᓄᒃᓄᑦ

Permitted Uses:
- Dwelling, Single-Unit
- Dwelling, Semi-Detached or Duplex
- Dwelling, Row house
- Park or Playground
- Any accessory building, structure or use, subject to section 5.1 of the Zoning By-law

Conditional Uses:
- Dwelling, Multi-Unit
- Dwelling, Mini Home
- Bed and Breakfast
- Craft Studio
- Day Care Centre
- Elders Facility
- Group Home
- Home Occupation
- Secondary Suite

COMMERCIAL / COMMUNITY USE (C)
ᓴᓇᕕᐅᔪᑦ/ᓄᓇᓕᒃᒧᑦ ᐊᑐᕐᑕᐅᓂᐊᑐᑦ

Permitted Uses:
- Automotive gas bar
- Bank
- Broadcasting studio
- Church / Place of worship
- Commercial recreation
- Communications facility
- Community hall or centre
- Convenience store
- Craft studio
- Day care centre
- Educational facility
- Elders' facility
- Emergency and protective services facility
- Government office
- Group home
- Health care facility
- Hotel
- Municipal garage
- Office
- Park or playground
- Parking lot
- Personal service
- Police Station
- Post office
- Restaurant
- Retail store
- Service Shop
- Any accessory building, utility, structure or use, subject to section 5.1 of the Zoning By-law.

Conditional Uses:
- Caretaker unit
- Cemetery
- Community freezer
- Dwelling unit for staff
- Dwelling unit(s) in a non-residential building provided that the dwelling unit(s) are above the ground floor.
- Home occupation

OPEN SPACE (OS)
ᐃᒡᓗᖃᖏᑦᑐᓴᓂᐊᖃᕐᑐᖅ

Permitted Uses:
- Beach shacks
- Boat storage
- Dock
- Golf Course
- Monument, cairn, or statue
- Park or playground
- Shed to store equipment for traditional, cultural, and recreational activities taking place in the Zone.
- Snow fence
- Sports field
- Temporary outdoor storage of sealift equipment during sealift
- Washroom facility

Conditional Uses:
- Communications facility
- Dog teams

INDUSTRIAL (M)
ᓱᕈᖅᑯᓯᓴᓄᑦ ᓴᓇᕕᒃᓄᑦ ᐃᓂᖃᕐᕕᒃᓴᖅ

Permitted Uses:
- Automotive gas bar
- Automotive repair, sales or facility
- Building supply or contractors shop
- Outdoor storage
- Rental shop
- Warehouse
- Communications facility
- Any accessory building, structure or use, subject to section 5.1 of the Zoning By-law.

Conditional Uses:
- Caretaker unit
- Hazardous goods storage
- Manufacturing plant
- Power plant
- Tank farm
- Temporary Outdoor Storage of sealifted materials and items

TRANSPORTATION (T)
ᓇᒍᓇᐃᔭᐃᓂᖅ ᓄᓇᓂᒃ ᐊᑐᖅᑕᐅᔭᕆᐊᓖᑦ

Permitted Uses:
- Airport and related uses
- Communications facility
- Sealift

NUNA (N)
ᓄᓇ

Permitted Uses:
- Dog team
- Temporary tenting or camping

Conditional Uses:
- Beach shack
- Quarry
- Cemetery
- Commercial harvesting
- Communications facility
- Permanent hunting and fishing cabins or camps
- Resource exploration and development
- Snow fence
- Tourist facilities
- Wind turbine
- Any accessory building, structure, or use, subject to section 5.1 of the Zoning By-law.

WASTE DISPOSAL (WD)
ᐃᑎᕈᓯᓄᑦ ᓄᐊᓯᓄᑦ ᓄᑯᐱᑦᑕᕕᒃᓴᖅ

Conditional Uses:
- Waste Disposal Site

MUNICIPAL RESERVE (MR)
Hᐊᒻᓚᑯᑦ ᓴᓂᕐᕙᖅᓯᒪᔭᖏᑦ

WATERSHED OVERLAY
ᐃᒻᒥᖅᑕᖅᑎᐅᑉ ᐋᖅᑭᒃᓯᓂᖓ

EROSION CONCERN
ᓄᓇᑉ ᓄᖑᐸᓪᓕᐊᓂᖓ ᐃᓱᒪᓇᖅᑐᖅ

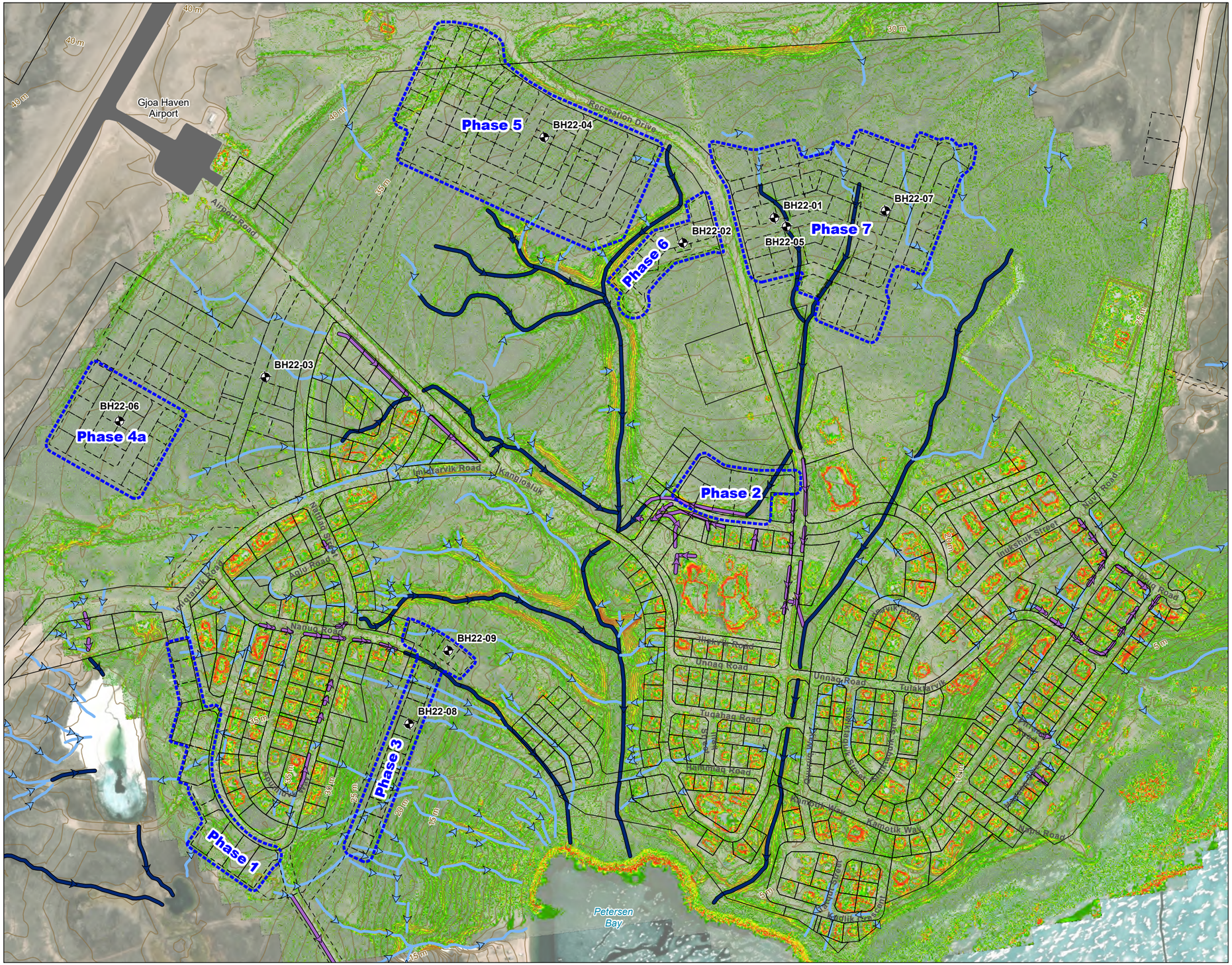
ARCHEOLOGICAL RESERVE

DRAFT
DRAFT
DRAFT

Nunavut ᓄᓇᕗᑦ

Hamlet of Gjoa Haven
ᐅᖅᓱᖅᑑᖅ
Community Plan

APPENDIX C Figures Geotechnical Evaluation



NUNAMI STANTEC

- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Development Phase
- Planned Parcel
- Parcel
- Runway
- Completed Borehole

Slope Gradient

- 0 - 10%
- 10 - 20%
- 20 - 30%
- 30 - 40%
- 40 - 50%
- 50 - 60%
- > 60%

N

0 50 100 150 200 m

(At original document size of 11x17)
1:6,200

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources: Government of Nunavut; Arctic UAV Drone Survey, 2022
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Earthstar Geographics

Project Location
Gjoa Haven, Nunavut

Prepared by WW on 2023-03-20
TR by MV on 2023-03-21

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix C-1

Title
Topography

S:\1232\projects\144903260\figures\Drainage_Report\GH_DrainageReport_Appendix_C.aprx Revised: 2023-04-11 By: LTrudell

NUNAMI STANTEC

- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Soil Surface Erosion and Gullying
- Planned Future Subdivision
- Planned Parcel
- Parcel
- 450 m Lagoon Setback / 450 m waste disposal setback
- Proposed Snow Fence Alignment / Snow Drift Impact Zone
- Runway
- Completed Borehole

Qualitative Construction Suitability

- Generally Suitable
- Conditionally Suitable
- Unsuitable

0 50 100 150 200 m

(At original document size of 11x17)
1:6,200

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Source: Government of Nunavut
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

Prepared by WW on 2023-03-20
TR by MV on 2023-03-21

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix C-2a

Title
Qualitative Construction Suitability

NUNAMI STANTEC

- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Soil Surface Erosion and Gullying
- Planned Future Subdivision
- Planned Parcel
- Parcel
- Proposed Snow Fence Alignment / Snow Drift Impact Zone
- Runway
- Completed Borehole

Qualitative Construction Suitability

- Generally Suitable
- Conditionally Suitable
- Unsuitable

N

0 50 100 150 200 m

(At original document size of 11x17)
1:4,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources: Government of Nunavut
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

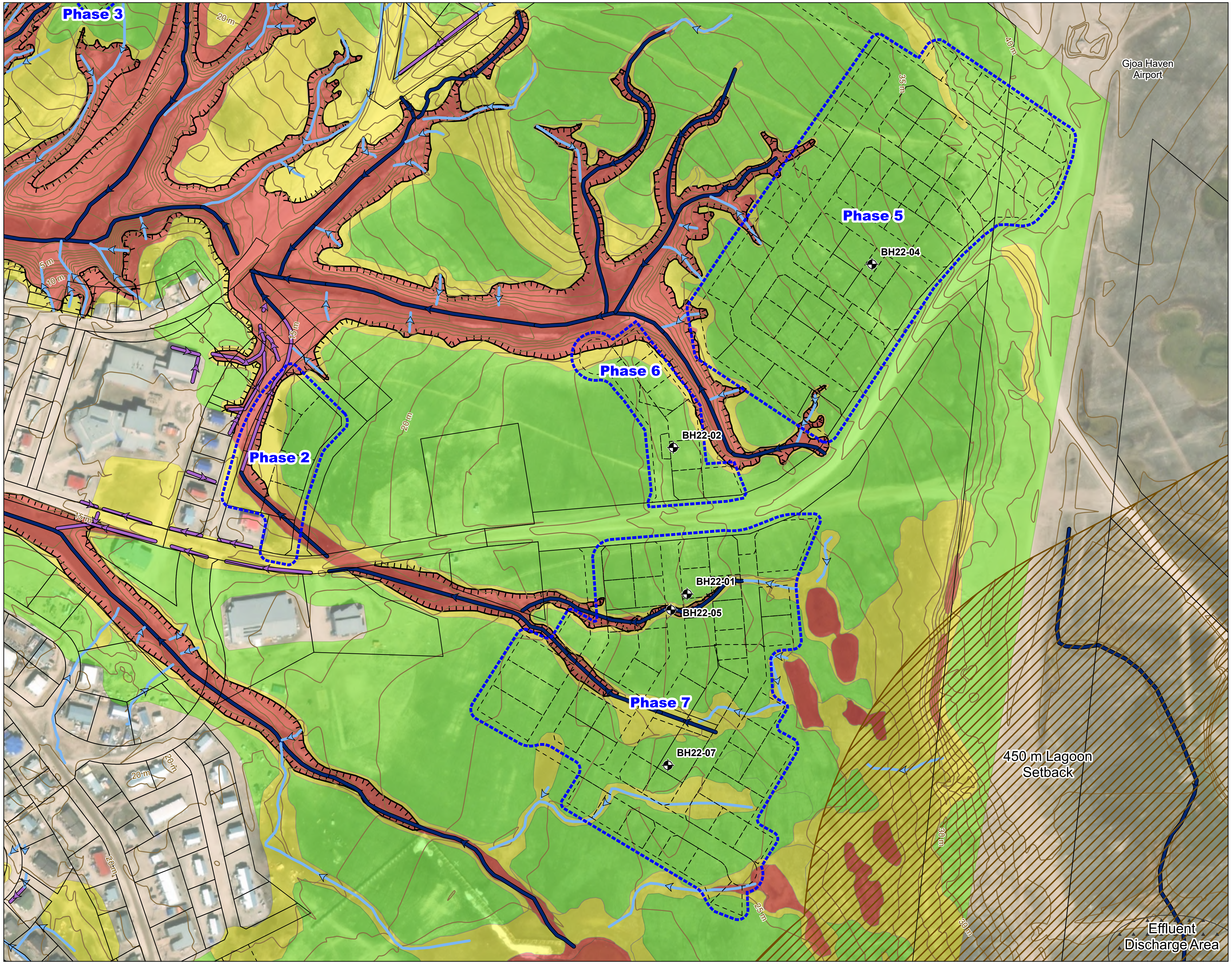
Project Location
Gjoa Haven,
Nunavut

Prepared by WW on 2023-03-20
TR by MV on 2023-03-21

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix C-2b

Title
Qualitative Construction Suitability (Phase 1, Phase 3 and Phase 4a)



NUNAMI STANTEC

- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Soil Surface Erosion and Gullying
- Planned Future Subdivision
- Planned Parcel
- Parcel
- 450 m Lagoon Setback / 450 m waste disposal setback
- Effluent Discharge Area
- Runway
- Completed Borehole

Qualitative Construction Suitability

- Generally Suitable
- Conditionally Suitable
- Unsuitable

N

0 50 100 150 200 m

(At original document size of 11x17)
1:4,000

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources: Government of Nunavut
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

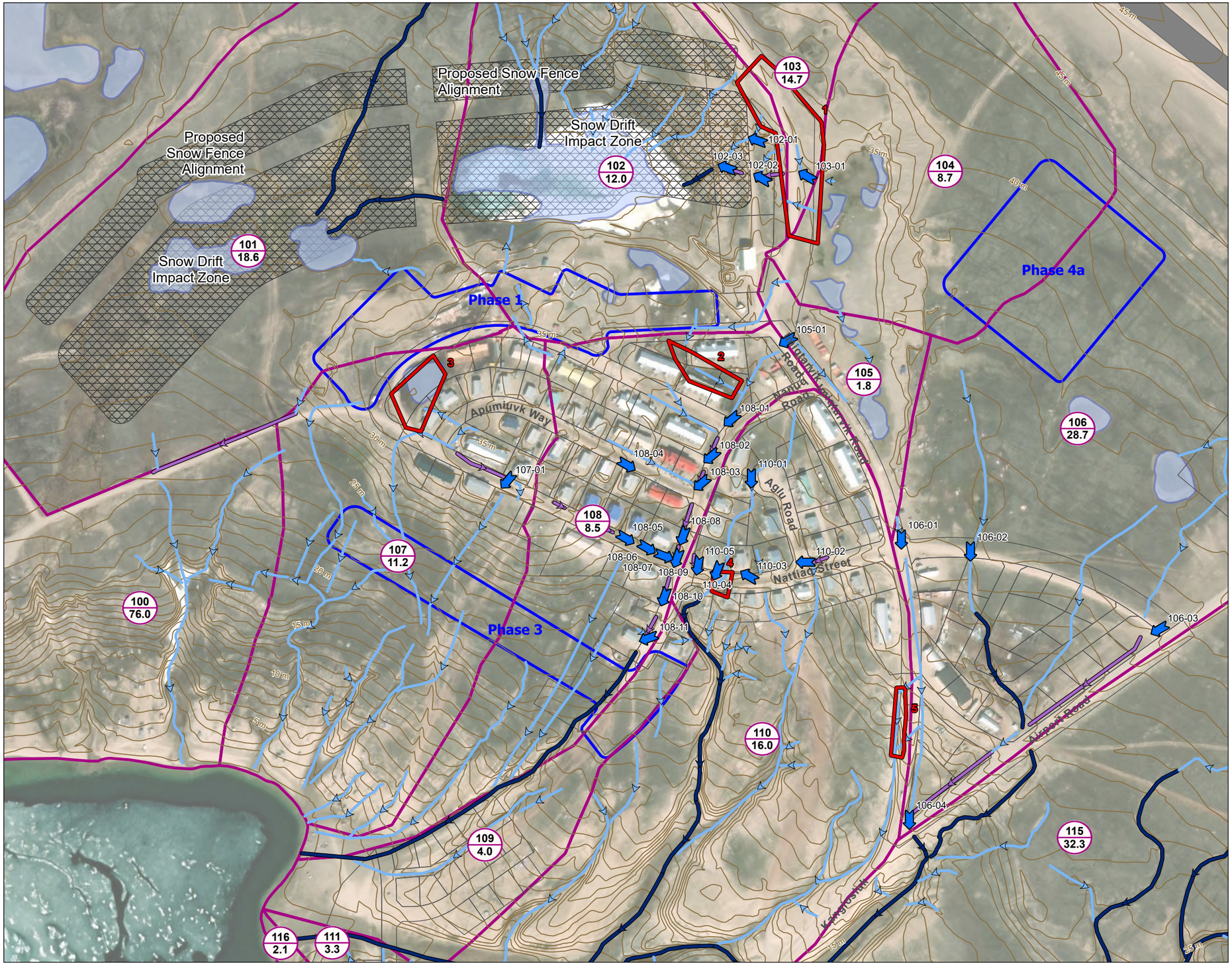
Prepared by WW on 2023-03-20
TR by MV on 2023-03-21

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix C-2c

Title
Qualitative Construction Suitability (Phase 2, Phase 5, Phase 6 and Phase 7)

APPENDIX D Figures Drainage Evaluation



NUNAMI STANTEC

- Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Identified Drainage Problem Area AGO
- Catchment
- Property Parcel
- Watercourse
- Waterbodies
- Development Phase
- Proposed Snow Fence Alignment / Snow Drift Impact Zone
- Runway

Basin No. / Area (ha)

N

0 50 100 150 m
(At original document size of 11x17)
1:4,000

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

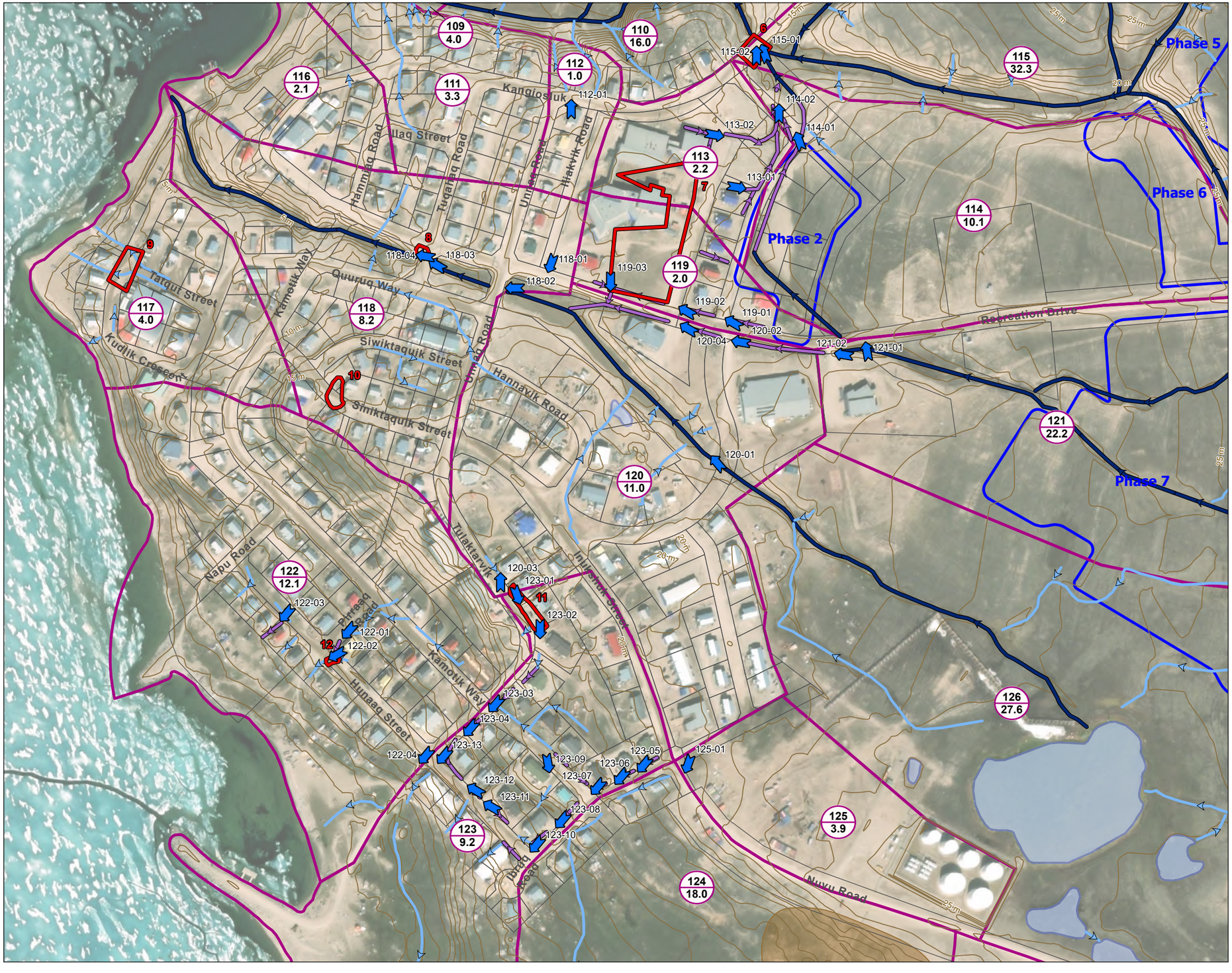
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-1, Figure 1 of 3

Title
Existing Conditions
North



NUNAMI STANTEC

- Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Identified Drainage Problem Area AGO
- Catchment
- Property Parcel
- Watercourse
- Waterbodies
- Development Phase
- Landfill

Basin No. / Area (ha)

N

0 50 100 150 m

(At original document size of 11x17)
1:4,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N

2. Data Sources:

3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

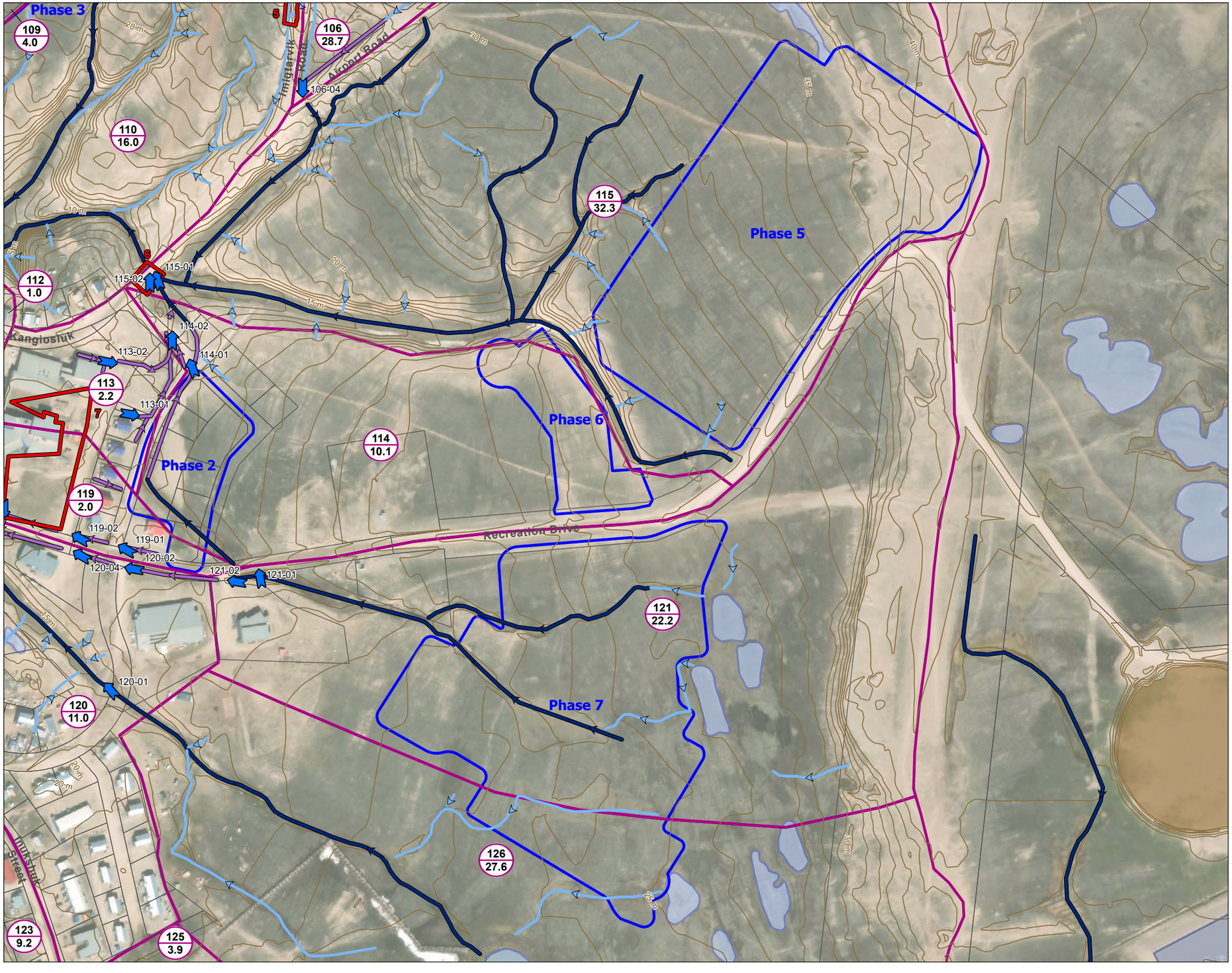
Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

144903260

Figure No.
Appendix D-1, Figure 2 of 3

Title
Existing Conditions
South



NUNAMI STANTEC

- Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Identified Drainage Problem Area AGO
- Catchment
- Property Parcel
- Watercourse
- Waterbodies
- Development Phase
- Sewage Lagoon

Basin No. / Area (ha)

N

0 50 100 150 m

(At original document size of 11x17)
1:4,000

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

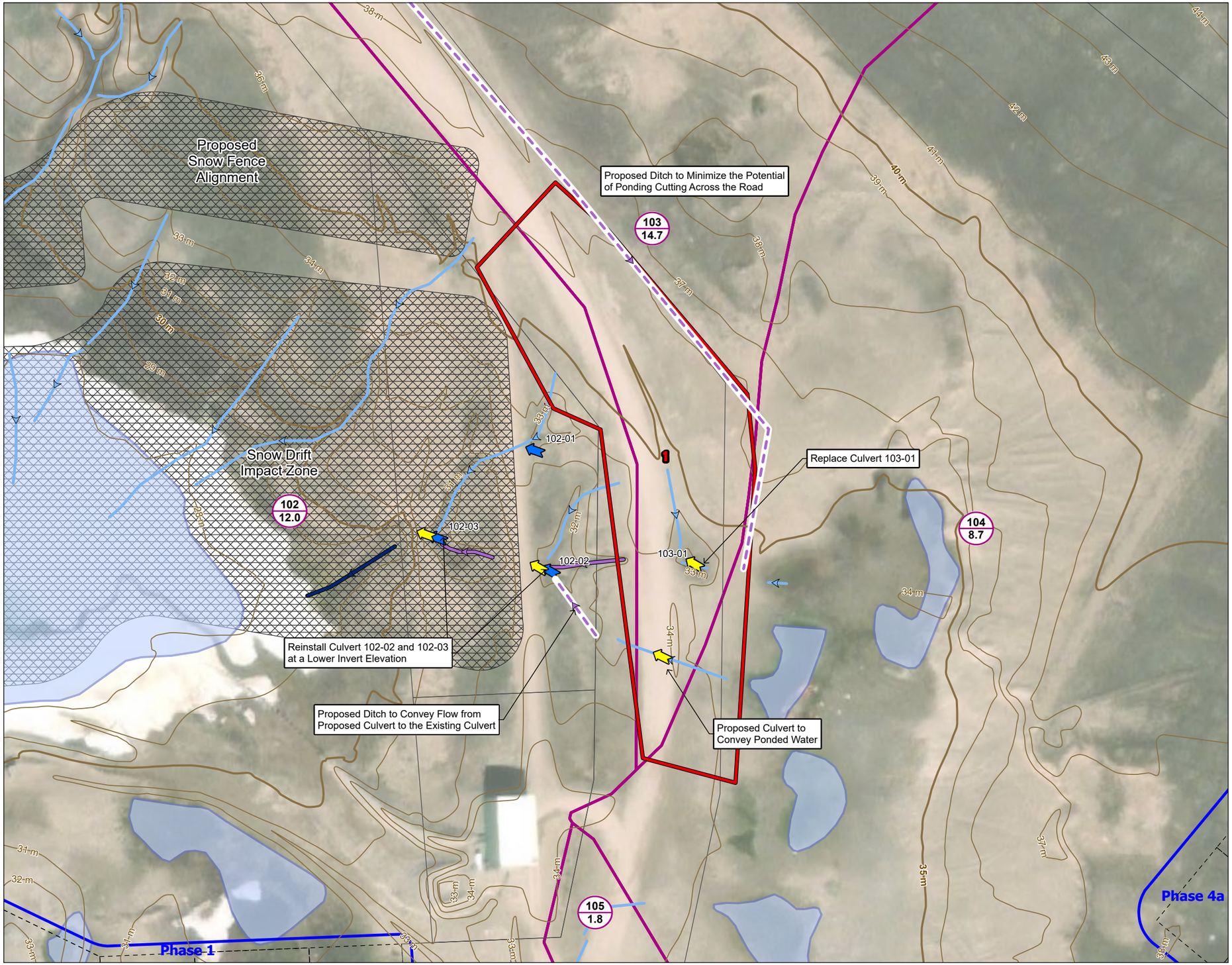
Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-1, Figure 3 of 3

Title
Existing Conditions
East



NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies

Basin No. / Area (ha)

zoning_plan_2019

Name

- Proposed Snow Fence Alignment / Snow Drift Impact Zone

N

0 10 20 30 40 50 m

(At original document size of 11x17)
1:1,250

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N

2. Data Sources:

3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 1 of 12

Title
Identified Drainage Problem Area #1

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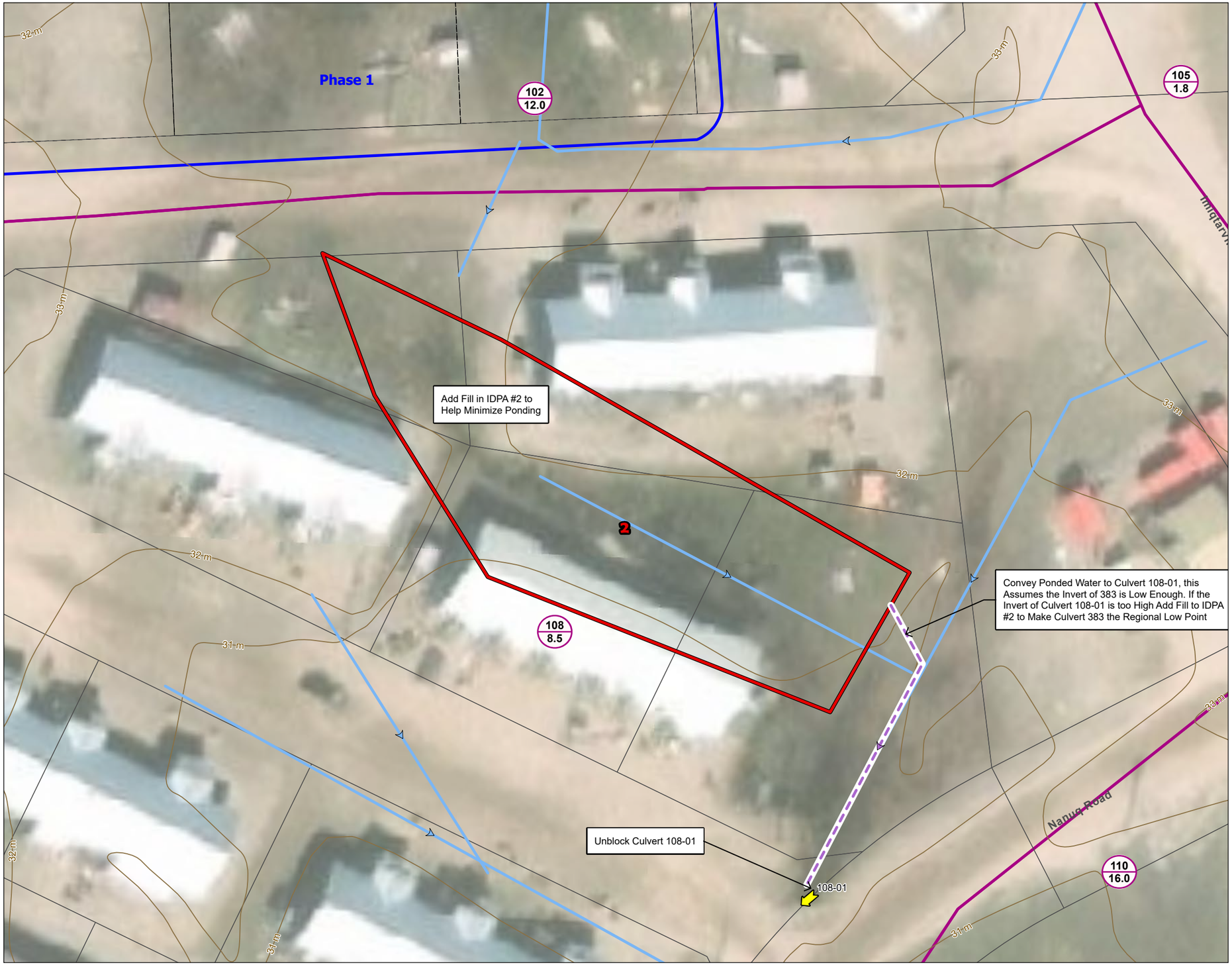


NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase

Basin No. / Area (ha)

N

0 4 8 12 16 20 m

(At original document size of 11x17)
1:500

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

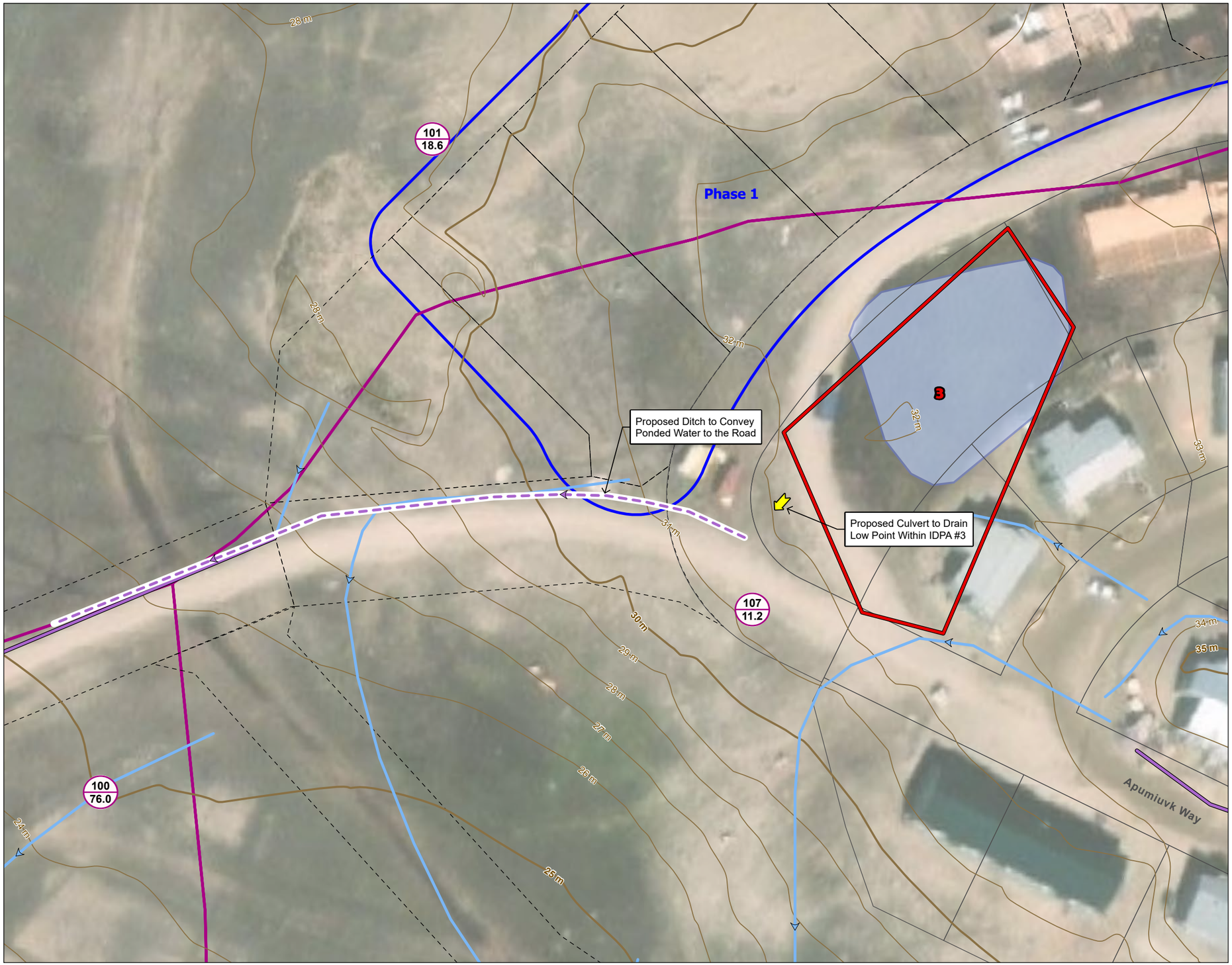
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 2 of 12

Title
Identified Drainage Problem Area #2



NUNAMI STANTEC

- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies

Basin No. / Area (ha)

N

0 6 12 18 24 30 m
(At original document size of 11x17)
1:750

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/ NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

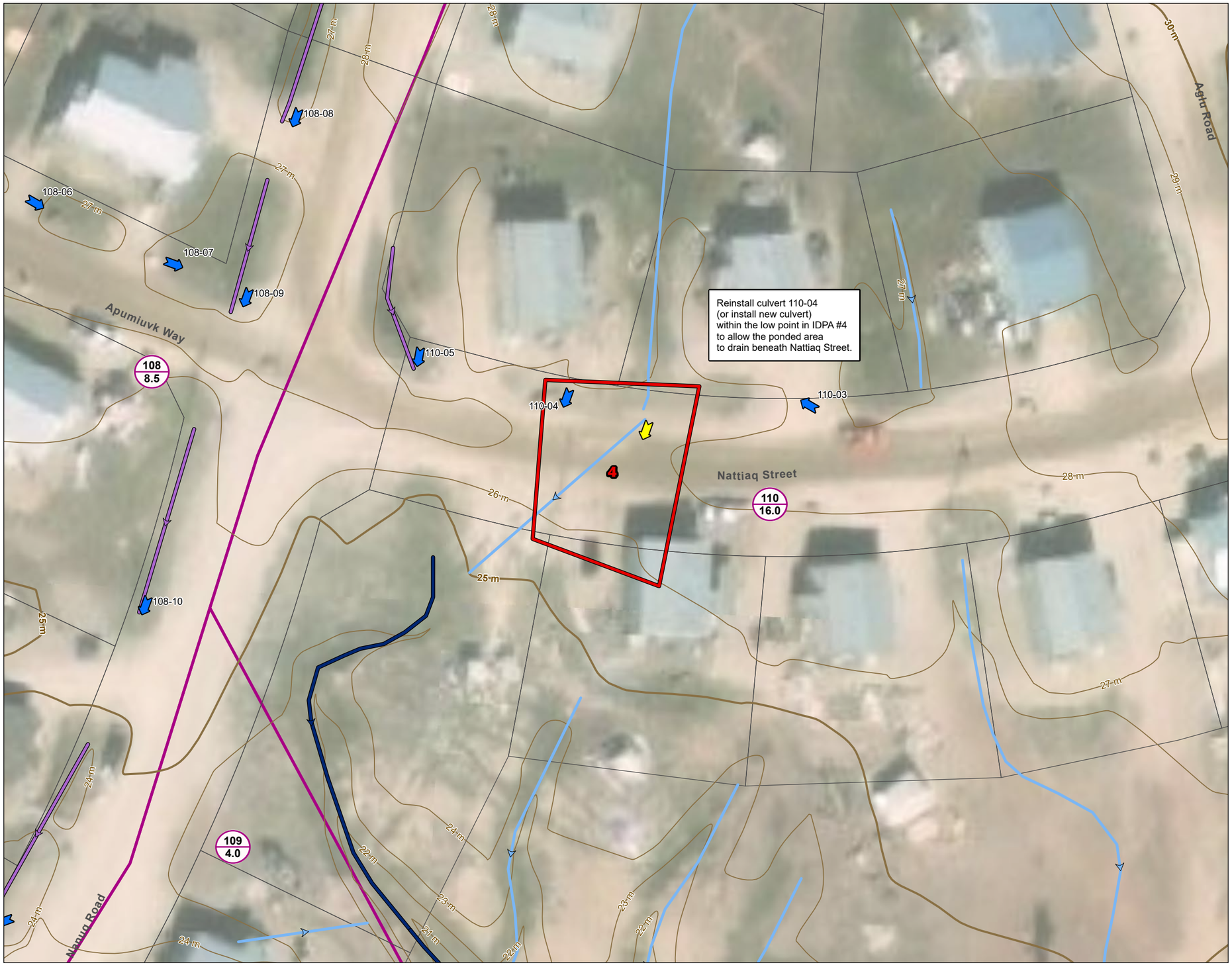
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 3 of 12

Title
Identified Drainage Problem Area #3



NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 4 8 12 16 20 m

(At original document size of 11x17)
1:500

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

144903260

Figure No.
Appendix D-2, Figure 4 of 12

Title
Identified Drainage Problem Area #4

NUNAMI STANTEC

- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 6 12 18 24 30 m

(At original document size of 11x17)
1:750

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven, Nunavut

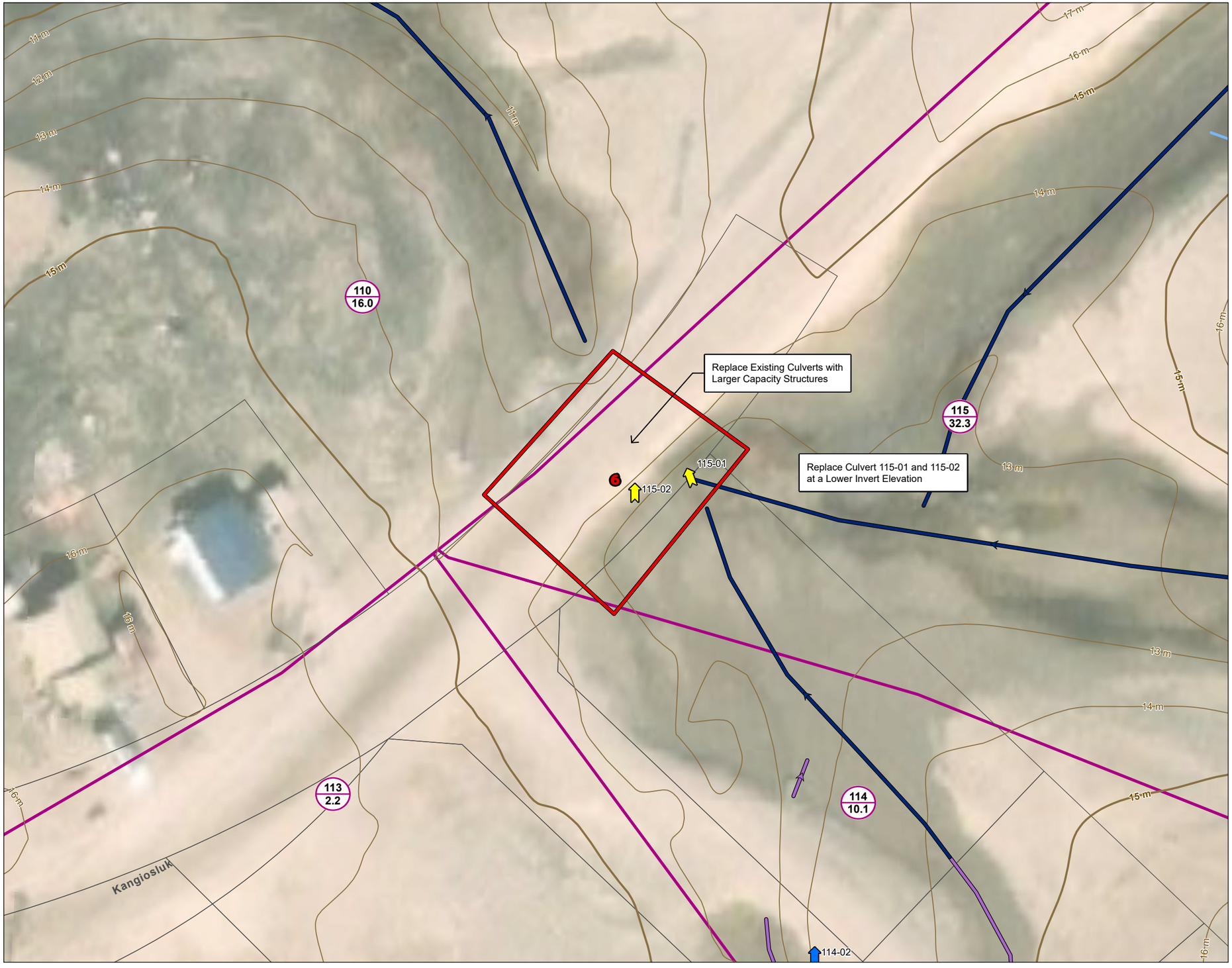
Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
Government of Nunavut – Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

144903260

Figure No.
Appendix D-2, Figure 5 of 12

Title
Identified Drainage Problem Area #5



NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 4 8 12 16 20 m

(At original document size of 11x17)
1:500

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

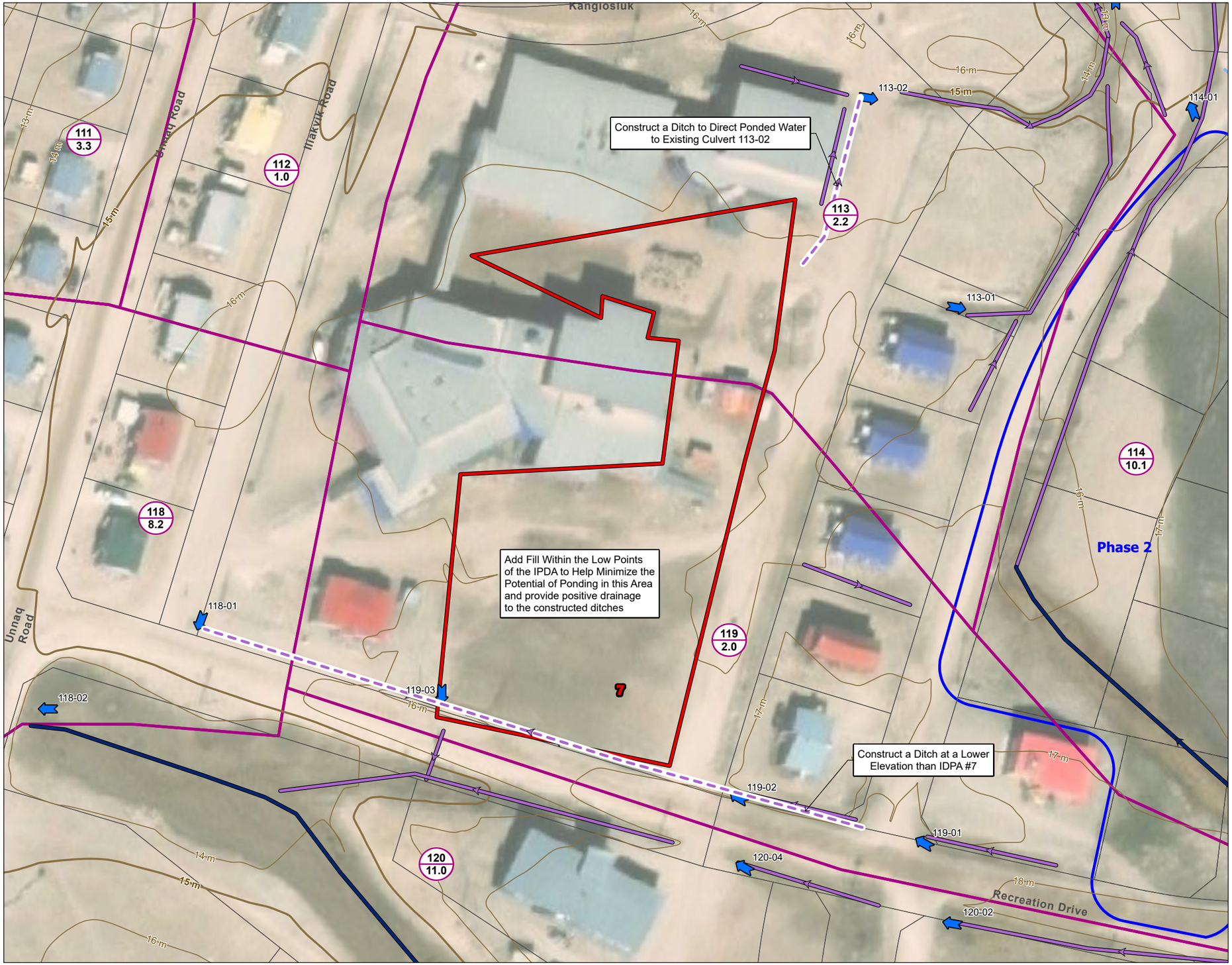
Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

144903260

Figure No.
Appendix D-2, Figure 6 of 12

Title
Identified Drainage Problem Area #6



NUNAMI STANTEC

- Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase

Basin No. / Area (ha)

N

0 8 16 24 32 40 m

(At original document size of 11x17)
1:1,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

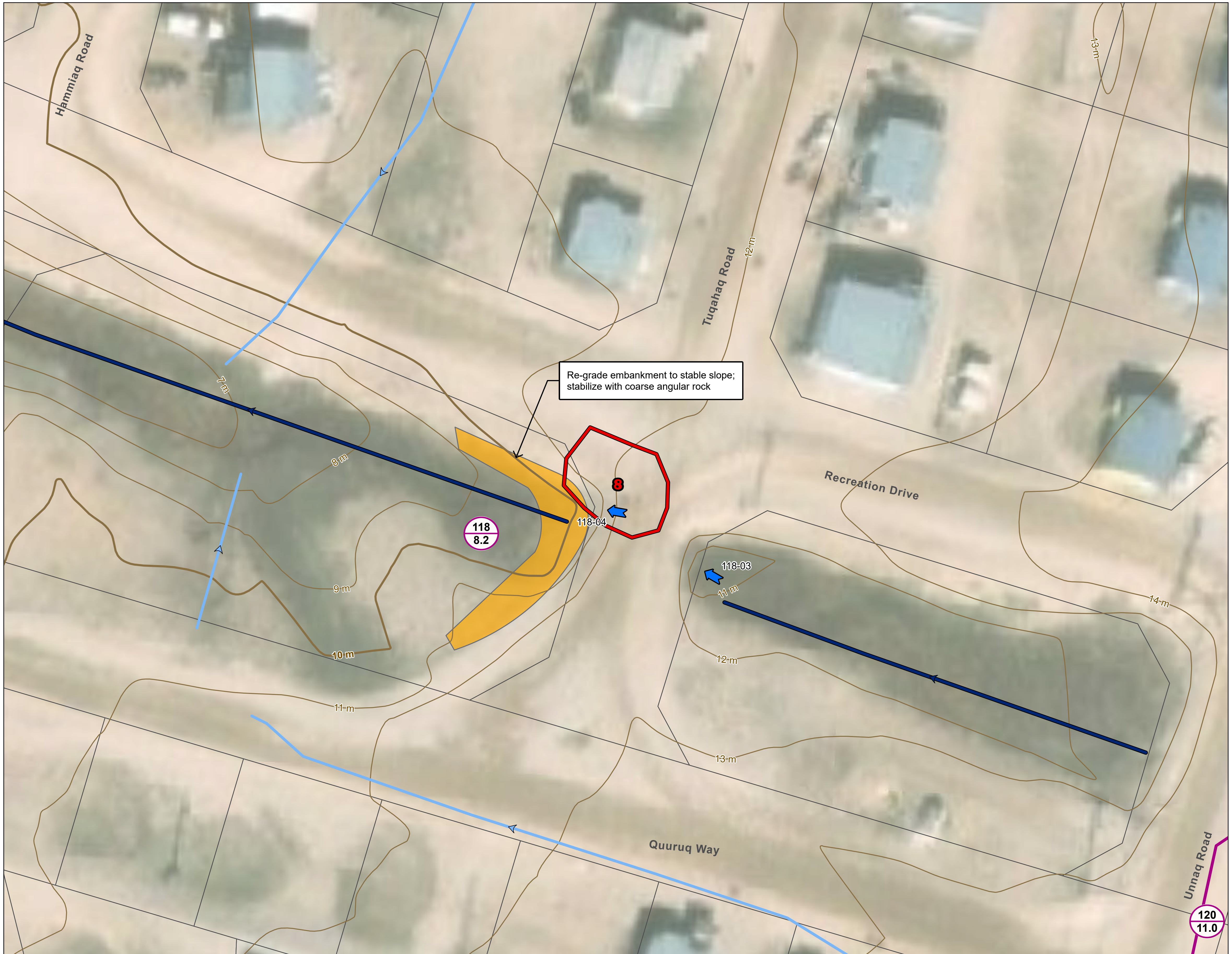
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 7 of 12

Title
Identified Drainage Problem Area #7



NUNAMI STANTEC

- Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Proposed Embankment
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 4 8 12 16 20 m

(At original document size of 11x17)
1:500

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

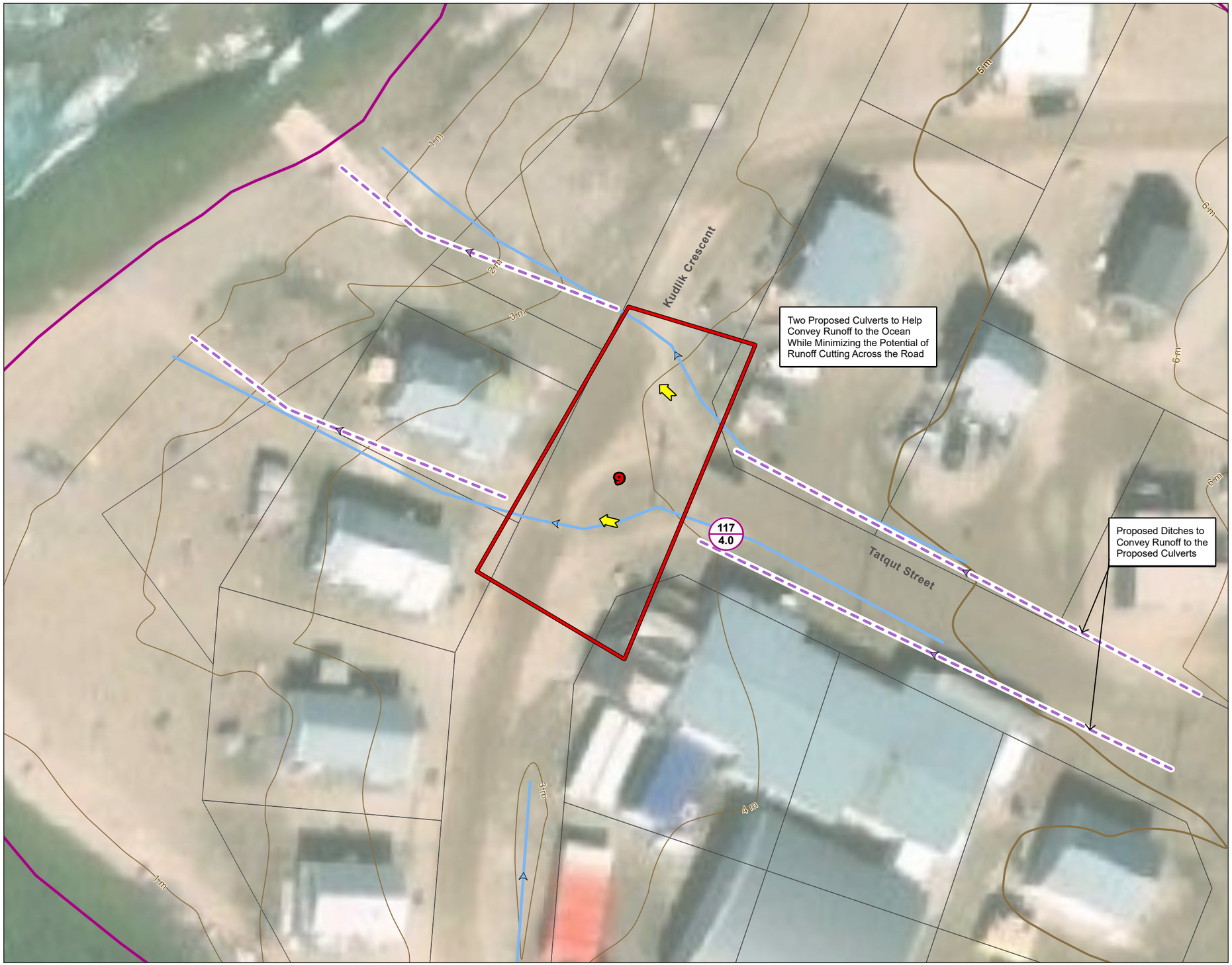
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 8 of 12

Title
Identified Drainage Problem Area #8



NUNAMI STANTEC

- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 4 8 12 16 20 m
(At original document size of 11x17)
1:500

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 9 of 12

Title
Identified Drainage Problem Area #9

NUNAMI STANTEC

- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 6 12 18 24 30 m

(At original document size of 11x17)
1:750

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

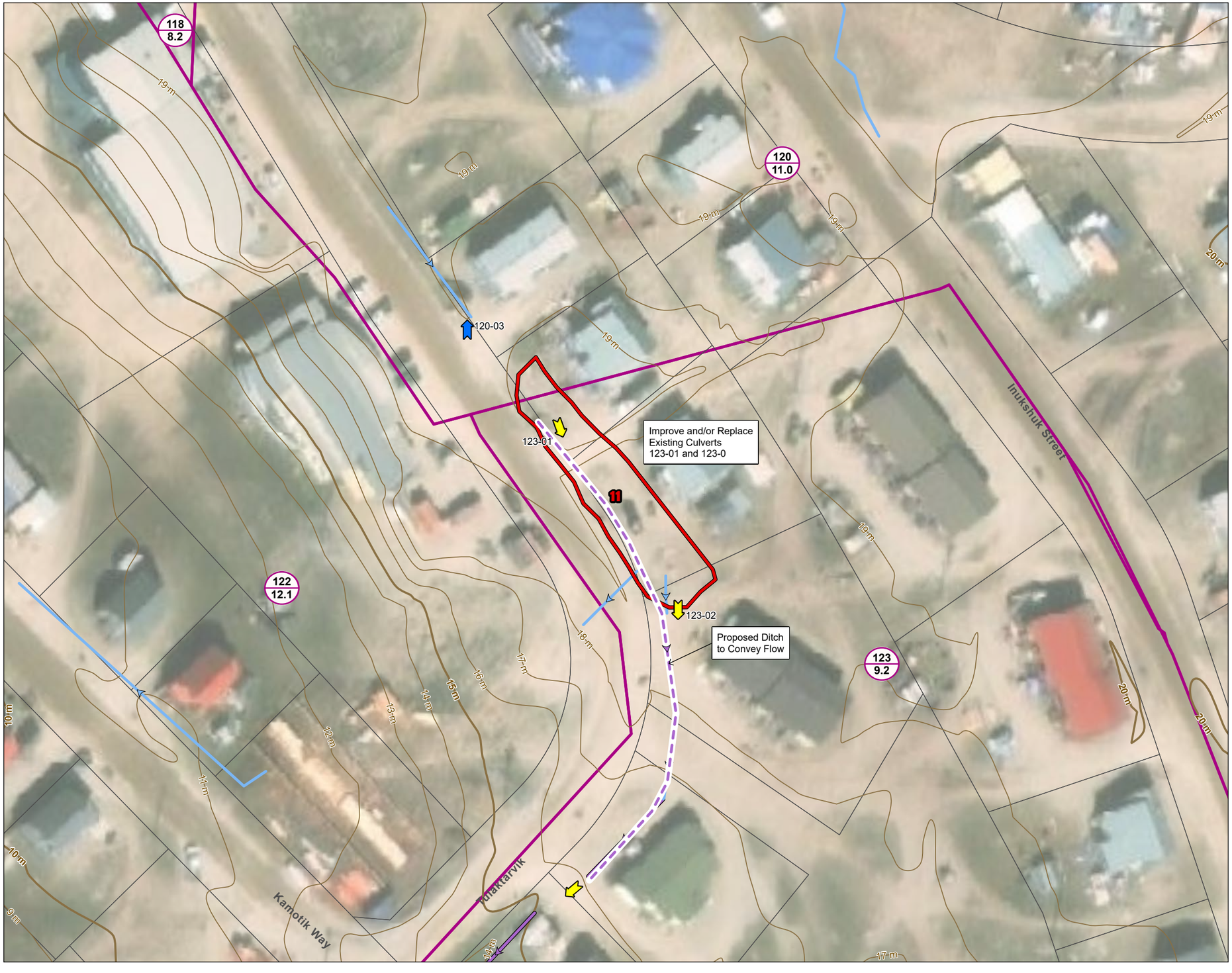
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 10 of 12

Title
Identified Drainage Problem Area #10



NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 6 12 18 24 30 m
(At original document size of 11x17)
1:750

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 11 of 12

Title
Identified Drainage Problem Area #11

NUNAMI STANTEC

- Culvert
- Proposed/Improved/Replaced Culvert
- Contours (1 m)
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel

Basin No. / Area (ha)

N

0 6 12 18 24 30 m
(At original document size of 11x17)
1:750

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

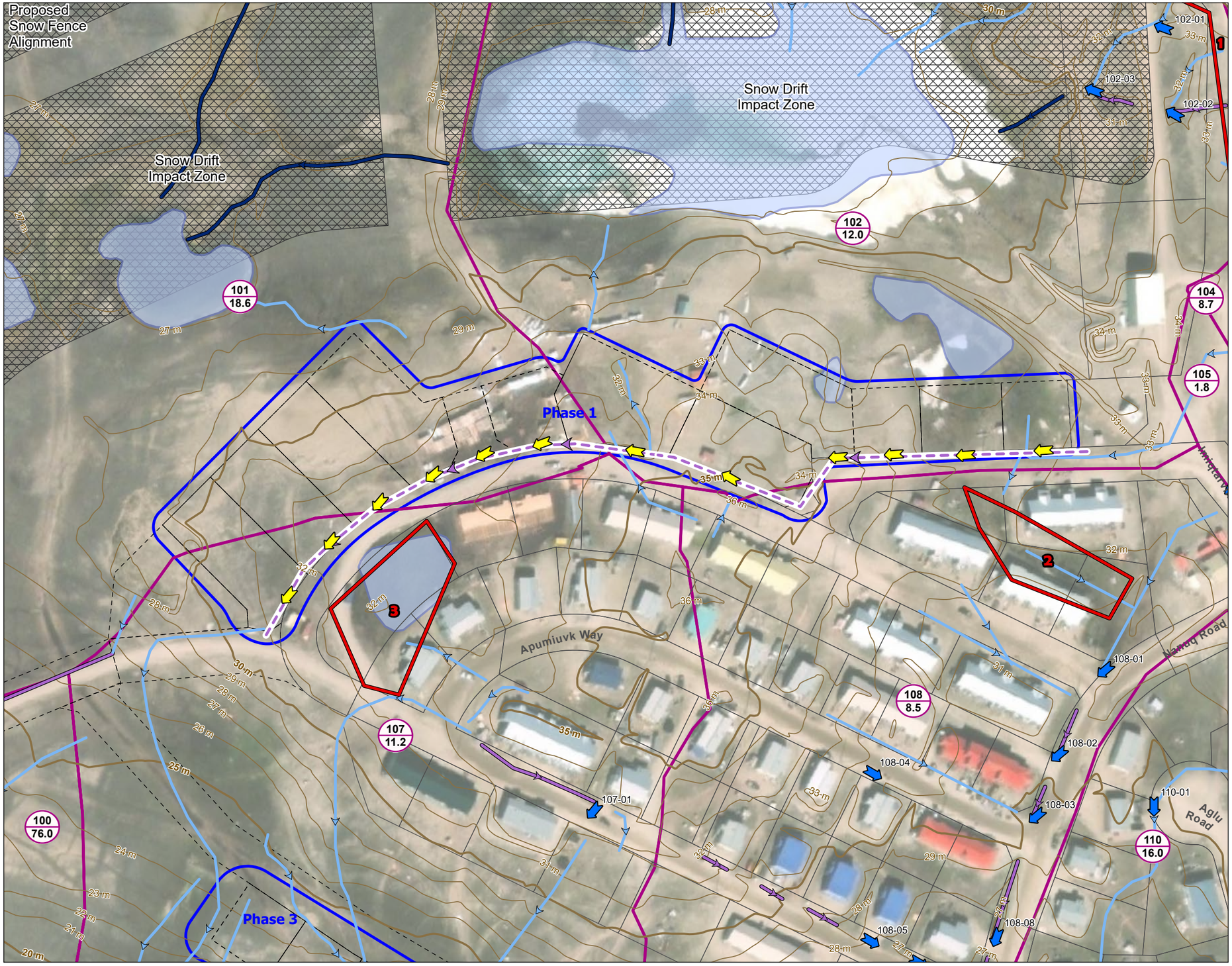
Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-2, Figure 12 of 12

Title
Identified Drainage Problem Area #12



NUNAMI STANTEC

- Culvert
- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies
- Proposed Snow Fence Alignment / Snow Drift Impact Zone

Basin No. / Area (ha)

N

0 10 20 30 40 50 m
(At original document size of 11x17)
1:1,750

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven,
Nunavut

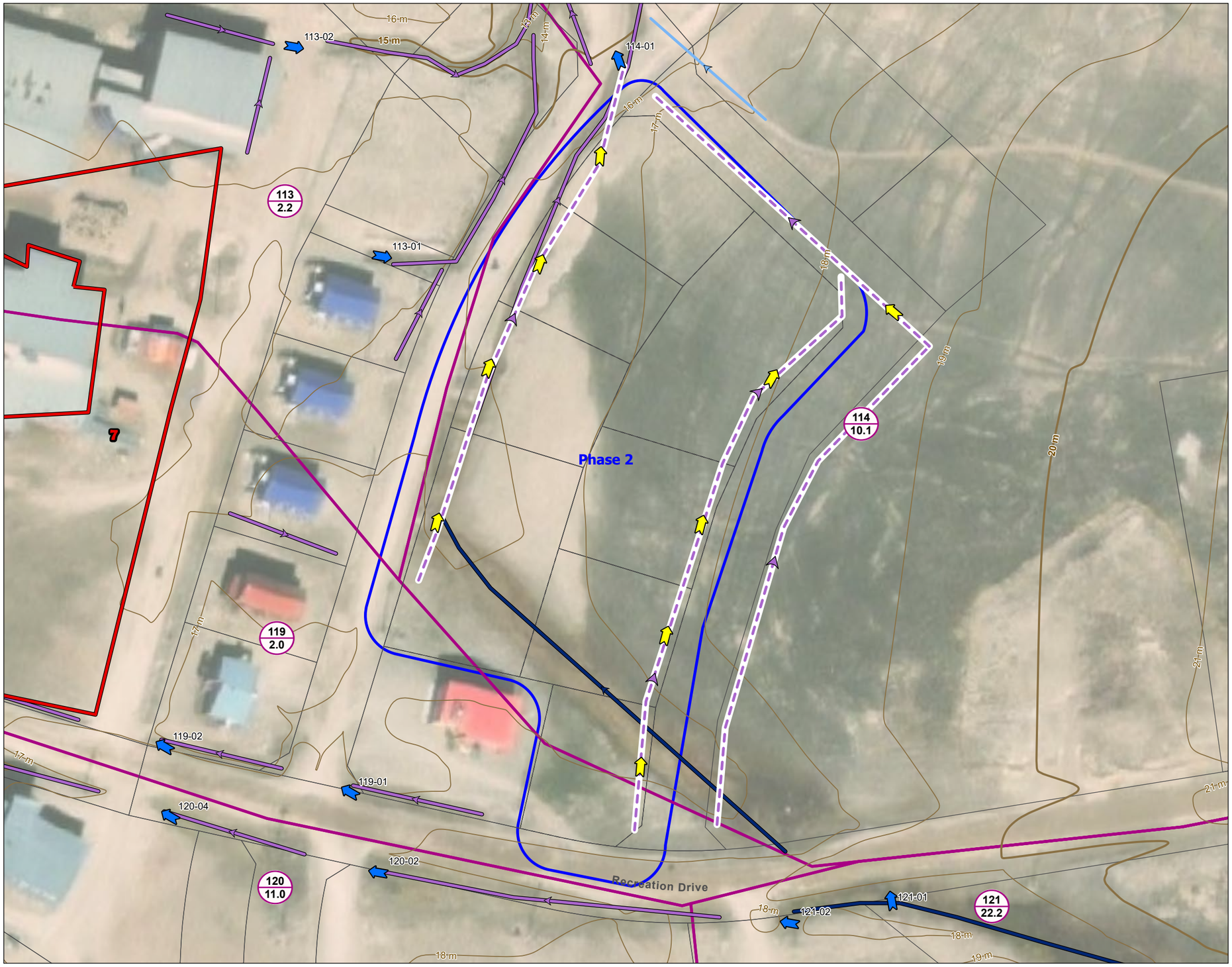
Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

144903260

Figure No.
Appendix D-3, Figure 1 of 7

Title
Proposed Development Area
Phase 1



NUNAMI STANTEC

- Culvert
- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase

Basin No. / Area (ha)

N

0 8 16 24 32 40 m

(At original document size of 11x17)
1:1,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

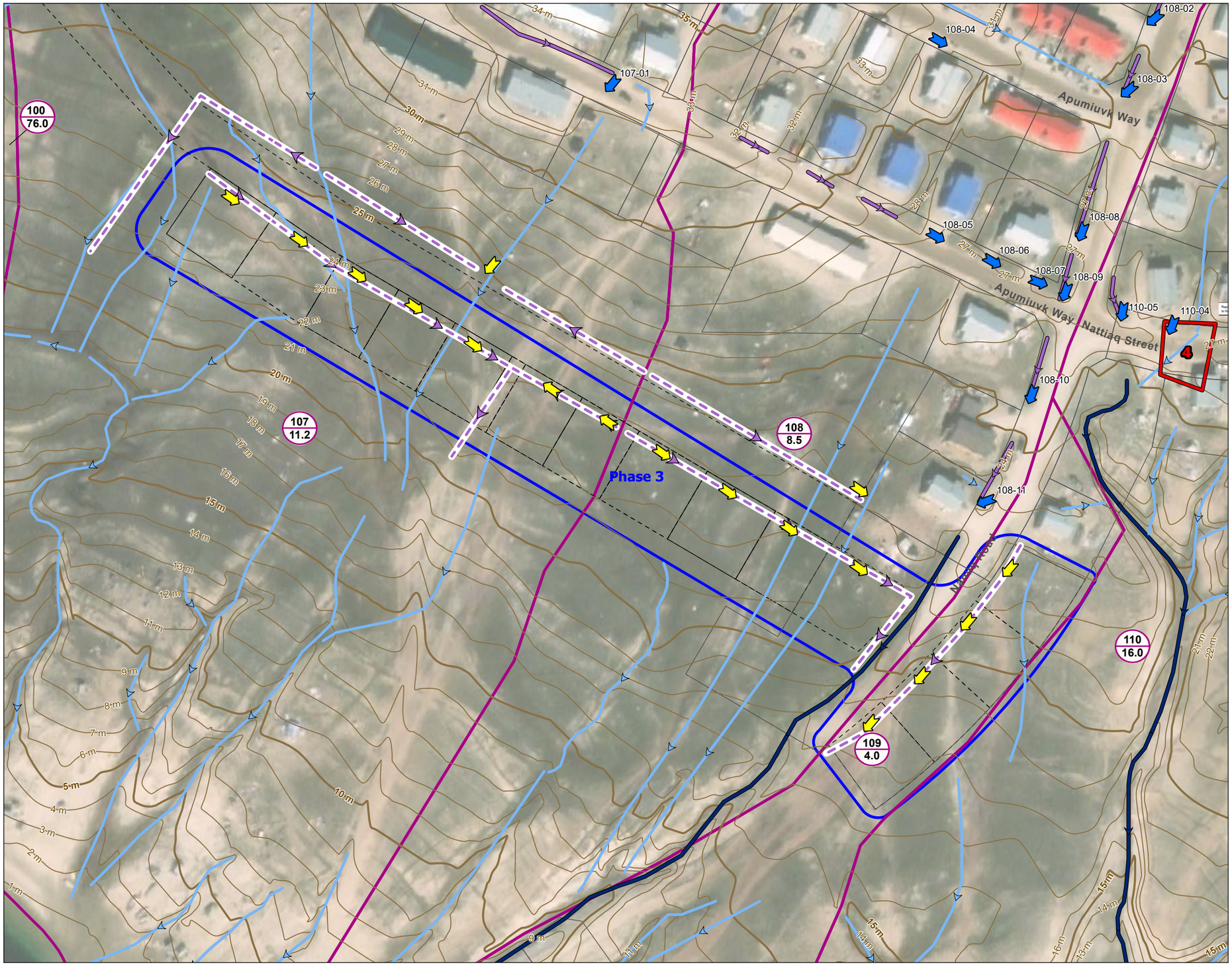
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 2 of 7

Title
Proposed Development Area
Phase 2



NUNAMI STANTEC

- Culvert
- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Identified Drainage Problem Area
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase

Basin No. / Area (ha)

N

0 10 20 30 40 50 m

(At original document size of 11x17)
1:1,500

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

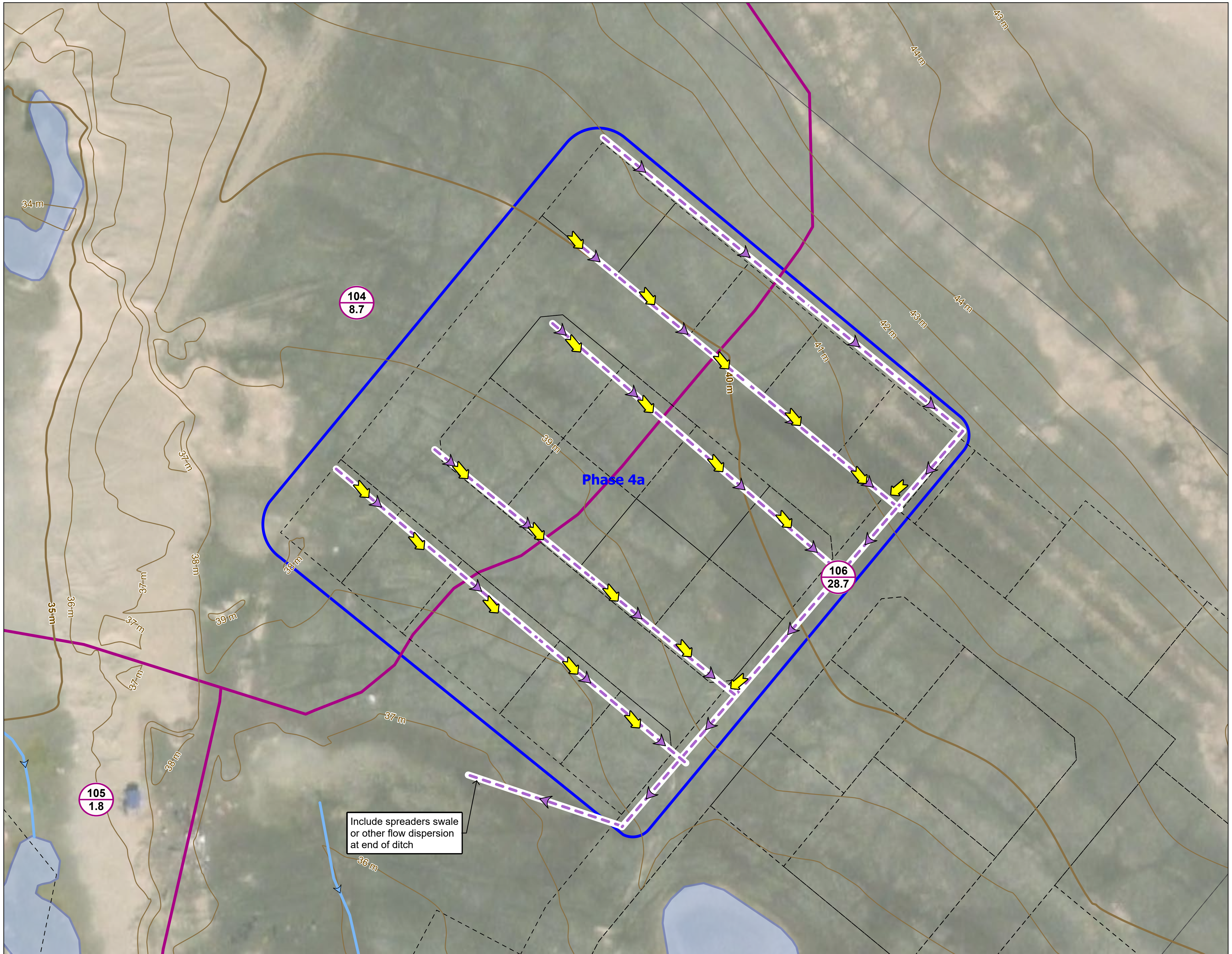
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 3 of 7

Title
Proposed Development Area
Phase 3



NUNAMI STANTEC

- Proposed Culvert
- Contours (1 m)
- Overland Flow Path
- Proposed Drainage Ditch
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies

Basin No. / Area (ha)

N

0 10 20 30 40 50 m

(At original document size of 11x17)
1:1,250

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

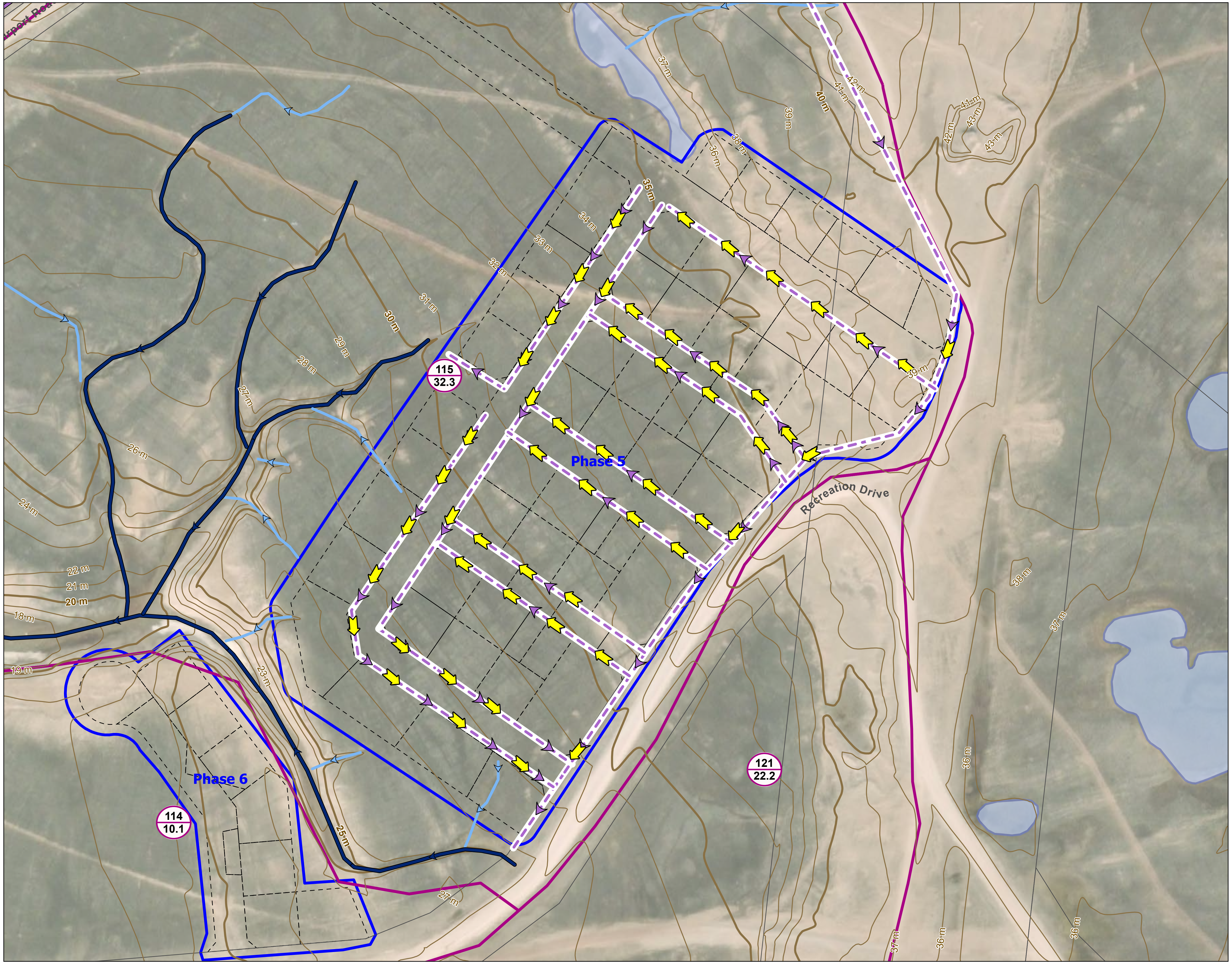
Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 4 of 7

Title
Proposed Development Area
Phase 4a



NUNAMI STANTEC

- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Drainage Ditch
- Proposed Drainage Ditch
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies

Basin No.
Area (ha)

N

0 10 20 30 40 50 m
(At original document size of 11x17)
1:2,250

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

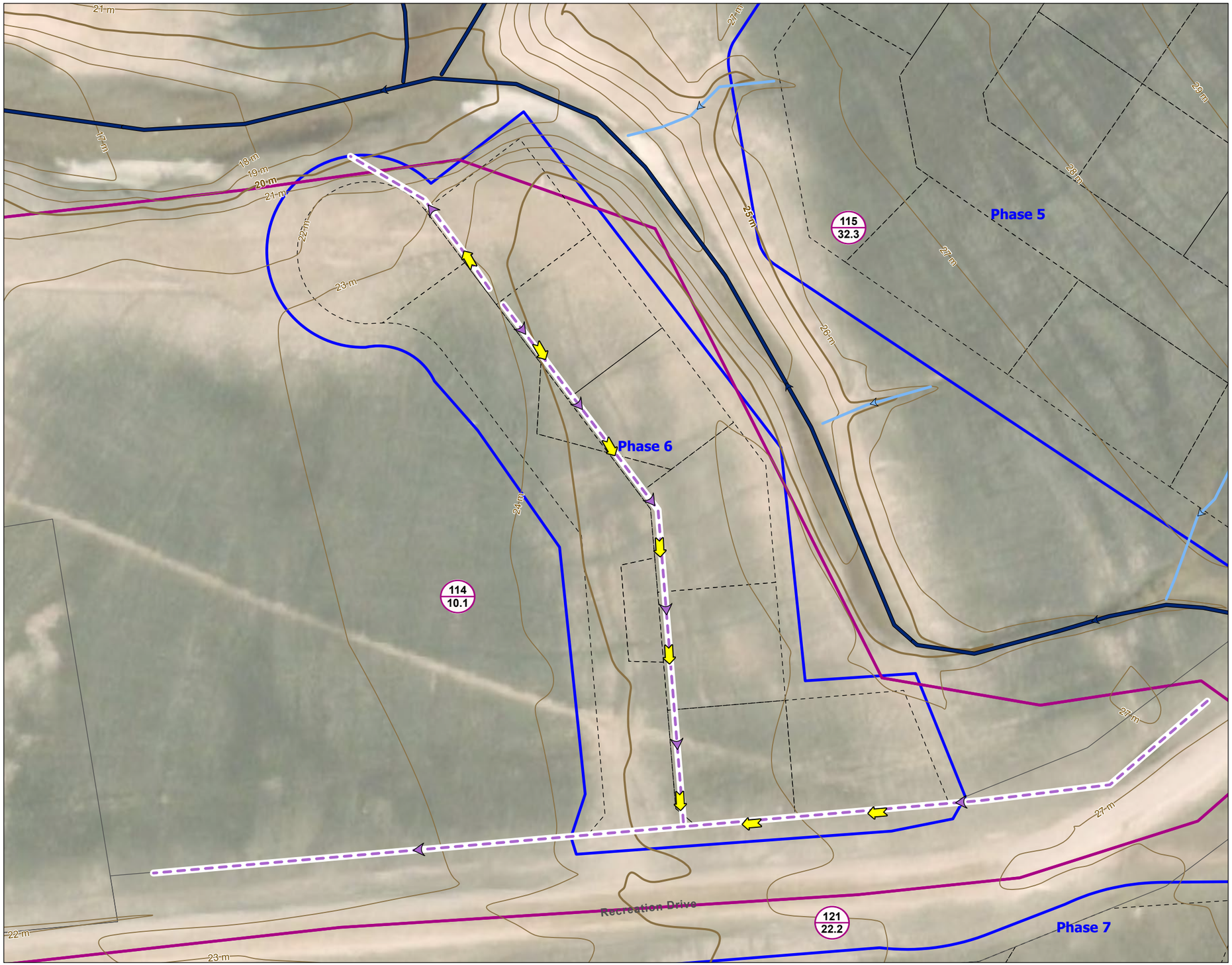
Project Location
Gjoa Haven,
Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project 144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 5 of 7

Title
Proposed Development Area
Phase 5



NUNAMI STANTEC

- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Proposed Drainage Ditch
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase

Basin No. / Area (ha)

N

0 8 16 24 32 40 m

(At original document size of 11x17)
1:1,000

Notes

1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

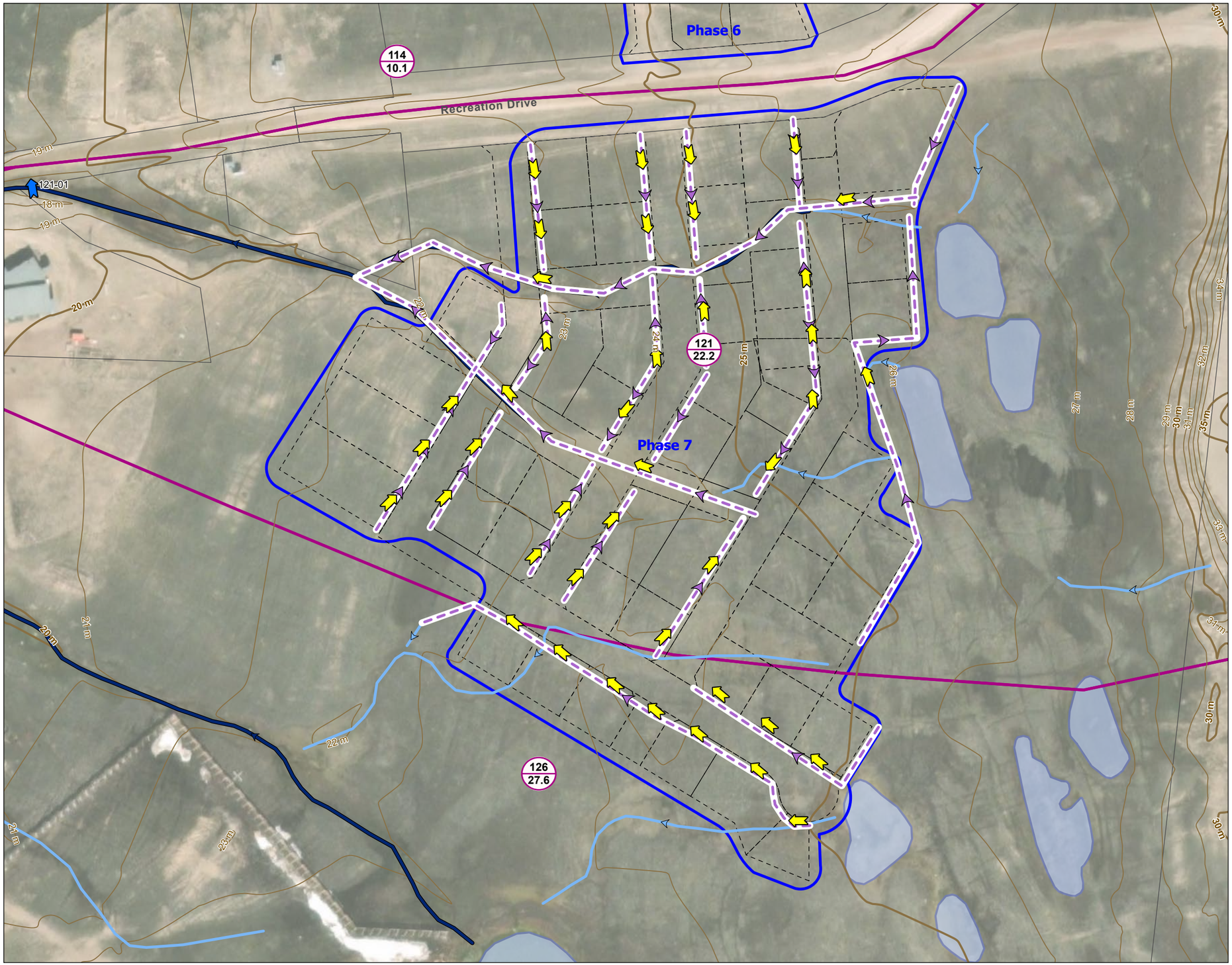
Project Location
Gjoa Haven, Nunavut

Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 6 of 7

Title
Proposed Development Area
Phase 6



NUNAMI STANTEC

- Culvert
- Proposed Culvert
- Contours (1 m)
- Drainage Channel
- Overland Flow Path
- Proposed Drainage Ditch
- Catchment
- Property Parcel
- Proposed Property Parcels
- Development Phase
- Waterbodies

Basin No. / Area (ha)

N

0 10 20 30 40 50 m
(At original document size of 11x17)
1:2,000

Notes
1. Coordinate System: NAD 1983 CSRS UTM Zone 15N
2. Data Sources:
3. Background: Hybrid Reference Layer: Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada
World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar

Project Location
Gjoa Haven, Nunavut

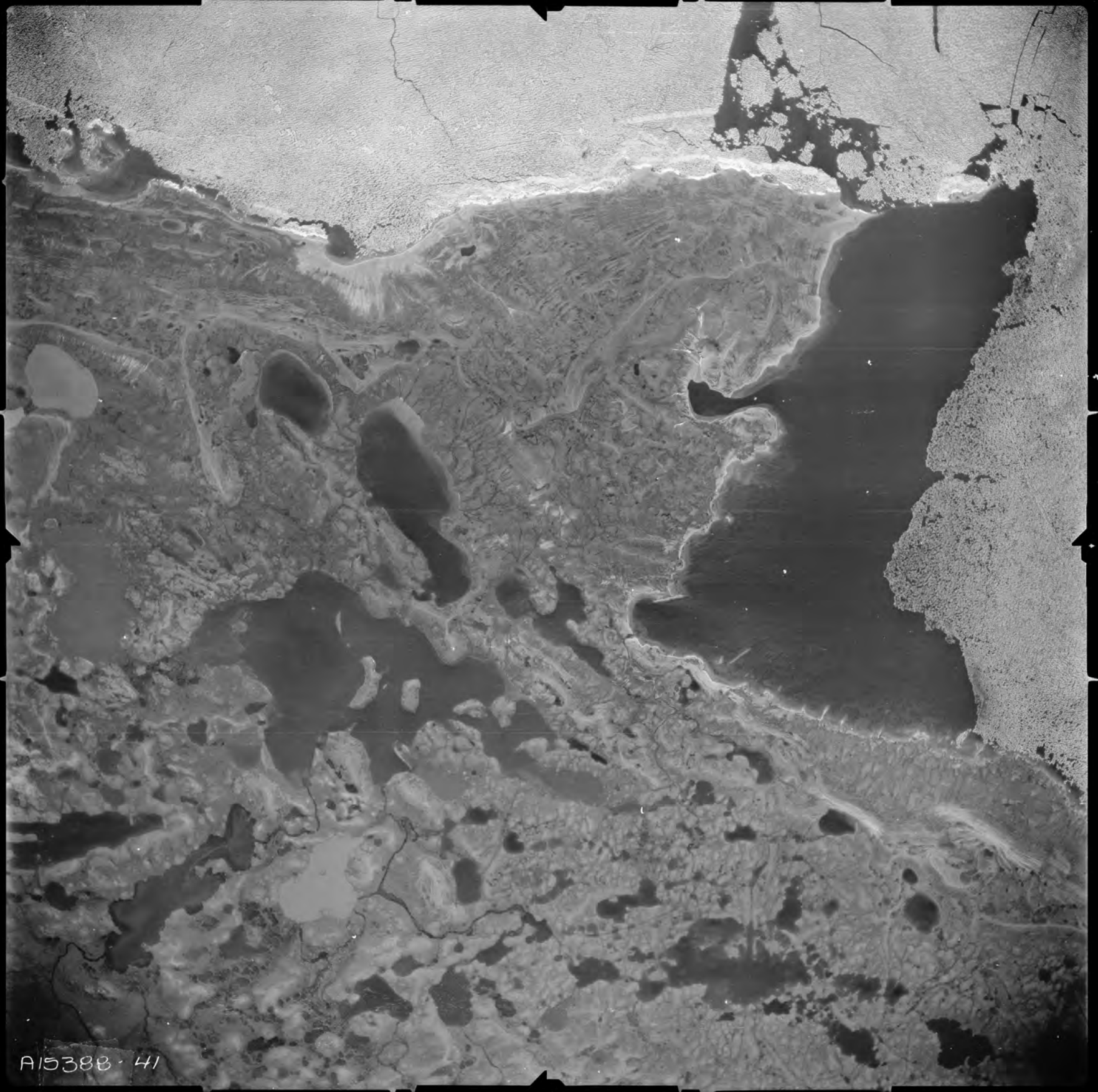
Prepared by LT on 2023-03-03
TR by MV on 2023-03-03

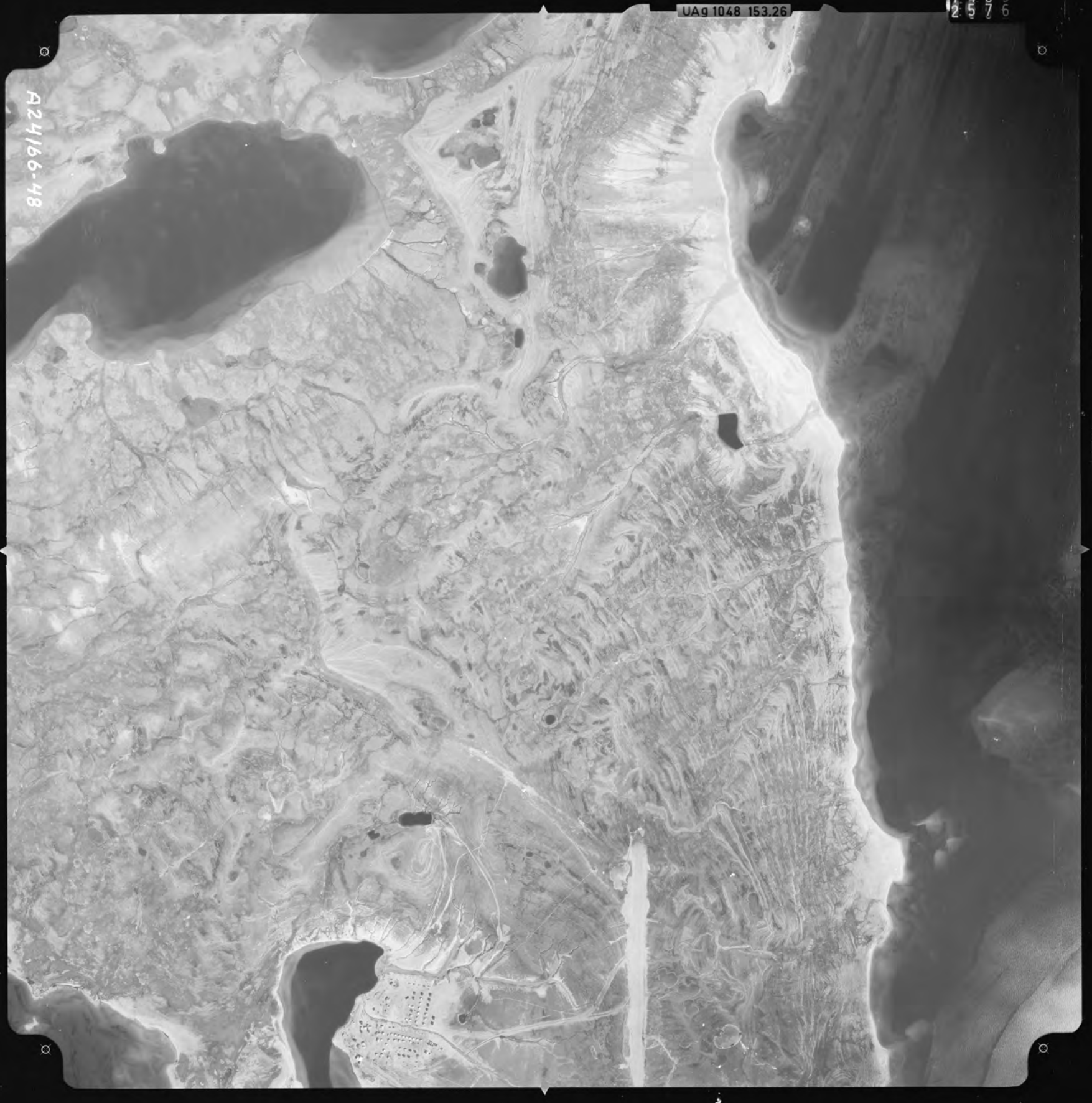
Client/Project
144903260
Government of Nunavut –
Department of Community and Government Services
Geotechnical Investigation and Drainage Planning in Gjoa Haven

Figure No.
Appendix D-3, Figure 7 of 7

Title
Proposed Development Area Phase 7

APPENDIX E Historical Air Photos


A15388 - 41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A 27144
75


A28279-206
1:15,000
27/07/96


A28279-207
1:15,000
27/07/96

APPENDIX F Borehole Records

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 974
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 615 250
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	

Borehole :	BH22-01
Page :	1 of 1
Start date :	2022-06-15
Inspector :	M. Verpaelst, M. Sc.
Depth :	2.95 m
Elevation :	25.7 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-15	0.40 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY

SAMPLES

TESTS

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt); W; 20 40 60 80)	REMARKS
		25.70												
		0.00 / 25.68	Thin cover of mosses and sod over black TOPSOIL.				A							
		0.02 / 25.45	Brown SAND with some gravel and traces of silt, moist.			MA-01	B					Unfrozen		
		0.25	- Presence of roots.				C				0.40 m			
			Light brown SAND with traces of silt and gravel, moist.			DC-02						Nbn		
			- Becoming frozen.			DC-03								
						DC-04								
1						DC-05								
			-Inferred depth of permafrost table			DC-06				G : 2.4 % S : 97.2 % F : 0.4 %		- Vx (5%, up to3 cm thick), includes a vertical ice vein (Vs, 1cm thick)	21.3	
	5					DC-07								
						DC-08								
		23.81												
2		1.89	Grey SAND with some gravel and traces of silt, frozen.			DC-09							22.0	VIC:44.4
						DC-10								
			- Presence of sea shells (between 2.25 and 2.60 m bgs).			DC-11						Nf		
						DC-12						Nbn, Vc (< 5%)		
		23.10												
		2.60	Grey SAND with traces of silt, frozen.			DC-13						Nbn		
		22.75												
3	10	2.95	END OF BOREHOLE											

General remarks: **Borehole drilled along an apparent ice wedge.**

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 960
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 615 398
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	

Borehole :	BH22-02
Page :	1 of 1
Start date :	2022-06-15
Inspector :	M. Verpaelst, M. Sc.
Depth :	1.55 m
Elevation :	26.2 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
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Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

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COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
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Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
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Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK
		26.20	
		0.00	Thin cover of mosses and sod over black TOPSOIL.
		26.18 / 0.02	Brown SAND with some gravel and traces of silt, moist.
			- Becoming frozen.
1			- Becoming grey.
	5	24.65 / 1.55	END OF BOREHOLE (Corer refusal on coarse material)
2			
3	10		

SAMPLES

SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)
		MA-01	A			
			B			
		DC-02				
		DC-03				
		DC-04				
		DC-05				

Active layer depth / Groundwater level: 0.40 m

GROUND ICE DESCRIPTION: Unfrozen; Nf; Nbn

TESTS

VIC: Volumetric Ice Content (%)
w: Water Content (%)
S: Salinity (ppt)

W
20 40 60 80

21.4

REMARKS: VIC:43.7

General remarks: **Borehole drilled along an apparent ice wedge.**

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 867
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 616 081
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	

Borehole :	BH22-03
Page :	1 of 1
Start date :	2022-06-15
Inspector :	M. Verpaelst, M. Sc.
Depth :	2.30 m
Elevation :	35.3 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-15	0.54 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt))	REMARKS
		35.30												
		0.00 35.28	Thin cover of mosses and sod over black TOPSOIL.				A							
		0.02	Light brown SAND with traces of silt and gravel, moist.			MA-01	B					Unfrozen		
		34.76									0.54 m			
		0.54	Brown SAND with traces of gravel, frozen.			DC-02						Nbn		
1						DC-03								
						DC-04						- Vc (< 5%)		
						DC-05								
						DC-06								
	5					DC-07				G : 0.0 % S : 99.9 % F : 0.1 %			14.2	
						DC-08								
2						DC-09								
		33.00												
		2.30	END OF BOREHOLE											
3	10													

General remarks: **Borehole drilled along an apparent ice wedge.**

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15	Borehole :	**BH22-04**
Project No.:	**144903260**	X :	**384 161**	Page :	**1 of 1**
Client:	**Government of Nunavut - Department of Community and Government Services**	Y :	**7 615 584**	Start date :	**2022-06-16**
		Type of borehole :	**Diamond Core**	Inspector :	**M. Verpaelst, M. Sc.**
Site:	**Gjoa Haven, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**0.90 m**
		Corer :	**82.5 mm**	Elevation :	**31.5 m**
		Figure :			

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-16	0.24 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES / TESTS

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt); W 20 40 60 80)	REMARKS
		31.50												
		0.00	Thin cover of mosses and sod over black TOPSOIL.			MA-01	A					Unfrozen		
		31.48					B							
		0.02	Dark brown SAND with traces to some silt and gravel, moist.			DC-02					0.24 m	Nbn		
			- Becoming frozen.			DC-03								
						DC-04						Nf, Vc (< 5%)		
		30.65												
		0.85	Dark brown SAND and GRAVEL with traces of silt, frozen.			DC-05								
1		30.60												
		0.90	END OF BOREHOLE (Corer refusal on coarse material)											
	5													
2														
3	10													

General remarks:

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 958
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 615 234
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	

Borehole :	BH22-05
Page :	1 of 1
Start date :	2022-06-16
Inspector :	M. Verpaelst, M. Sc.
Depth :	1.30 m
Elevation :	24.4 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-16	0.30 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES / TESTS

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%); w: Water Content (%); S: Salinity (ppt))	REMARKS
		24.40												
0		0.00	Thin cover of mosses and sod over black TOPSOIL.				A							
		24.35												
		0.05	Brown SAND with traces of silt, saturated.			MA-01	B				0.15 m	Unfrozen		
			- Becoming frozen.								0.30 m			
						DC-02						Nbn		
						DC-03								
						DC-04								
1						DC-05								
						DC-06								
		23.10												
		1.30	END OF BOREHOLE (Corer refusal from material infilling the hole)											
	5													
2														
3	10													

W: 20 40 60 80

General remarks: **Borehole drilled within low relief gullied area.**

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 839
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 616 318
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	
		Borehole :	**BH22-06**
		Page :	1 of 1
		Start date :	2022-06-16
		Inspector :	M. Verpaelst, M. Sc.
		Depth :	2.00 m
		Elevation :	39.0 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-16	0.30 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES / TESTS

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt); W 20 40 60 80)	REMARKS
		39.00												
		0.00	Thin cover of mosses and sod over black TOPSOIL.			MA-01	A					Unfrozen		
		38.98					B							
		0.02	Dark-brown SAND with traces to some silt and gravel, moist.			DC-02					0.30 m	Nbn		
			- Becoming frozen.											
			- Presence of roots.			DC-03								
						DC-04								
1			- Becoming brown.											
						DC-05	A						40.5	VIC:58.5
			- Inferred depth of permafrost table.				B					I+S (2 cm wide on the side of the core, along the length)		
			- Becoming Gravelly.			DC-06								
	5					DC-07						Nbe, Vc (< 5%)		
						DC-08				G : 22.2 % S : 77.3 % F : 0.5 %			19.5	
2		37.00				DC-09								
		2.00	END OF BOREHOLE (Corer refusal on coarse material)											
3	10													

General remarks: **Borehole drilled along an apparent ice wedge.**

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15	Borehole :	**BH22-07**
Project No.:	**144903260**	X :	**383 955**	Page :	**1 of 1**
Client:	**Government of Nunavut - Department of Community and Government Services**	Y :	**7 615 077**	Start date :	**2022-06-17**
		Type of borehole :	**Diamond Core**	Inspector :	**M. Verpaelst, M. Sc.**
Site:	**Gjoa Haven, Nunavut**	Equipment :	**STIHL FB200**	Depth :	**2.35 m**
		Corer :	**82.5 mm**	Elevation :	**24.9 m**
		Figure :			

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-17	0.39 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt))	REMARKS
		24.90												
		0.00 / 24.88	Thin cover of mosses and sod over black TOPSOIL.				A							
		0.02	Black SAND with traces of silt and gravel, moist.			MA-01	B					Unfrozen		
		24.51 / 0.39	- Presence of roots.								0.39 m			
			Brown SAND with some gravel and traces of silt, frozen.			DC-02						Nbn		
						DC-03						- Vc (< 5%)		
						DC-04								
1						DC-05								
						DC-06	A						24.8	
			- Inferred depth of permafrost table.			DC-07	B					Vs (10%, 1 cm thick vertical ice vein) - I + S (1 cm wide on the side of the core, along the length)	49.9	VIC:78.5
	5					DC-08				G : 3.2 % S : 96.1 % F : 0.7 %			46.1	VIC:64.2
						DC-09								
2						DC-10						Nbn, Vx (5%)		
		22.55 / 2.35	END OF BOREHOLE			DC-11							19.9	VIC:40.0
3	10													

General remarks:

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 292
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 615 953
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	
		Borehole :	**BH22-08**
		Page :	1 of 1
		Start date :	2022-06-17
		Inspector :	M. Verpaelst, M. Sc.
		Depth :	0.65 m
		Elevation :	21.7 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1	2022-06-17	0.46 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt))	REMARKS
		21.70												
		0.00	Thin cover of mosses and sod over black TOPSOIL.				A							
		21.68												
		0.02	Brown SAND and GRAVEL with traces of silt, moist.			MA-01	B					Unfrozen		
			- Cobbles and boulders observed at ground surface.								0.46 m			
			- Frozen.			DC-02						Nf		
		21.05												
		0.65	END OF BOREHOLE (Corer refusal on coarse material)											
1	5													
2														
3	10													

W: 20 40 60 80

General remarks:

Stantec

BOREHOLE REPORT

Project:	Geotechnical Investigation and Drainage Planning in Gjoa Haven, Nunavut	Location :	Geo. System: UTM Zone: 15
Project No.:	144903260	X :	383 394
Client:	Government of Nunavut - Department of Community and Government Services	Y :	7 615 873
Site:	Gjoa Haven, Nunavut	Type of borehole :	Diamond Core
		Equipment :	STIHL FB200
		Corer :	82.5 mm
		Figure :	

Borehole :	BH22-09
Page :	1 of 1
Start date :	2022-06-17
Inspector :	M. Verpaelst, M. Sc.
Depth :	2.40 m
Elevation :	18.7 m

SAMPLE TYPE

SS	Split spoon
CS	Continuous sampling
DC	Diamond rock core
AS	Auger
MA	Manual sample

QUALITATIVE TERMINOLOGY

Clay	< 0.002 mm
Silt	0.002 - 0.08 mm
Sand	0.08 - 5 mm
Gravel	5 - 80 mm
Cobbles	80 - 200 mm
Boulders	> 200 mm

QUANTITATIVE TERMINOLOGY

Traces	< 10 %
Some	10 - 20 %
Adjective (...y)	20 - 35 %
and (ex: and gravel)	> 35 %
Main word	Dominant fraction

SYMBOLS

N	Standard penetration value (ASTM D 1586)
Nc	Dynamic cone penetration value (BNQ 2501-145)
RQD	Rock Quality Designation (%)

ACTIVE LAYER DEPTH

	Date	Depth
Reading 1		0.47 m
Reading 2		m

Remarks :

SAMPLE STATE

- Remoulded (unfrozen sample)
- Intact (thin wall sampler)
- Lost
- Core (frozen core sample)

MECHANIC CHARACTERISTICS OF SOILS

COMPACTION	INDEX "N"	CONSISTENCY	Cu OR Su (kPa)
Very loose	0 - 4	Very soft	< 12
Loose	4 - 10	Soft	12 - 25
Compact	10 - 30	Firm	25 - 50
Dense	30 - 50	Stiff	50 - 100
Very dense	> 50	Very stiff	100 - 200
		Hard	> 200

ROCK QUALITY DESIGNATION

QUALIFICATIVE	RQD
Very poor	< 25 %
Poor	25 - 50 %
Fair	50 - 75 %
Good	75 - 90 %
Excellent	90 - 100 %

CRYOSTRUCTURES (ASTM D4083-89)

Nf:	Poorly-bonded
Nbn:	Well-bonded no excess ice
Nbe:	Well-bonded excess ice
Vx:	Individual ice
Vc:	Ice coating
Vr:	Random ice
Vs:	Stratified ice
I+S:	Ice with soil inclusions
Ice:	Soil < 25 mm thick

STRATIGRAPHY / SAMPLES / TESTS

DEPTH (m)	DEPTH (ft)	ELEVATION (m) / DEPTH (m)	DESCRIPTION OF SOILS AND ROCK	SYMBOL	STATE	TYPE N°	SUB - SAMPLE	RECOVERY (%)	N - RQD	Grain size analysis (BNQ 2501-025)	Active layer depth / Groundwater level	GROUND ICE DESCRIPTION	TESTS (VIC: Volumetric Ice Content (%), w: Water Content (%), S: Salinity (ppt))	REMARKS
		18.70												
		0.00	Thin cover of mosses and sod over black TOPSOIL.				A							
		18.68												
		0.02	Black to light brown SAND with traces of silt, moist. Presence of roots.			MA-01	B					Unfrozen		
		18.23	- Becoming Gravelly with presence of cobbles.								0.47 m			
		0.47	Brown SAND with traces of silt, frozen.			DC-02						Nbn		
						DC-03								
						DC-04								
1						DC-05								
						DC-06								
						DC-07								
	5		- Becoming grey.			DC-08								
						DC-09								
2						DC-10				G : 0.1 % S : 95.7 % F : 4.2			21.6	
						DC-11								
						DC-12								
		16.30												
		2.40	END OF BOREHOLE											
3	10													

General remarks:

APPENDIX G Laboratory Testing Results

Stantec

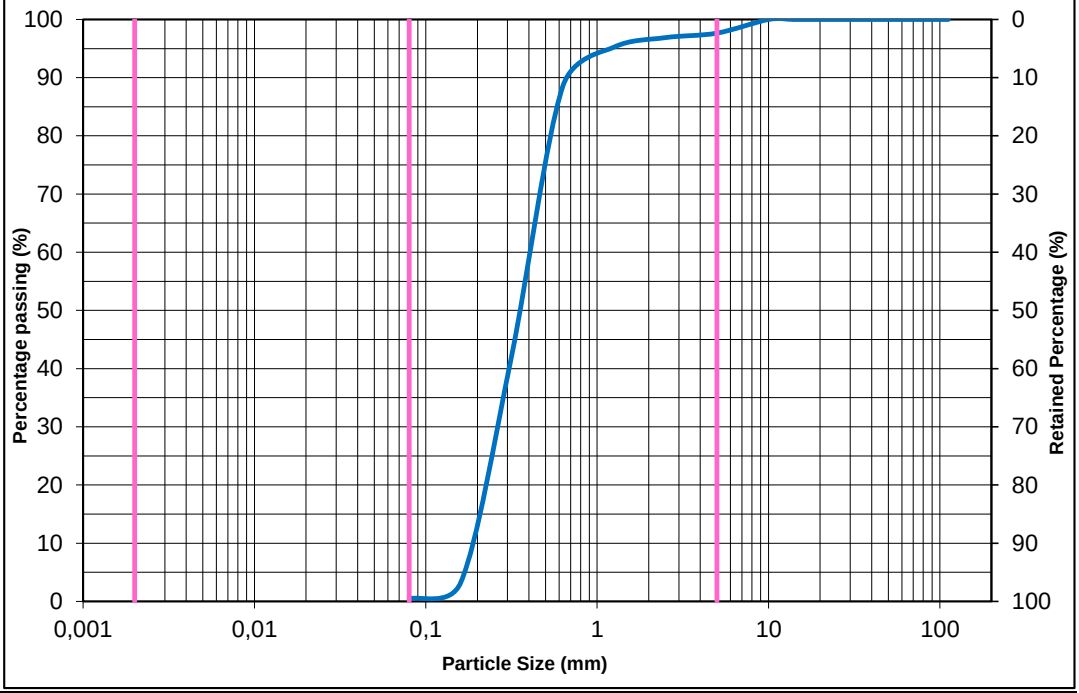
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	Manuel Verpaelst
	Department of Community and Government Services	Sampling Date :	June 15, 2022
Project :	Gjoa Haven, NU		
Project No :	144903260.200.800		
Sample No :	BH22-01 DC-06	Material Description :	Sand, traces of Gravel, traces of fine particles
Depth :	1,10 - 1,26m		

Grain Size Analysis (BNQ 2501-025)

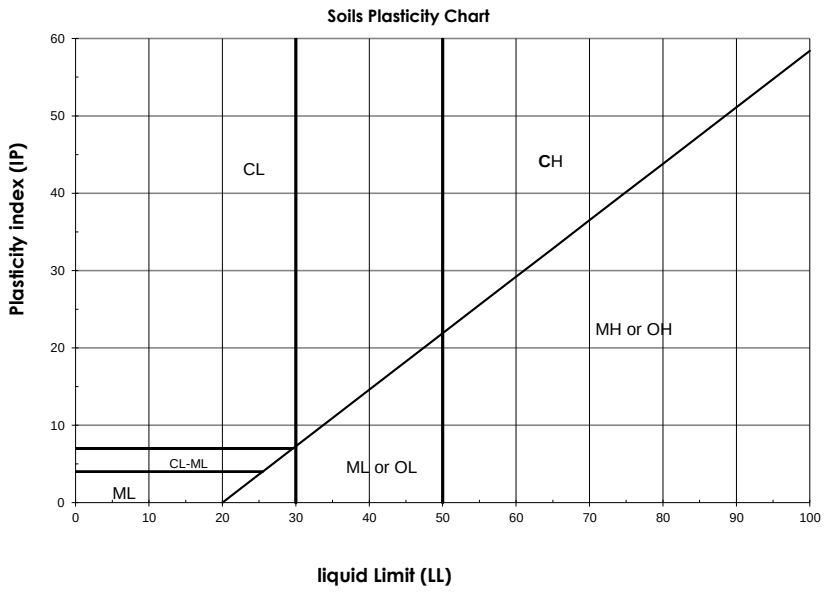
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	98
2,50	97
1,25	95
0,630	88
0,315	42
0,160	3
0,080	0,4



% Gravel : 2,4 % Sand : 97,2 % Fine particles : 0,4

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	21,3



Remarks :

Prepared by : Benoit Cyr, Geo. **Date :** July 21, 2022

Stantec

2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

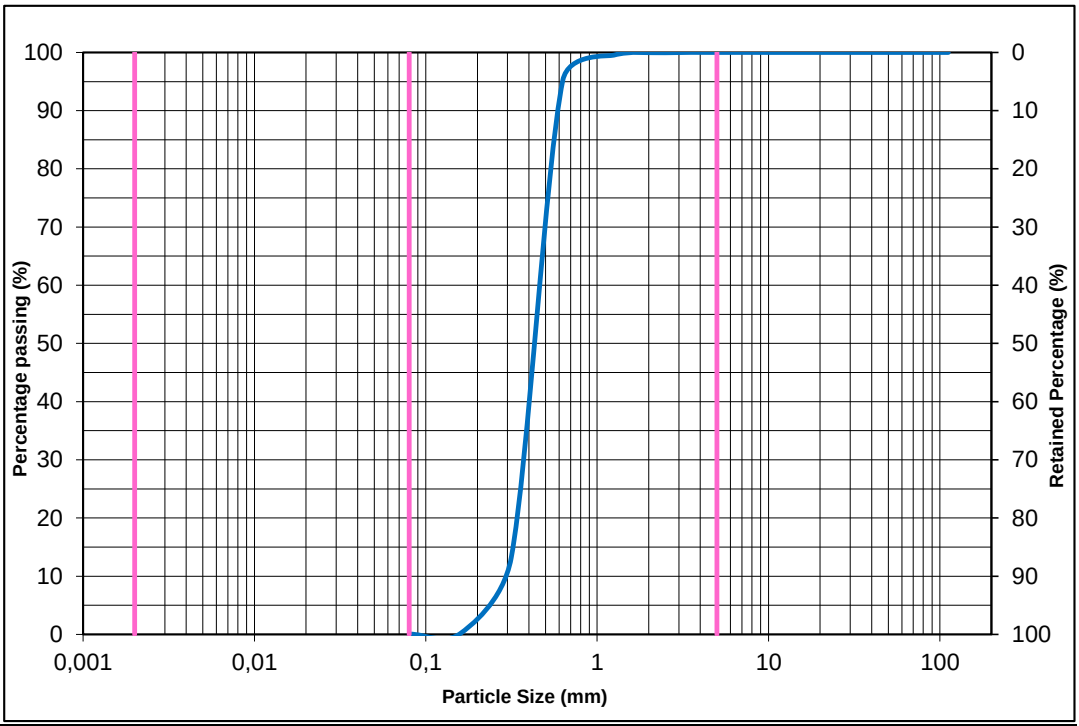
Client : Government of Nunavut
Department of Community and Government Services
Project : Gjoa Haven, NU
Project No : 144903260.200.800
Sample No : BH22-03 DC-07
Depth : 1,46 - 1,65m

Sampled by : Manuel Verpaelst
Sampling Date : June 15, 2022

Material Description : Sand, traces of fine particles

Grain Size Analysis (BNQ 2501-025)

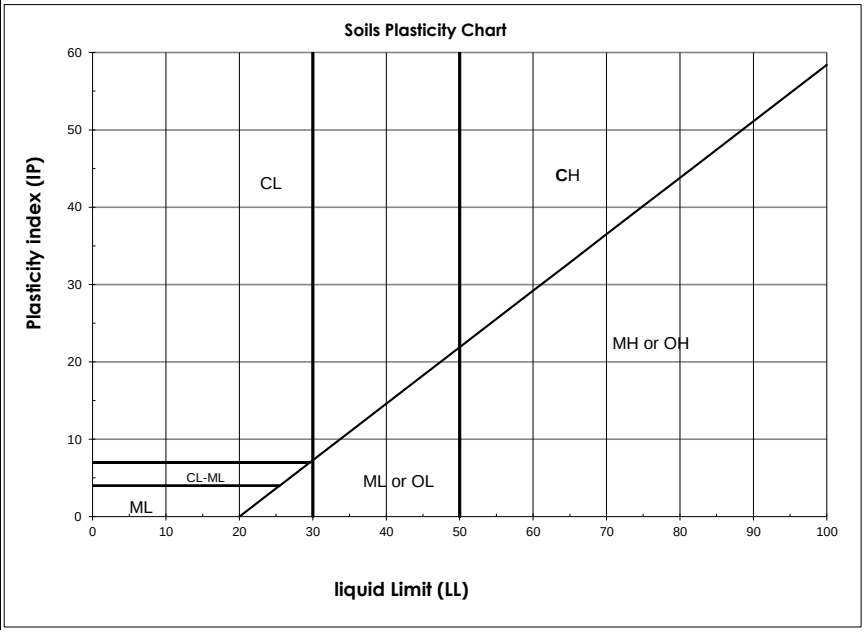
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	100
2,50	100
1,25	100
0,630	95
0,315	13
0,160	0
0,080	0,1



% Gravel : 0,0 % Sand : 99,9 % Fine particles : 0,1

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	14,2



Remarks :

Prepared by : Benoit Cyr, Geo.

Date : July 21, 2022

Stantec

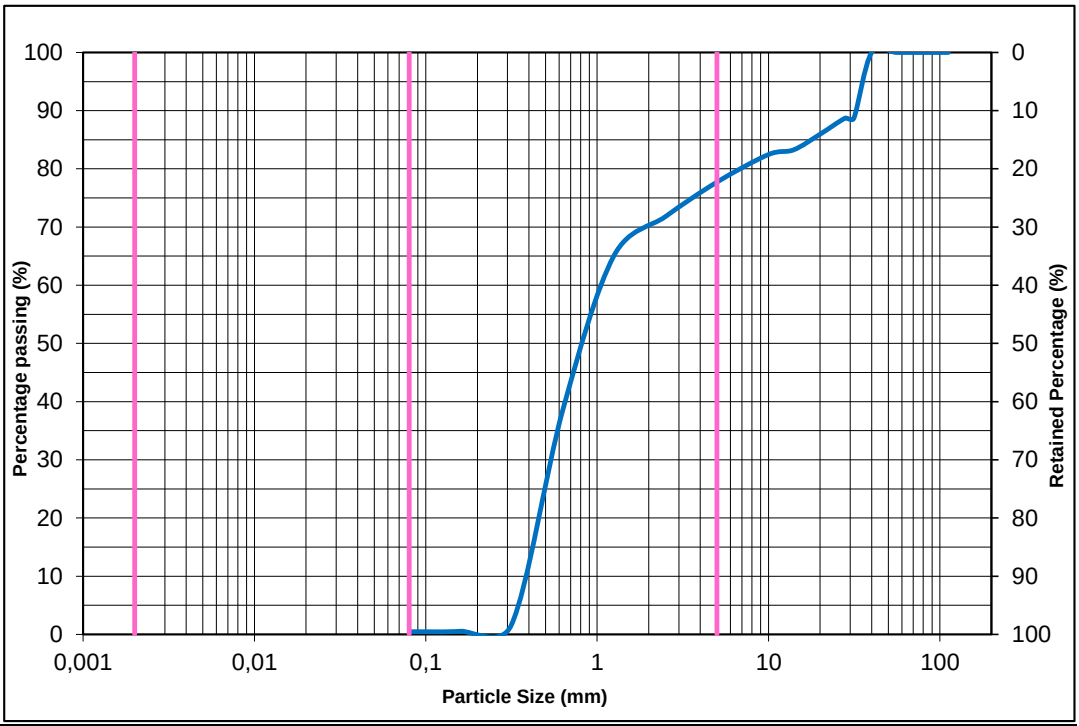
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	Manuel Verpaelst
	Department of Community and Government Services	Sampling Date :	June 16, 2022
Project :	Gjoa Haven, NU		
Project No :	144903260.200.800		
Sample No :	BH22-06 DC-08	Material Description :	Gravely Sand, traces of fine particles
Depth :	1,70 - 1,90m		

Grain Size Analysis (BNQ 2501-025)

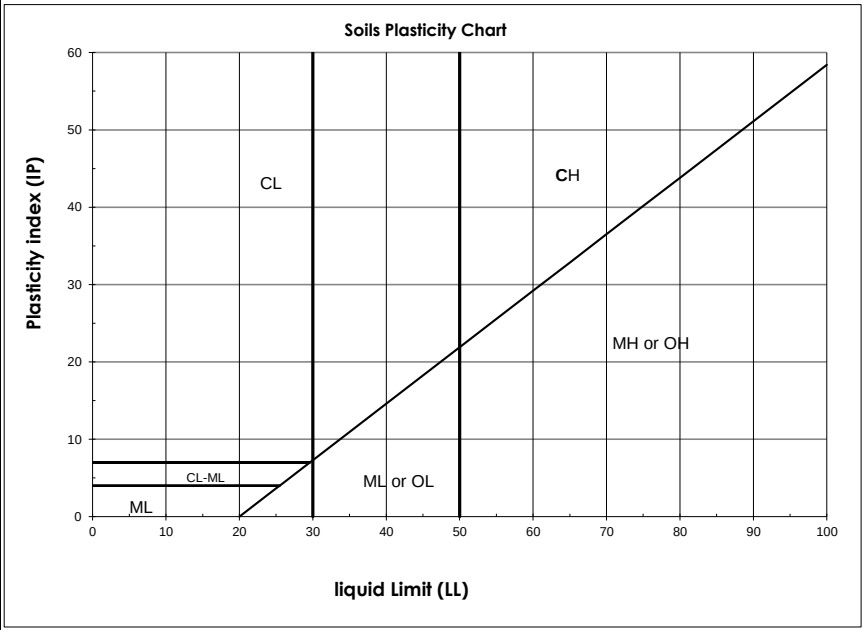
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	89
28,0	89
20,0	86
14,0	83
10,0	82
5,00	78
2,50	72
1,25	65
0,630	39
0,315	2
0,160	1
0,080	0,5



% Gravel : 22,2 % Sand : 77,3 % Fine particles : 0,5

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	19,5



Remarks :

Prepared by : Benoit Cyr, Geo. **Date :** July 21, 2022

Stantec

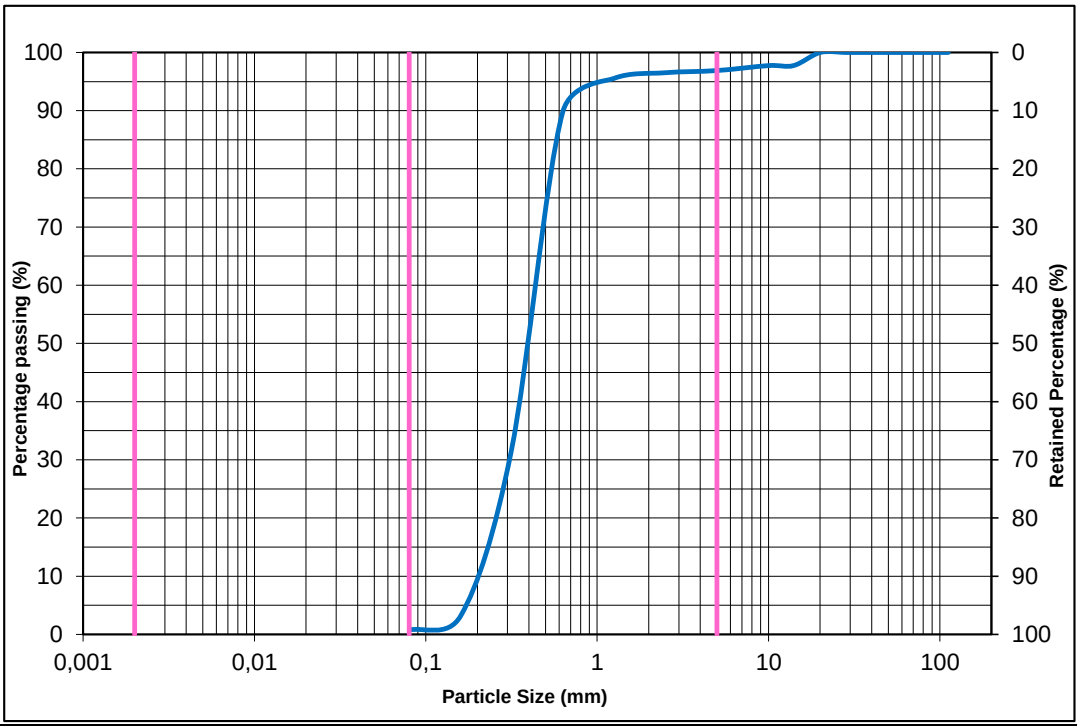
2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

Client :	Government of Nunavut	Sampled by :	Manuel Verpaelst
	Department of Community and Government Services	Sampling Date :	June 17, 2022
Project :	Gjoa Haven, NU		
Project No :	144903260.200.800		
Sample No :	BH22-07 DC-08	Material Description :	Sand, traces of Gravel, traces of fine particles
Depth :	1,50 - 1,65m		

Grain Size Analysis (BNQ 2501-025)

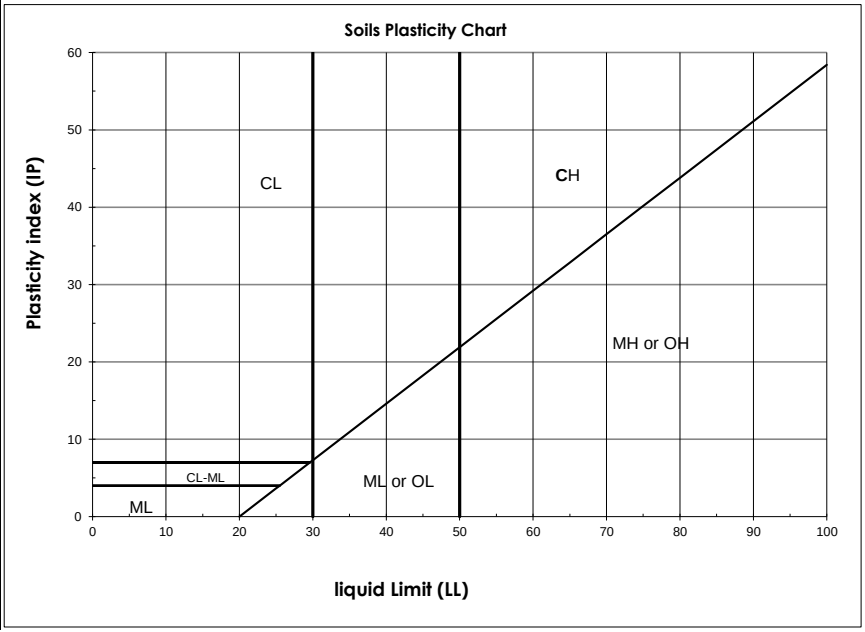
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	98
10,0	98
5,00	97
2,50	97
1,25	96
0,630	90
0,315	31
0,160	3
0,080	0,7



% Gravel : 3,2 % Sand : 96,1 % Fine particles : 0,7

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	46,1



Remarks :

Prepared by : Benoit Cyr, Geo. **Date :** July 21, 2022

Stantec

2273 Michelin Street,
Laval QC, H7L 5B8

LABORATORY TESTING REPORT

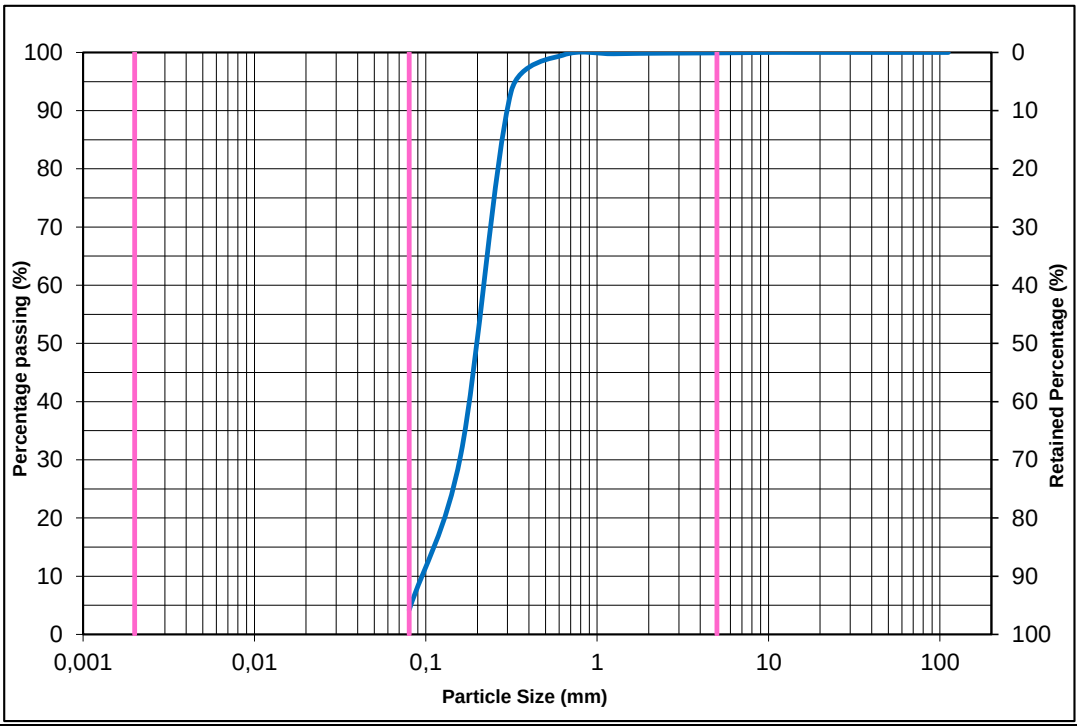
Client : Government of Nunavut
Department of Community and Government Services
Project : Gjoa Haven, NU
Project No : 144903260.200.800
Sample No : BH22-09 DC-10
Depth : 1,92 - 2,05m

Sampled by : Manuel Verpaelst
Sampling Date : June 17, 2022

Material Description : Sand, traces of fine particles, traces of Gravel

Grain Size Analysis (BNQ 2501-025)

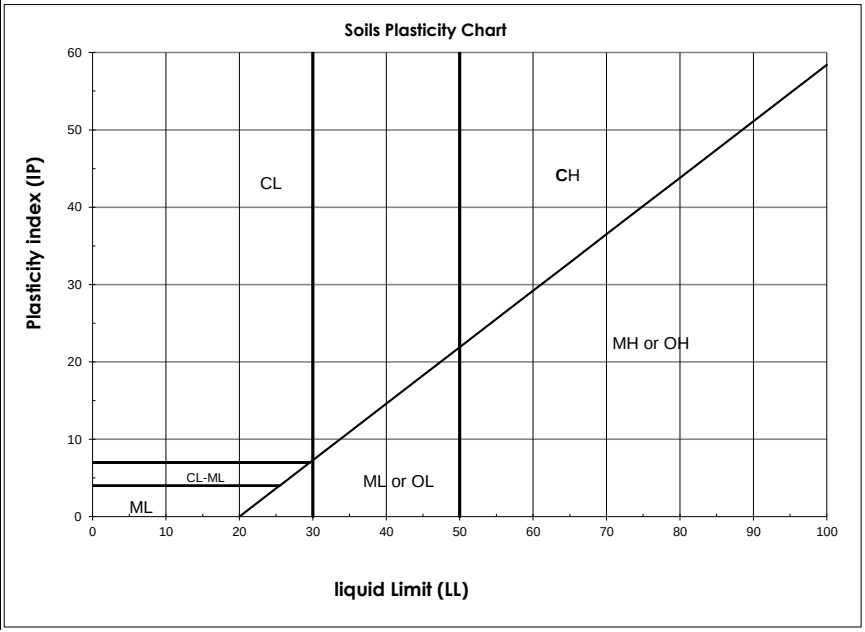
Openings Dimensions	Cumulative Results
mm	%
112	100
80,0	100
56,0	100
40,0	100
31,5	100
28,0	100
20,0	100
14,0	100
10,0	100
5,00	100
2,50	100
1,25	100
0,630	100
0,315	93
0,160	31
0,080	4,2



% Gravel : 0,1 % Sand : 95,7 % Fine particles : 4,2

Other tests

Test / Standard	Results
Water Content (NQ 2501-170) (%)	21,6



Remarks :

Prepared by : Benoit Cyr, Geo. **Date :** July 21, 2022

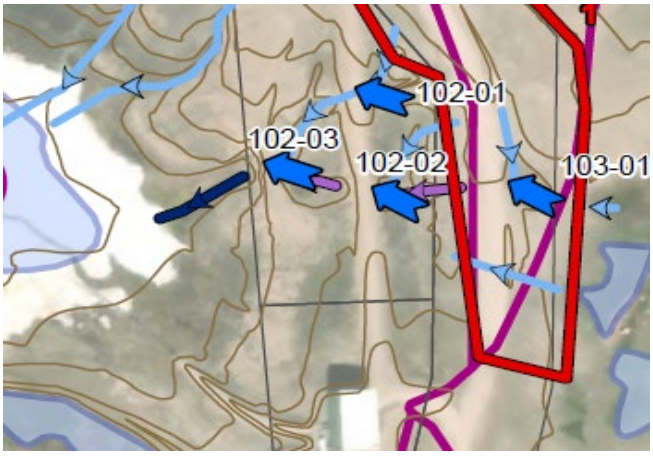
APPENDIX H Drainage Assessment and Planning

Culvert ID	Street / Location	Northing	Easting	Culvert Type	Shape	Material	Diameter or Dimensions (mm)	Marker Post Present (Y/N)	Crushing		Infill (mm)		Culvert Condition Rating (CSA 2020; MTO 2013)					Recommended Actions	Priority (None, Low, Medium, High)	Comments
									Upstream	Downstream	Upstream	Downstream	Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)			
102-01	Unnamed	7616459	383522	Cross				No					NM	NM	0	NM	NM	Inspect when unfrozen	None	Covered by ice could not analyze culvert condition.
102-02	Unnamed	7616422	383528	Cross	Round	CSP	500	No	No	Yes	0	0	0	2	0	1	0	Reinstall culvert at a lower elevation	Medium	Ponding upstream (invert should be lower). Perched downstream.
102-03	Unnamed	7616432	383492	Cross	Round	CSP	500	No	No	No	0	0	0	0	0	1	1	Reinstall culvert at a lower elevation	Low	Ponding upstream (invert too high). Perched downstream
103-01	Unnamed	7616424	383573	Cross	Round	CSP	500	No	Yes	Yes	5	0	0	4	1	1	1	Replace culvert	High	Water ponding upstream, material upstream preventing good drainage. Downstream end perched. Erosion downstream. Isolated culvert. Cant properly drain all upstream ponding in old gravel pit
105-01	Imiqtarvik Road	7616254	383553	Cross	Round	PVC	250	No	No	No	50	0	0	1	1	0	0	Reinstall culvert at a lower elevation	Low	Shallow overburden. Inadequate size, invert elevation too high. Ponding upstream
106-01	Imiqtarvik Road	7616050	383672	Cross	Round	CSP	300	No	Yes	No	50	100	0	1	2	0	0	Flush culvert	High	None
106-02	Nattiaq Street	7616038	383742	Cross	Round	CSP	300	No	No	No	0	0	0	2	2	0	0	Unblock culvert	High	Upstream end is under water. Blocked, potentially frozen inside.
106-03	Nattiaq Street	7615961	383930	Cross	Round	CSP	300	No	Yes	No	0	0	0	4	0	1	1	Replace culvert at a lower elevation	High	Minor perched upstream and downstream. Ponding upstream
106-04	Kangiqsluk Road	7615767	383680	Cross	Round	CSP	900	No	Yes	Yes	50	0	0	2	1	1	0	None	Medium	Few debris(rock, wood) at culvert inlet
107-01	Apumiuvik Way	7616111	383271	Cross	Round	PVC	250	No	No	No	50	0	0	0	2	0	0	Unblock culvert	High	Ponding upstream, no flow through to downstream end. Upstream end likely block.
108-01	Nanuq Road	7616173	383497	Entrance	Round	PVC	250	No	No	No	50	0	0	0	1	0	2	Regrade upstream ditch	High	Ponding upstream, shallow overburden.
108-02	Nanuq Road	7616136	383476	Entrance	Round	CSP	400	No	Yes	Yes	200	350	0	0	2	0	1	Unblock culvert	High	Ponding, garbage and infill upstream. Downstream end partially buried
108-03	Nanuq Road	7616109	383467	Cross	Round	CSP	500	No	Yes	Yes	0	0	0	1	0	0	2	Regrade upstream ditch	High	Ponding upstream. Should clean upstream ditch to better drain
108-04	Apumiuvik Way	7616128	383397	Entrance	Round	CSP	400	No	Yes	No	50	150	0	1	2	0	0	Unblock culvert	High	None
108-05	Apumiuvik Way	7616053	383396	Entrance	Round	PVC	250	No	Yes	No	0	50	0	1	1	0	2	Reinstall culvert at a lower elevation	High	Shallow overburden. Upstream invert is too high. Poor drainage efficiency
108-06	Apumiuvik Way	7616044	383417	Entrance	Round	PVC	250	No	No	No	0	0	0	0	2	0	2	Reinstall culvert at a lower elevation	High	Culivert invert too high.
108-07	Apumiuvik Way	7616036	383435	Entrance	Round	PVC	250	No	No	No	0	0	0	0	0	0	2	Reinstall culvert at a lower elevation	High	Upstream invert high. Appears to pond upstream.
108-08	Nanuq Road	7616054	383449	Entrance	Round	CSP	500	No	Yes	Yes	200	100	0	1	2	1	2	Regrade ditch, flush culvert	High	Major ponding upstream. Better defined ditch would help
108-09	Nanuq Road	7616032	383443	Cross	Round	CSP	500	No	Yes	Yes	50	0	0	2	1	1	0	Flush culvert	Medium	None
108-10	Nanuq Road	7615993	383430	Entrance	Round	PVC	250	No	No	Yes	0	0	0	0	1	1	2	Regrade ditch, flush culvert	High	Some ponding upstream. Ditch undefined. Two culverts. One is flowing the other is blocked.
108-11	Nanuq Road	7615953	383412	Entrance	Round	CSP	900	No	Yes	Yes	0	50	0	2	1	1	0	Remove bent CSP at the downstream end	Medium	None
110-01	Aglu Road	7616112	383520	Entrance	Round	PVC	250	No	No	No	0	0	0	1	0	0	2	Reinstall culvert at a lower elevation	High	Shallow overburden, perched at the downstream end (minor)
110-02	Nanuq Road	7616031	383571	Cross	Round	CSP	500	No	?	Yes	500	200	0	2	2	1	1	Repair or replace culvert	High	Upstream buried. Does not work. Need repair
110-03	Nanuq Road	7616019	383514	Entrance	Round	CSP	280	No	No	No	0	100	0	2	2	1	1	Clean downstream end to maximize drainage	High	Downstream end infilled
110-04	Nanuq Road	7616019	383484	Cross	Round	PVC	250	No	No	No	50	0	0	0	1	0	2	Consider relocating culvert	High	Not well placed. Ponding upstream. Improper ditch.
110-05	Nanuq Road	7616024	383465	Cross	Round	CSP	500	No	Yes	Yes	200	50	0	1	2	1	2	Regrade upstream ditchn remove rocks	High	Upstream half filed with rocks
112-01	Kangiqsluk Road	7615522	383337	Cross	Round	PVC	250	No	No	No	200	0	0	0	2	0	2	Clear conveyance channel to upstream end	High	Upstream almost buried
113-01	Unnamed	7615439	383508	Entrance	Round	CSP	500	No		No		500	0	0	2	1	2	Flush inlet, reinstall culvert	High	All frozen and filled. Can't find the inlet. Maybe near school
113-02	Unnamed	7615492	383486	Entrance	Round	CSP	600	No	No	No	200	350	0	1	2	1	0	Flush culvert	High	Downstream end infilled
114-01	Unnamed	7615489	383567	Cross	Round	PVC	1120	No	No	No	75	550	0	0	2	2	0	Replace with one larger capacity culvert at a lower elevation	High	4 x 280 mm pvc put together. 1 1/2 partially filled downstream. Tension cracks present on embankment surrounding culvert
114-02	Unnamed	7615518	383548	Cross	Round	CSP	1100	No	No	No	350	300	0	0	2	0	0	Flush culvert	High	None
115-01	Kangiqsluk Road	7615578	383532	Cross	Round	CSP	900	No	Yes	Yes	0	0	0	3	2	1	0	Flush culvert	High	Upstream mostly under water. Major ponding. Blocked by ice. No drainage
115-02	Kangiqsluk Road	7615576	383525	Cross	Round	CSP	600	No	No	No	0	0	0	0	0	0	2	Lower invert elevation to maximize drainage	High	Perched upstream and downstream. Major ponding upstream
118-01	Recreation Drive	7615359	383316	Cross	Round	PVC	250	No	Yes	No	0	0	0	1	0	0	1	Create conveyance channel towards culvert	Low	No proper ditch drain to culvert. Downstream perched
118-02	Unnaq Road	7615337	383276	Cross	Round	CSP		No					NM	NM	0	NM	NM	Analyze culvert	None	Two CSP Culverts not analyzed
118-03	Tuqaqhiaq Road	7615362	383198	Cross	Round	CSP	900	No	No	No	50	0	0	0	1	0	2	Reinstall culvert at a lower elevation	High	Invert elevation too high, ponding upstream, perched end
118-04	Tuqaqhiaq Road	7615370	383186	Cross			800	No		Yes	150	500	NM	NM	2	NM	NM	Flush Culvert	None	Culvert inlet buried. But still minor flow. Culvert located close to slope instability. If culvert was effective it may trigger additional bank instability
119-01	Recreation Drive	7615304	383498	Cross	Round	PVC	250	No	No	No	0	0	0	0	0	0	1	Regrade upstream and downstream ditch	Low	Ponding upstream and downstream
119-02	Recreation Drive	7615315	383451	Cross	Round	CSP	500	No	No	Yes	50	0	0	3	1	0	1	Replace culvert	High	Upstream end of culvert crushed
119-03	Recreation Drive	7615340	383377	Cross	Round	CSP	800	No		No	800	50	0	0	2	0	0	Rplace culvert	High	Can't find upstream end. Either buried or under water. Downstream culvert end blocked by ice
120-01	Unnamed	7615163	383483	Cross	Round	PVC/CSP	250/600	No	No	No	0	0	0	0	2	0	0	Flush CSP Culverts, install PVC culvert at lower elevation	High	Major ponding upstream. 2 metal under water and blocked by ice. Pvc downstream end is perched. Only PVC flowing
120-02	Recreation Drive	7615283	383505	Cross	Round	CSP	400	No	Yes	No	0	100	0	1	1	1	0	None	None	None
120-03	Tulaktarvik Way	7615043	383266	Entrance	Round	CSP	300	No		Yes	300	150	0	4	2	0	2	Replace culvert at a lower elevation	High	Only outlet visible. Inlet is buried. Not too clear where low point is. Resident says ponding occurs here.
120-04	Recreation Drive	7615298	383453	Cross	Round	CSP	500	No	No	Yes	50	50	0	2	1	0	1	Regrade channel	Low	None
121-01	Recreation Drive	7615277	383636	Cross	Round	PVC	250	No	Yes	No	0	0	0	1	0	0	2	Regrade upstream channel	High	Upstream invert high. Not good drainage. Ponding upstream
121-02	Recreation Drive	7615270	383610	Entrance	Round	CSP	400	No	No	No	0	200	0	0	2	1	0	Flush culvert	High	None
122-01	Pirraaq Road	7614987	383110	Entrance	Round	CSP	600	No	Yes	Yes	300	100	0	4	2	0	2	Upstream culvert end crushed, improve upstream conveyance	High	Upstream end crushed
122-02	Pirraaq Road	7614964	383097	Cross	Round	PVC	250	No	Yes	No	0	100	0	0	2	0	2	Flush culvert, improve upstream conveyance	High	Inlet obstructed by rock and material. Minor ponding upstream. Undefined ditch upstream
122-03	Hinaaq Street	7615005	383047	Cross	Round	CSP	300	No	No	No	0	0	0	2	2	0	1	Flush culvert, improve upstream conveyance	High	Undefined ditch upstream. Minor ponding
122-04	Tulaktarvik Way	7614861	383188	Cross	Round	CSP	500	No		Yes	500	200	0	3	2	0	1	Replace culvert	High	Upstream end buried
123-01	Tulaktarvik Way	7615023	383284	Entrance	Round	PVC	250	No	No	No	0	0	0	0	0	0	0	Survey to determine culvert orientation	Low	Low and high points unknown
123-02	Tulaktarvik Way	7614988	383306	Cross	Round	PVC	250	No	Yes	Yes	0	50	0	2	1	0	1	None	Medium	None
123-03	Tulaktarvik Way	7614913	383258	Cross	Round	CSP	400	No	Yes	Yes	50	50	0	4	1	0	1	Replace culvert	High	Upstream and downstream end crushed
123-04	Tulaktarvik Way	7614889	383233	Entrance	Round	CSP	400	No	Na	Na	400	400	0	0	2	0	0	Replace culvert at a lower elevation	High	Both ends buried. Shallow overburden. Flow occurs over the culvert. Ponding upstream
123-05	Ibruq Road	7614852	383409	Entrance	Round	CSP	400	No	Yes	No	300	150	0	1	2	0	2	Replace culvert at a lower elevation, improve upstream conveyance	High	Upstream end almost buried
123-06	Ibruq Road	7614839	383386	Entrance	Round	PVC	250	No	Yes	No	50	50	0	1	1	0	2	Regrade ditch	High	Upstream ponding. Ditch not well defined. Upstream invert too high.Debris in culvert
123-07	Ibruq Road	7614829	383362	Cross	Round	CSP	500	No	Yes	Yes	50	0	0	3	1	0	0	Replace culvert, ends crushed	High	None
123-08	Ibruq Road	7614795	383326	Entrance	Round	CSP	500	No	No	No	50	350	0	2	2	0	0	None	High	None
123-09	Kamotik Way	7614852	383314	Entrance	Round	PVC	250	No	No	No	150	0	0	0	2	0	2	Reinstall culvert at a lower elevation	High	Shallow overburden. No proper ditch to convey flow.
123-10	Ibruq Road	7614771	383300	Cross	Round	CSP	800	No	Yes	No	50	400	0	1	2	0	0	Flush culvert	High	Partially blocked by ice downstream. Ponding upstream. Ditch not defined
123-11	Hinaaq Street	7614813	383254	Entrance	Round	CSP	400	No	Yes	No		0	0	4	0	0	0	Repalce culvert	High	Upstream almost buried and very crushed. Cant see inside
123-12	Hinaaq Street	7614830	383237	Entrance	Round	CSP	400	No	No	No	100	250	0	2	2	0	0	Clear rock	High	Debris in front of upstream end
123-13	Hinaaq Street	7614861	383206	Cross	Round	CSP	600	No	No	Yes	No	0	0	2	2	1	0	Reinstall culvert at a lower elevation	High	Upstream invert high. Dont drain efficiently
125-01	Nuvu Road	7614852	383454	Cross	Round	PVC	250	No	No	No	200	0	0	0	2	0	1	Flush culvert	High	Culvert inlet almost buried. Ponding upstream. No clear ditch to the culvert

Culvert Information		
Culvert ID		Culvert ID
Type		Cross
Shape		0
Material		0
Diameter or Dimensions (mm)		0
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	0
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Covered by ice could not analyze culvert condition.	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7616459
Easting (m) [1]	383522

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
NM	NM	0	NM	NM

Recommended Action(s):	Inspect when unfrozen	Priority:	None

Upstream View

No Photo US, Looking US

Upstream Culvert End

Downstream View

No Photo DS, looking DS

Downstream Culvert End

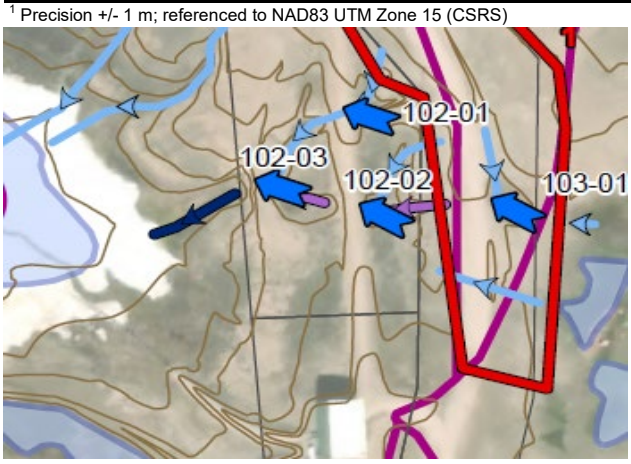
No Photo DS end of culvert

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		102-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Ponding upstream (invert should be lower). Perched downstream.	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7616422
Easting (m) [1]	383528

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	0	1	0

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

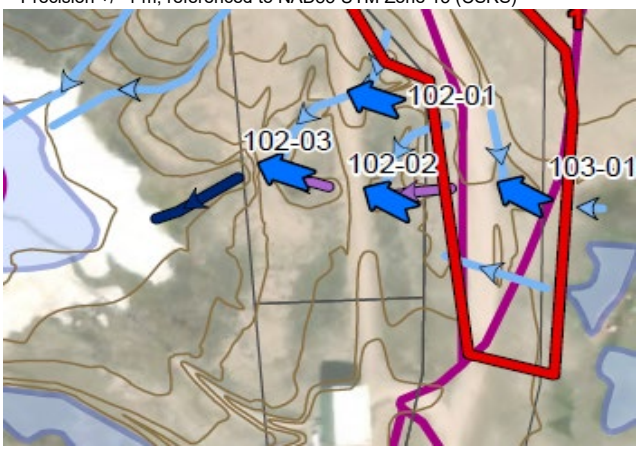
No photo DS end of culvert

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		102-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Ponding upstream (invert too high). Perched downstream	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7616432
Easting (m) [1]	383492

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	1	1

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

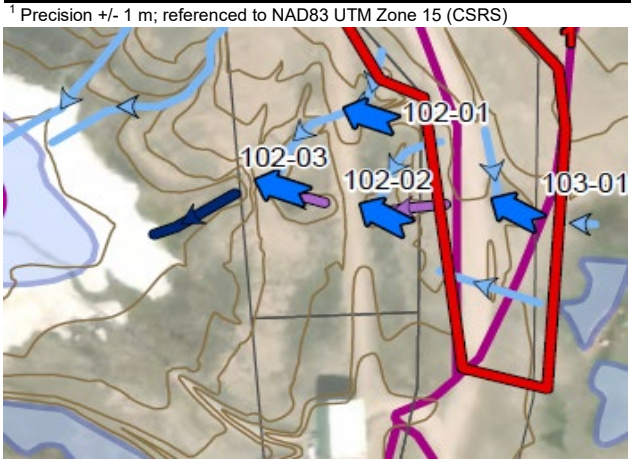
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		103-01
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	5
	Downstream	0
Other Comments	Water ponding upstream, material upstream preventing good drainage. Downstream end perched. Erosion downstream. Isolated culvert. Cant properly drain all upstream ponding in old gravel pit	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7616424
Easting (m) [1]	383573

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	1	1	1

Recommended Action(s):	Replace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

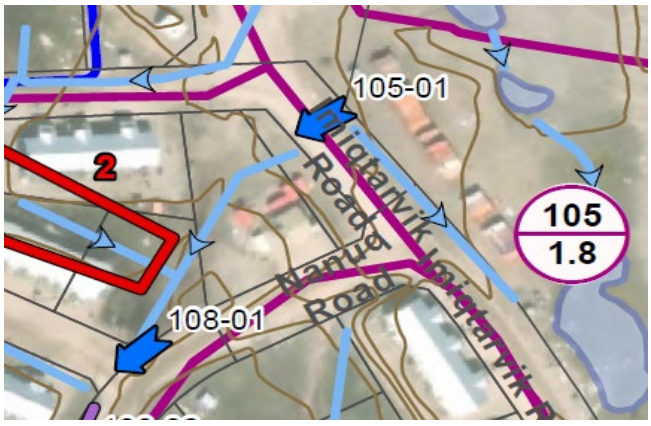
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		105-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Shallow overburden. Inadequate size, invert elevation too high. Ponding upstream	

Culvert Location	
Street	Imiqtarvik Road
Northing (m) [1]	7616254
Easting (m) [1]	383553

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	0	0

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

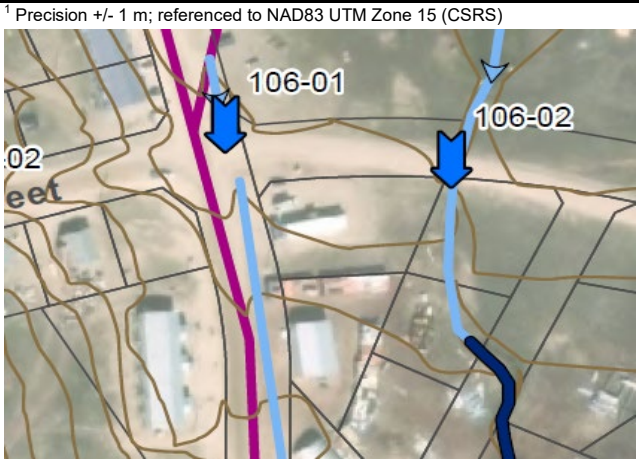
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		106-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments		

Culvert Location	
Street	Nattiaq Street
Northing (m) [1]	7616038
Easting (m) [1]	383742

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	0	0

Recommended Action(s):	Unblock culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

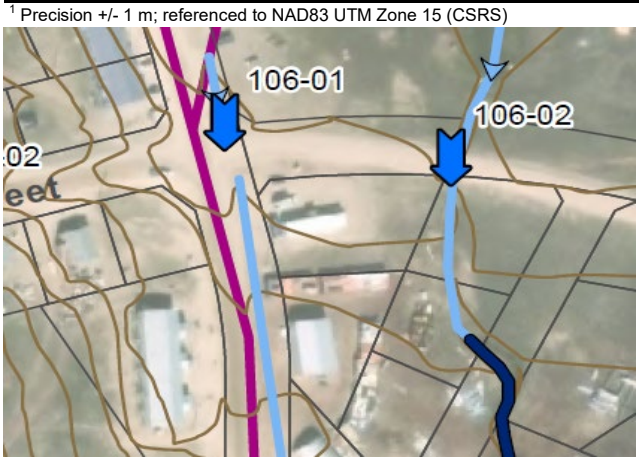
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		106-01
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	100
Other Comments	Upstream end is under water. Blocked, potentially frozen inside.	

Culvert Location	
Street	Imiqtarvik Road
Northing (m) [1]	7616050
Easting (m) [1]	383672

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	0	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

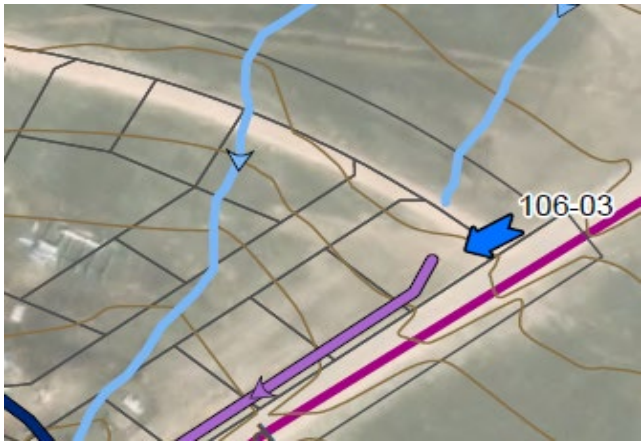
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		106-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Minor perched upstream and downstream. Ponding upstream	

Culvert Location	
Street	Nattiaq Street
Northing (m) [1]	7615961
Easting (m) [1]	383930

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	0	1	1

Recommended Action(s):	Replace culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

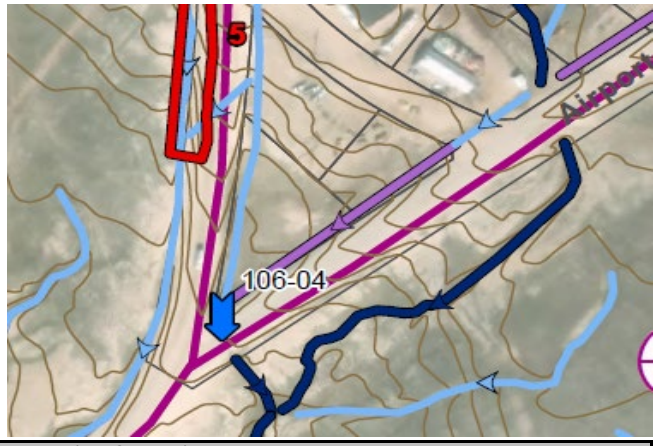
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		106-04
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		900
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Few debris(rock, wood) at culvert inlet	

Culvert Location	
Street	Kangiqsluk Road
Northing (m) [1]	7615767
Easting (m) [1]	383680

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	1	1	0

Recommended Action(s):	None	Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

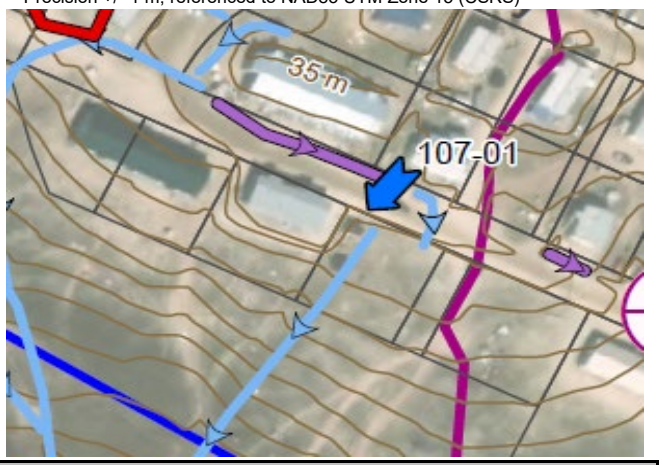
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		107-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Ponding upstream, no flow through to downstream end. Upstream end likely block.	

Culvert Location	
Street	Apumiuvik Way
Northing (m) [1]	7616111
Easting (m) [1]	383271

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Unblock culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

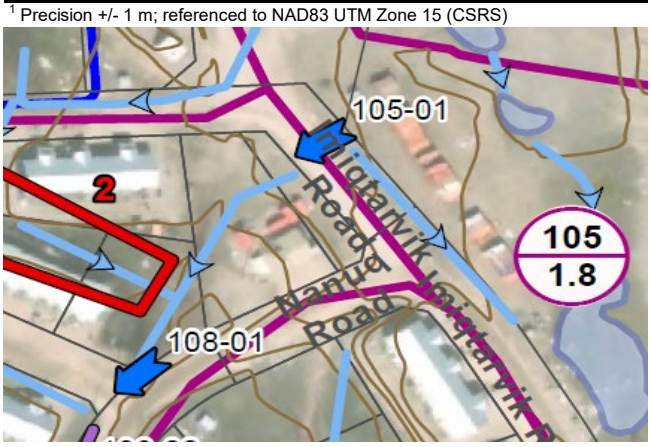
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-01
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Ponding upstream, shallow overburden.	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616173
Easting (m) [1]	383497

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	2

Recommended Action(s):	Regrade upstream ditch	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

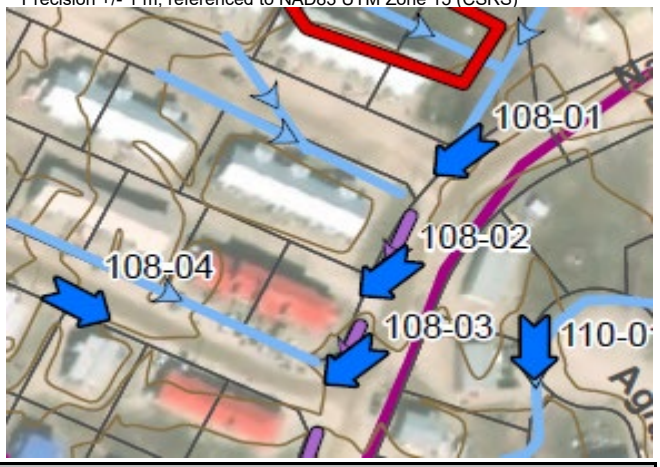
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-02
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	200
	Downstream	350
Other Comments	Ponding, garbage and infill upstream. Downstream end partially buried	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616136
Easting (m) [1]	383476

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	1

Recommended Action(s):	Unblock culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

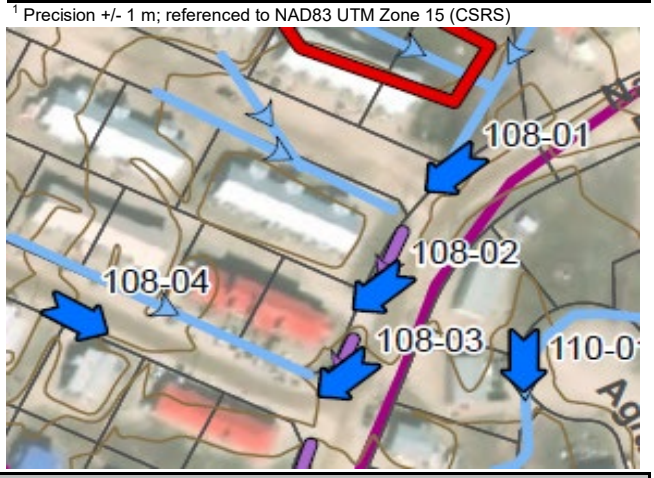
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Ponding upstream. Should clean upstream ditch to better drain	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616109
Easting (m) [1]	383467

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	0	0	2

Recommended Action(s):	Regrade upstream ditch	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

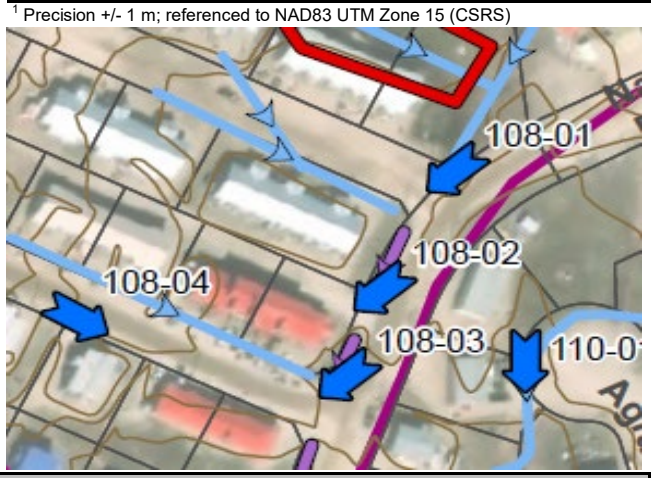
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-04
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	150
Other Comments	None	

Culvert Location	
Street	Apumiuvik Way
Northing (m) [1]	7616128
Easting (m) [1]	383397

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	0	0

Recommended Action(s):	Unblock culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

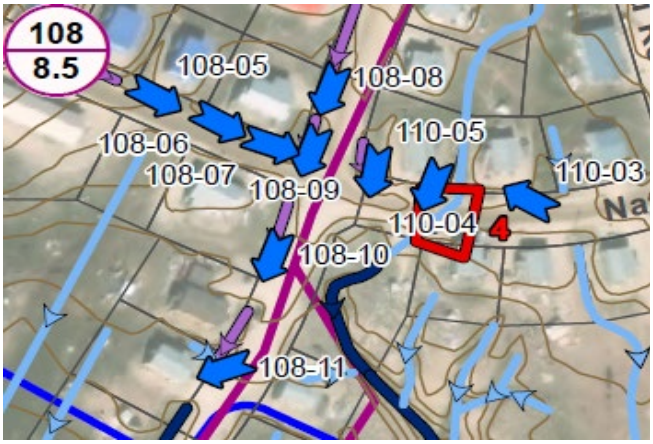
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-05
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	50
Other Comments	Shallow overburden. Upstream invert is too high. Poor drainage efficiency	

Culvert Location	
Street	Apumiuvik Way
Northing (m) [1]	7616053
Easting (m) [1]	383396

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

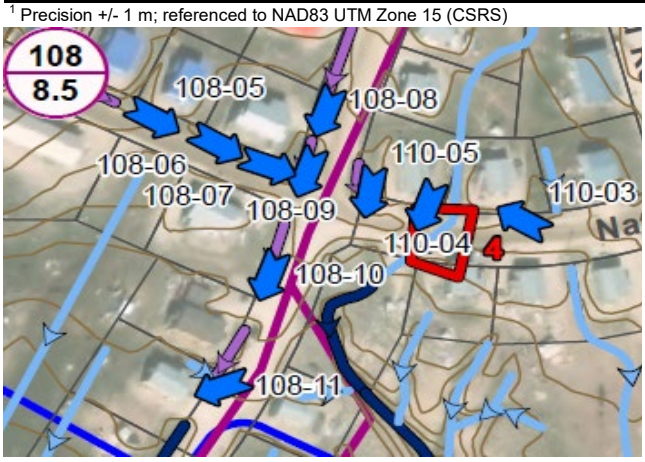
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-06
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Cullvert invert too high.	

Culvert Location	
Street	Apumiuvik Way
Northing (m) [1]	7616044
Easting (m) [1]	383417

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

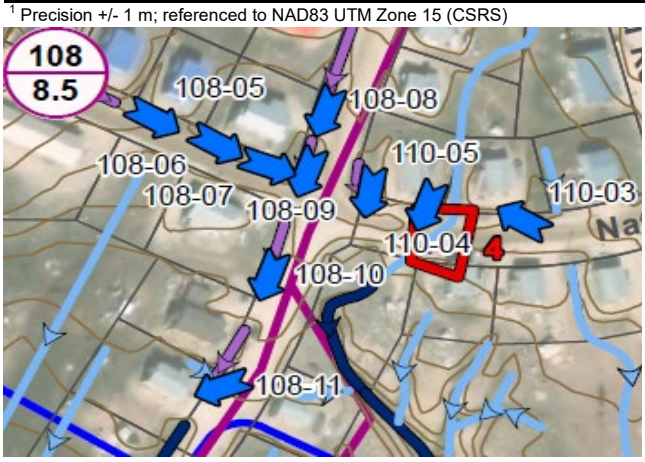
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-07
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Upstream invert high. Appears to pond upstream.	

Culvert Location	
Street	Apumiuvik Way
Northing (m) [1]	7616036
Easting (m) [1]	383435

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

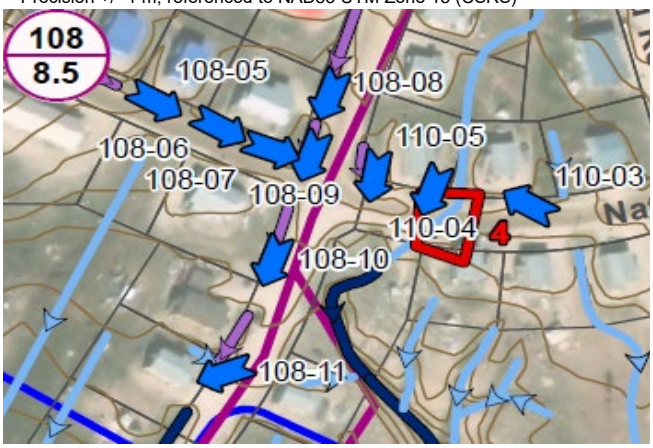
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-08
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	200
	Downstream	100
Other Comments	Major ponding upstream. Better defined ditch would help	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616054
Easting (m) [1]	383449

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	1	2

Recommended Action(s):	Regrade ditch, flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

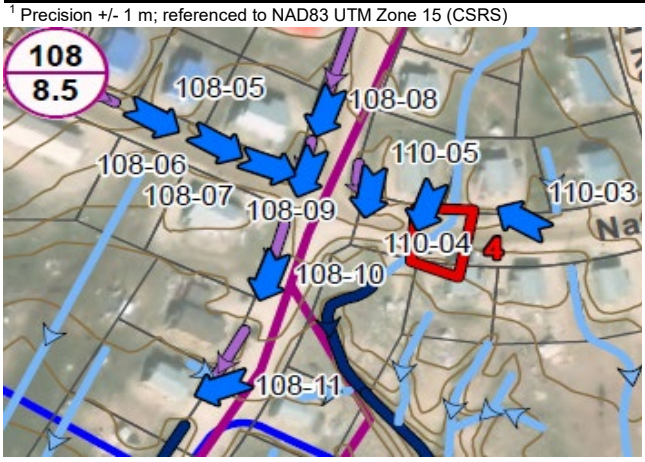
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-09
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	None	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616032
Easting (m) [1]	383443

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	1	1	0

Recommended Action(s):	Flush culvert	Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

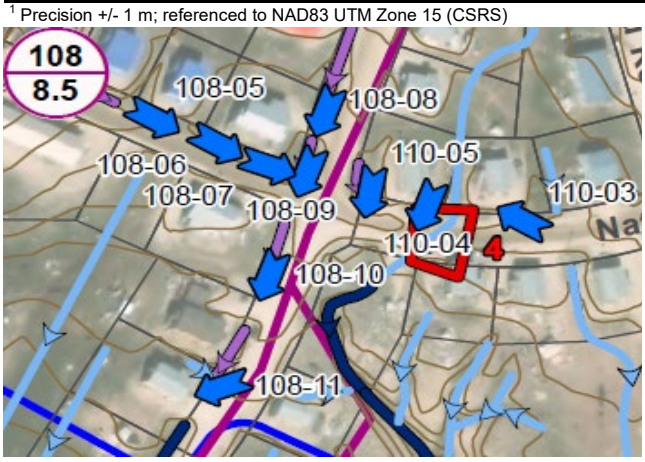
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-10
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Some ponding upstream. Ditch undefined. Two culverts. One is flowing the other is blocked.	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7615993
Easting (m) [1]	383430

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	1	2

Recommended Action(s):	Regrade ditch, flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

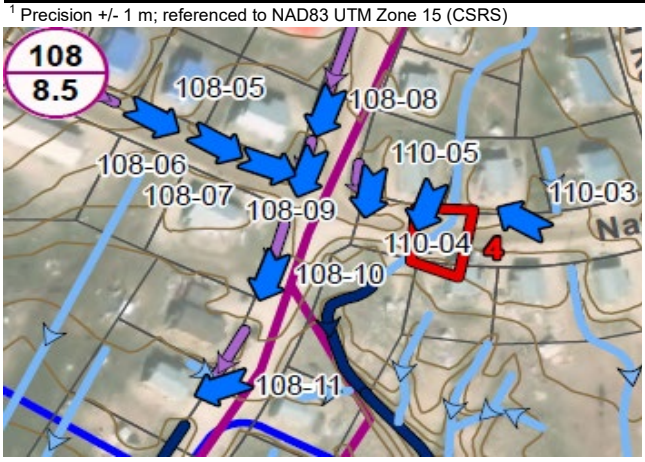
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		108-11
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		900
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	50
Other Comments	None	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7615953
Easting (m) [1]	383412

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	1	1	0

Recommended Action(s):	Remove bent CSP at the downstream end	Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

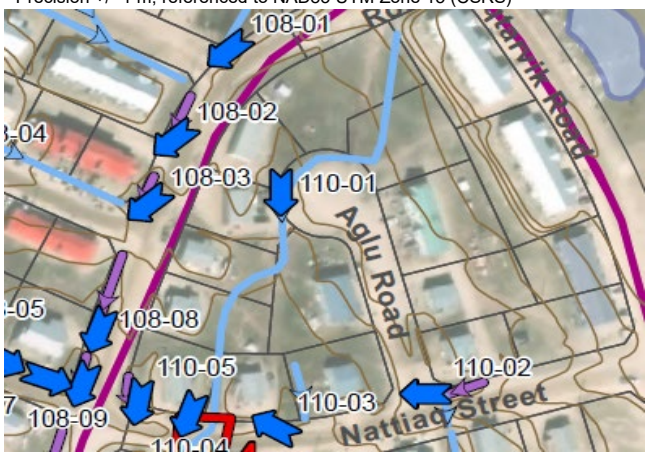
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		110-01
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Shallow overburden, perched at the downstream end (minor)	

Culvert Location	
Street	Aglu Road
Northing (m) [1]	7616112
Easting (m) [1]	383520

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	0	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

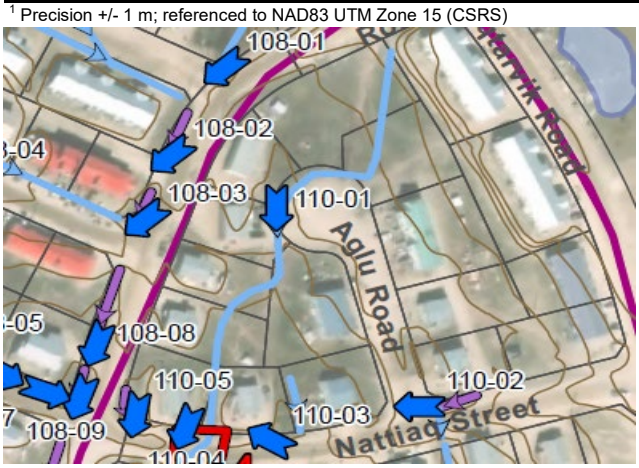
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		110-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	?
	Downstream	Yes
Infill Depth (mm)	Upstream	500
	Downstream	200
Other Comments	Upstream buried. Does not work. Need repair	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616031
Easting (m) [1]	383571

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	1	1

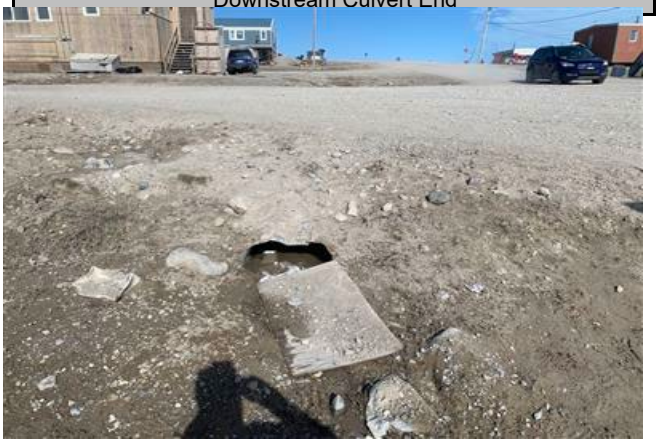
Recommended Action(s):	Repair or replace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

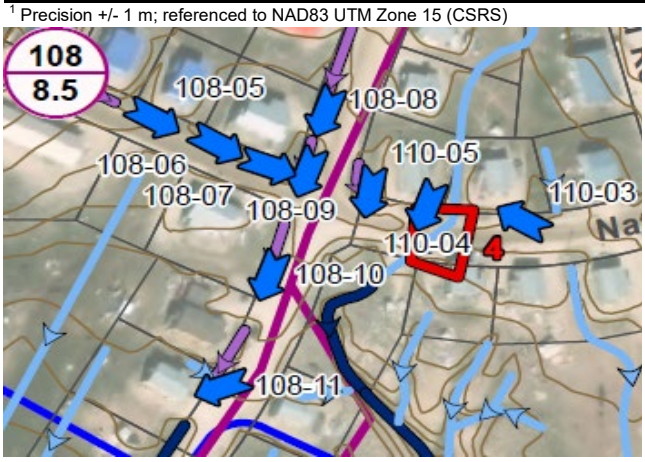


*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		110-03
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		280
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	100
Other Comments	Downstream end infilled	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616019
Easting (m) [1]	383514

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	1	1

Recommended Action(s):	Clean downstream end to maximize drainage	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

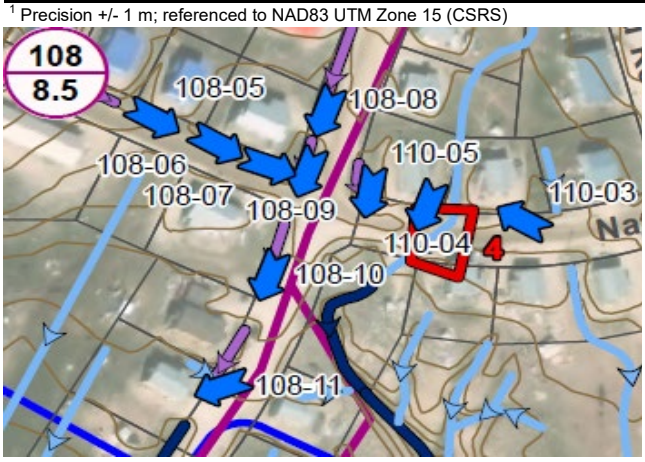
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		110-04
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Not well placed. Ponding upstream. Improper ditch.	

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616019
Easting (m) [1]	383484

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	2

Recommended Action(s):	Consider relocating culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

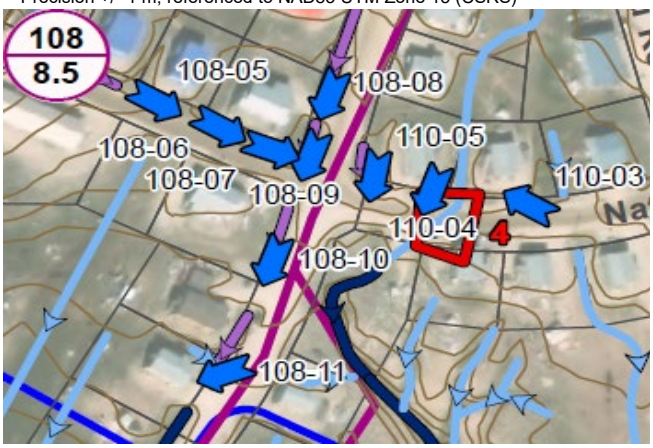
NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		110-05
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	200
	Downstream	50
Other Comments	Upstream half filed with rocks	

Clea

Culvert Location	
Street	Nanuq Road
Northing (m) [1]	7616024
Easting (m) [1]	383465

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	1	2

Recommended Action(s):	Regrade upstream ditchn remove rocks	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

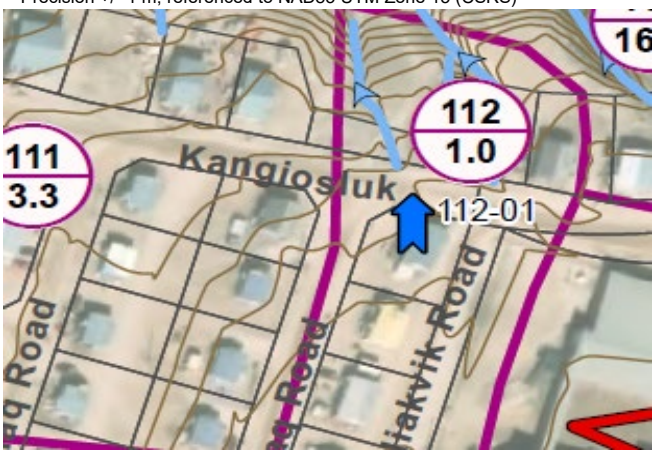
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		112-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	200
	Downstream	0
Other Comments	Upstream almost buried	

Culvert Location	
Street	Kangiqsluk Road
Northing (m) [1]	7615522
Easting (m) [1]	383337

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	2

Recommended Action(s):	Clear conveyance channel to upstream end	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

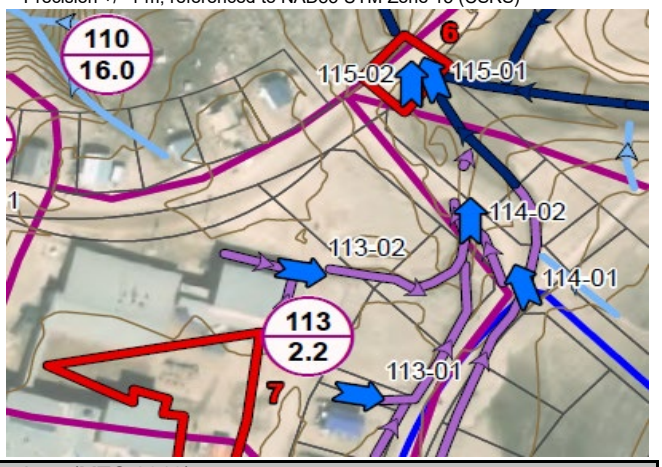
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		113-01
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	500
Other Comments	All frozen and filled. Can't find the inlet. Maybe near school	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7615439
Easting (m) [1]	383508

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	2

Recommended Action(s):	Flush inlet, reinstall culvert	Priority:	High

Upstream View

No Photo US, Looking US

Upstream Culvert End

No Photo US end of culvert

Downstream View

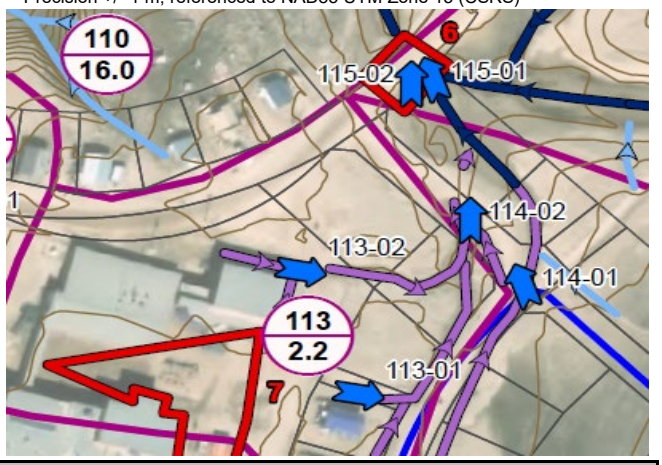
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		113-02
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	200
	Downstream	350
Other Comments	Downstream end infilled	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7615492
Easting (m) [1]	383486

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



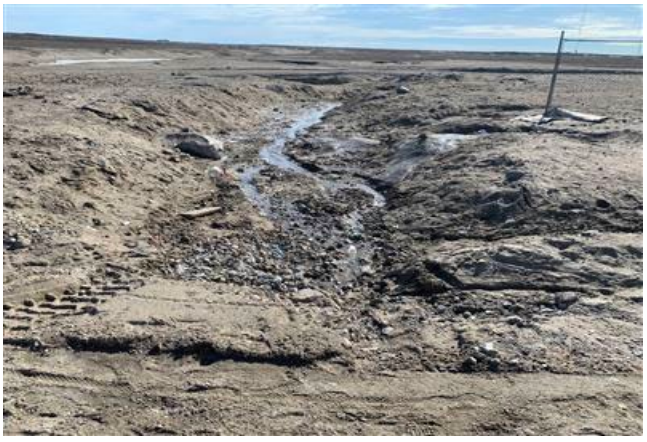
Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	1	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View



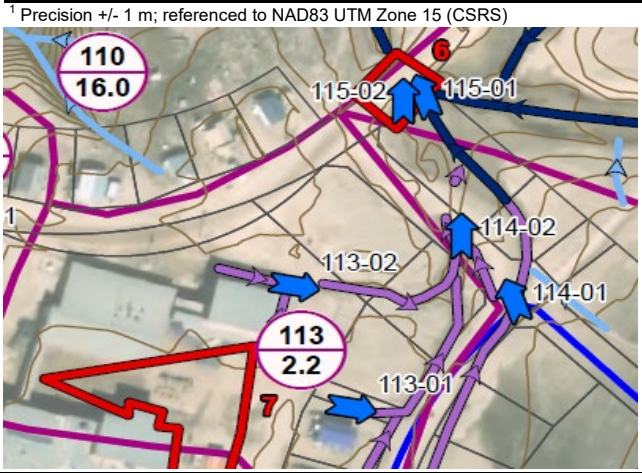
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		114-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		1120
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	75
	Downstream	550
Other Comments	4 x 280 mm pvc put together. 1 1/2 partially filled downstream. Tension cracks present on	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7615489
Easting (m) [1]	383567

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	2	0

Recommended Action(s):	place with one larger capacity culvert at a lower elevat	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

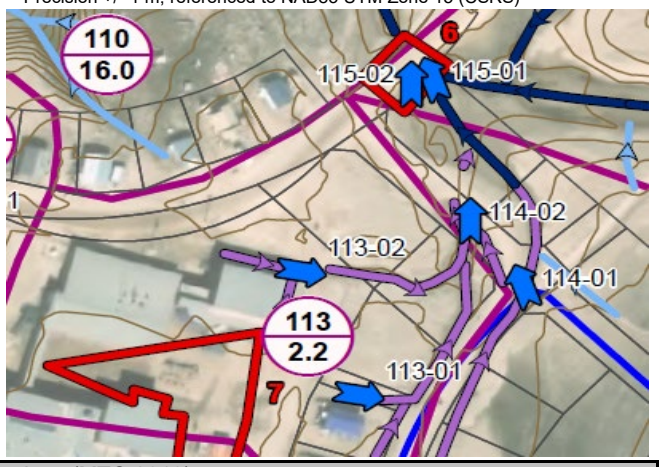
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		114-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		1100
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	350
	Downstream	300
Other Comments	0	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7615518
Easting (m) [1]	383548

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

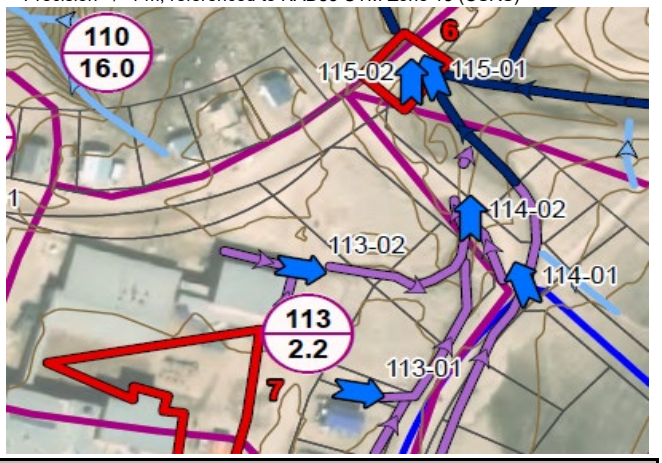
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		115-01
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		900
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Upstream mostly under water. Major ponding. Blocked by ice. No drainage	

Culvert Location	
Street	Kangiqsluk Road
Northing (m) [1]	7615578
Easting (m) [1]	383532

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	3	2	1	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

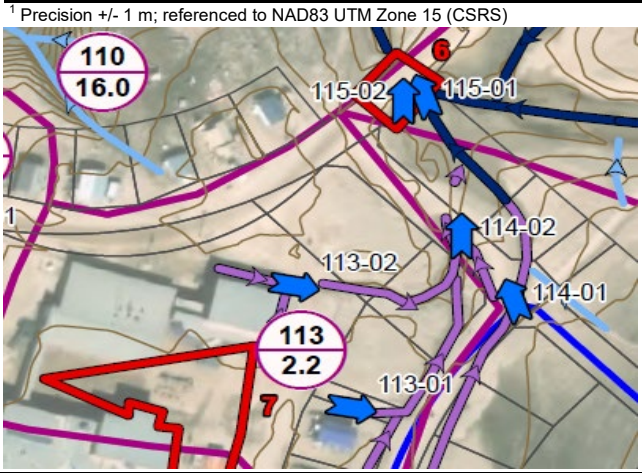
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		115-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Perched upstream and downstream. Major ponding upstream	

Culvert Location	
Street	Kangiqsluk Road
Northing (m) [1]	7615576
Easting (m) [1]	383525

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	2

Recommended Action(s):	Lower invert elevation to maximize drainage	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

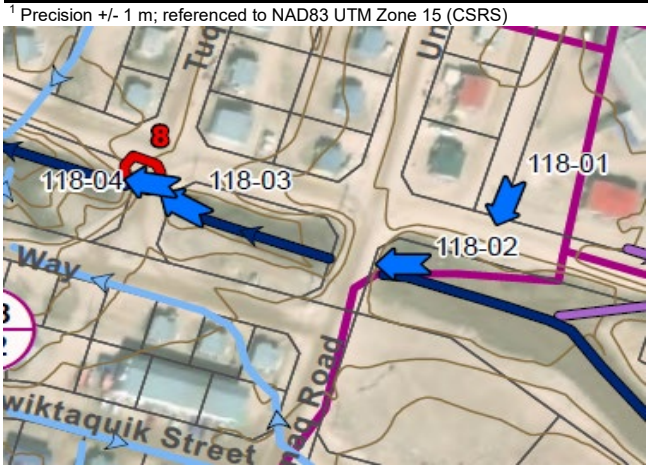
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		118-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	No proper ditch drain to culvert. Downstream perched	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615359
Easting (m) [1]	383316

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	0	0	1

Recommended Action(s):	Create conveyance channel towards culvert	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

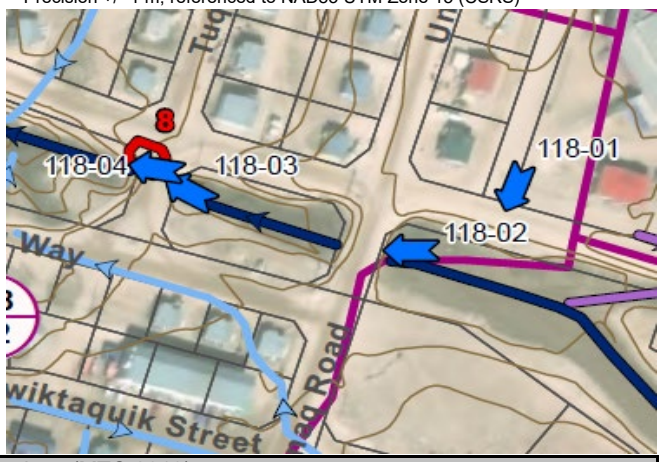
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		118-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		0
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	0
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Two CSP Culverts not analyzed	

Culvert Location	
Street	Unnaq Road
Northing (m) [1]	7615337
Easting (m) [1]	383276

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
NM	NM	0	NM	NM

Recommended Action(s):	Analyze culvert	Priority:	None

Upstream View	Upstream Culvert End
No Photo US, Looking US	No Photo US end of culvert

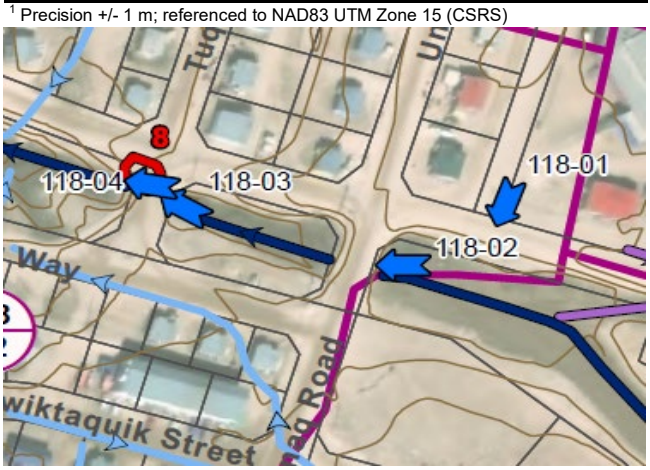
Downstream View	Downstream Culvert End
No Photo DS, looking DS	No Photo DS end of culvert

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		118-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		900
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Invert elevation too high, ponding upstream, perched end	

Culvert Location	
Street	Tuqaqhiaq Road
Northing (m) [1]	7615362
Easting (m) [1]	383198

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	1	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

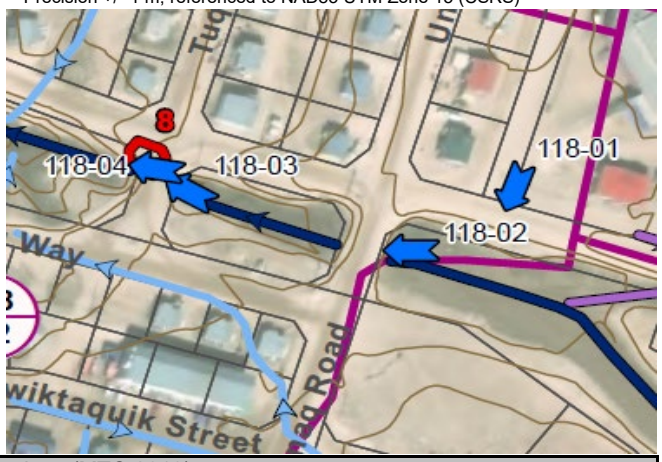
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		118-04
Type		Cross
Shape		0
Material		0
Diameter or Dimensions (mm)		800
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	Yes
Infill Depth (mm)	Upstream	150
	Downstream	500
Other Comments	Culvert inlet buried. But still minor flow. Culvert located close to slope instability. If culvert was effective it may trigger additional bank instability	

Culvert Location	
Street	Tuqaqhiaq Road
Northing (m) [1]	7615370
Easting (m) [1]	383186

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
NM	NM	2	NM	NM

Recommended Action(s):	Flush Culvert	Priority:	None

Upstream View	Upstream Culvert End
No Photo US, Looking US	No Photo US end of culvert

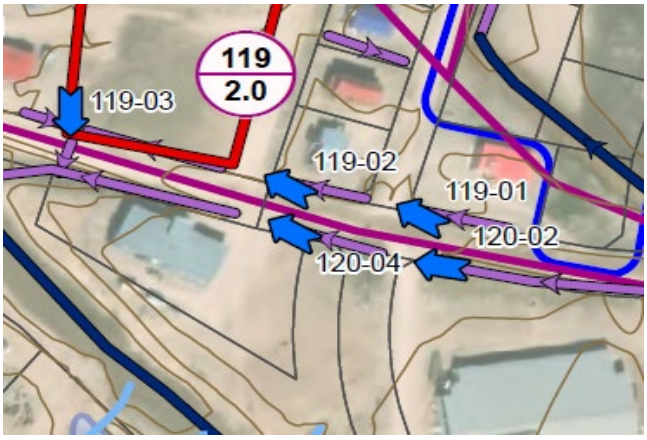
Downstream View	Downstream Culvert End
No Photo DS, looking DS	No Photo DS end of culvert

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		119-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Ponding upstream and downstream	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615304
Easting (m) [1]	383498

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	1

Recommended Action(s):	Regrade upstream and downstream ditch	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

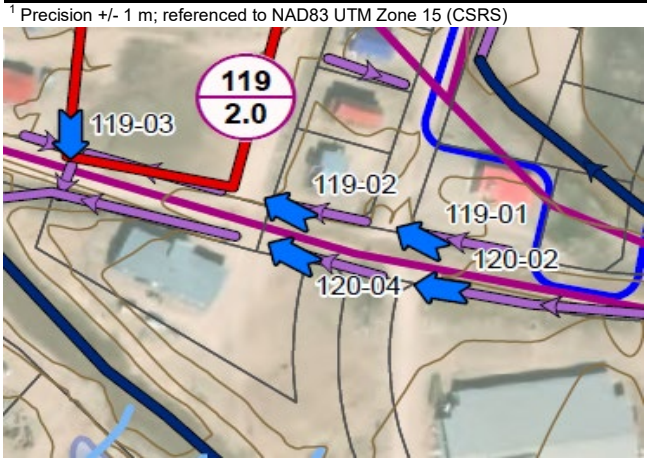
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		119-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	Upstream end of culvert crushed	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615315
Easting (m) [1]	383451

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	3	1	0	1

Recommended Action(s):	Replace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

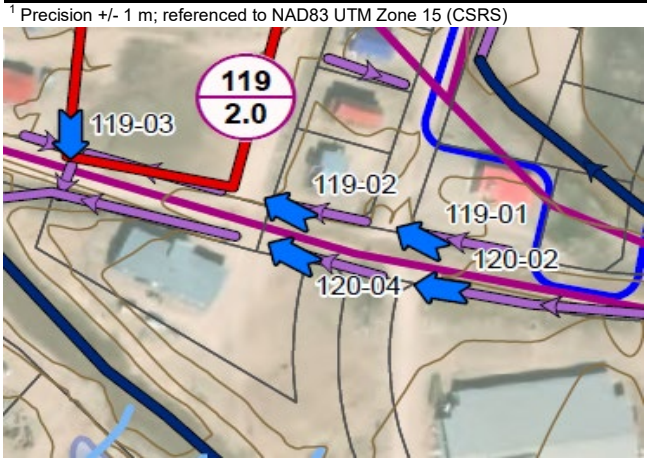
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		119-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	No
Infill Depth (mm)	Upstream	800
	Downstream	50
Other Comments	Can't find upstream end. Either buried or under water. Downstream culvert end blocked by ice	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615340
Easting (m) [1]	383377

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Rplace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

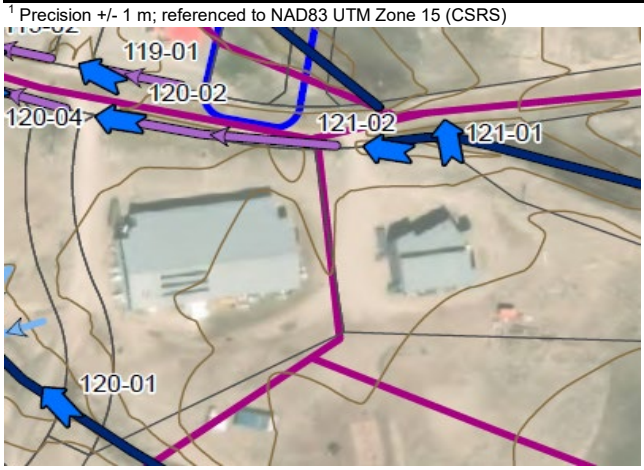
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		120-01
Type		Cross
Shape		Round
Material		PVC/CSP
Diameter or Dimensions (mm)		250/600
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Major ponding upstream. 2 metal under water and blocked by ice. Pvc downstream end is perched.	

Culvert Location	
Street	Unnamed
Northing (m) [1]	7615163
Easting (m) [1]	383483

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Flush CSP Culverts, install PVC culvert at lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

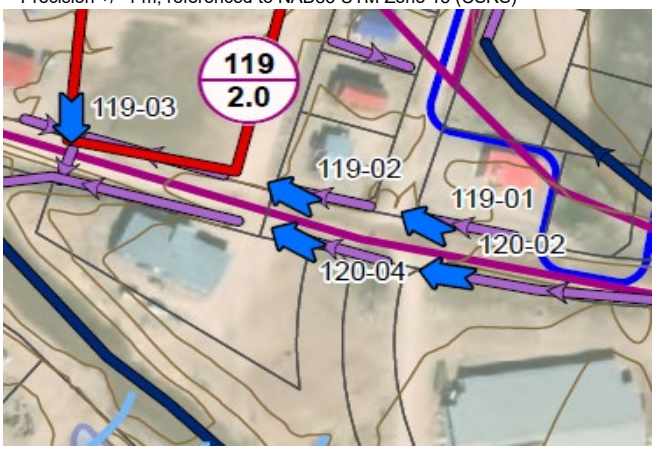
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		120-02
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	100
Other Comments	None	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615283
Easting (m) [1]	383505

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	1	0

Recommended Action(s):	None	Priority:	None

Upstream View

Upstream Culvert End

Downstream View

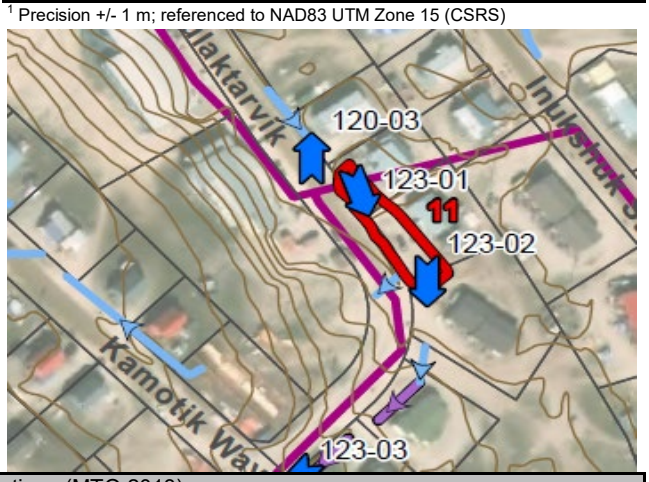
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		120-03
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	Yes
Infill Depth (mm)	Upstream	300
	Downstream	150
Other Comments	Only outlet visible. Inlet is buried. Not too clear where low point is. Resident says ponding occurs	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7615043
Easting (m) [1]	383266

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	0	2

Recommended Action(s):	Replace culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

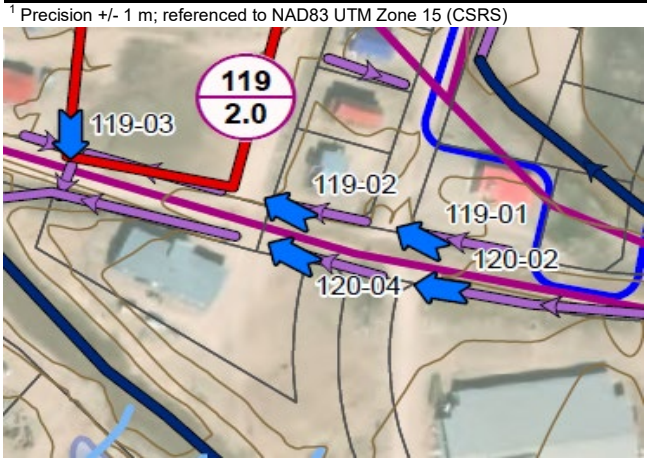
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		120-04
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	50
Other Comments	None	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615298
Easting (m) [1]	383453

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	1	0	1

Recommended Action(s):	Regrade channel	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

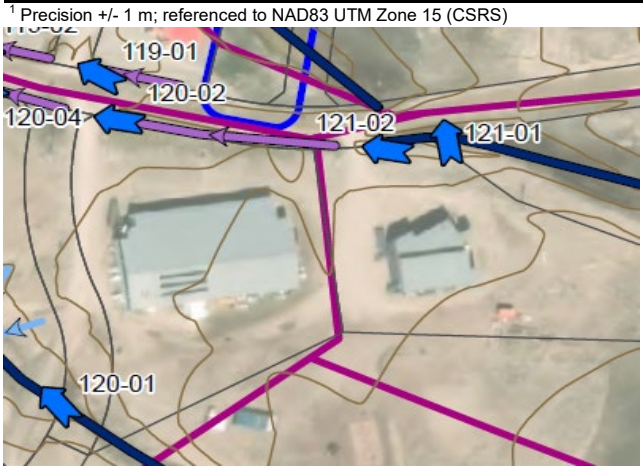
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		121-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Upstream invert high. Not good drainage. Ponding upstream	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615277
Easting (m) [1]	383636

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	0	0	2

Recommended Action(s):	Regrade upstream channel	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

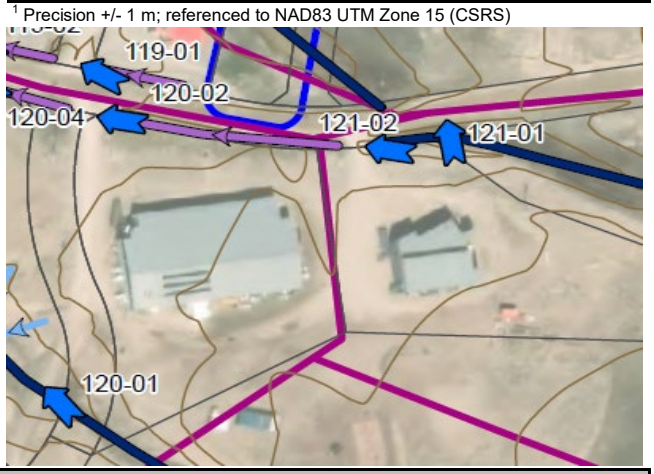
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		121-02
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	200
Other Comments	None	

Culvert Location	
Street	Recreation Drive
Northing (m) [1]	7615270
Easting (m) [1]	383610

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	1	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

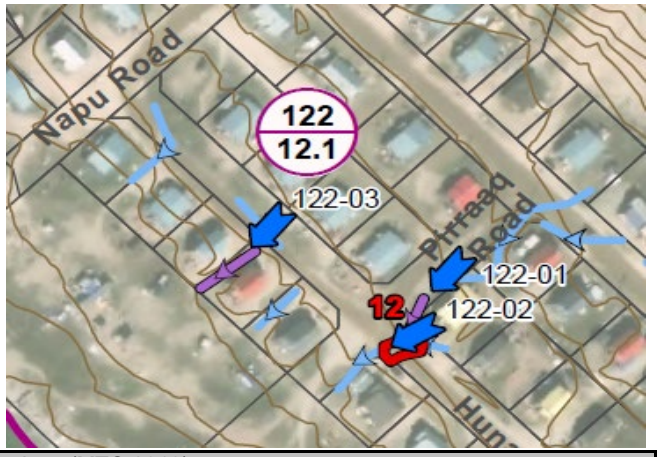
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		122-01
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	300
	Downstream	100
Other Comments	Upstream end crushed	

Culvert Location	
Street	Pirraaq Road
Northing (m) [1]	7614987
Easting (m) [1]	383110

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	2	0	2

Recommended Action(s):	Upstream culvert end crushed, improve upstream conveyance	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

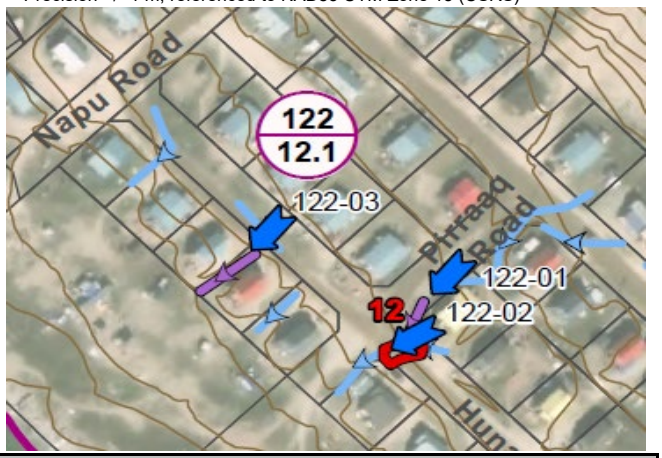
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		122-02
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	100
Other Comments	Inlet obstructed by rock and material. Minor ponding upstream. Undefined ditch upstream	

Culvert Location	
Street	Pirraaq Road
Northing (m) [1]	7614964
Easting (m) [1]	383097

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	2

Recommended Action(s):	Flush culvert, improve upstream conveyance	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

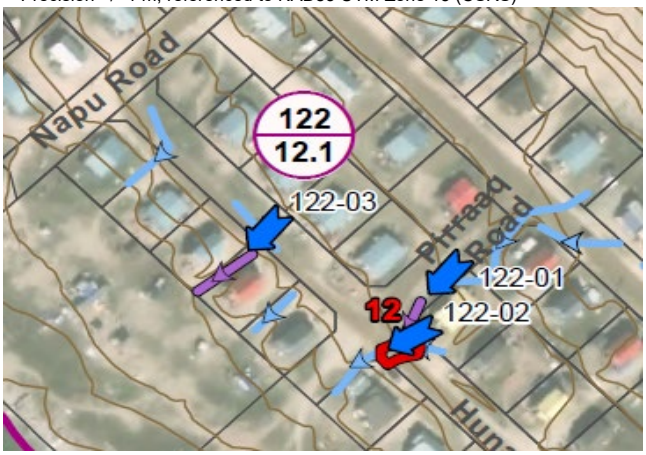
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		122-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		300
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Undefined ditch upstream. Minor ponding	

Culvert Location	
Street	Hinaaq Street
Northing (m) [1]	7615005
Easting (m) [1]	383047

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	0	1

Recommended Action(s):	Flush culvert, improve upstream conveyance	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

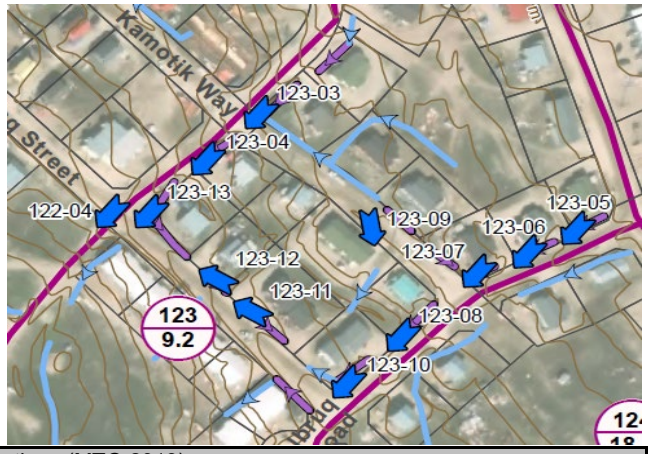
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		122-04
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	0
	Downstream	Yes
Infill Depth (mm)	Upstream	500
	Downstream	200
Other Comments	Upstream end buried	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7614861
Easting (m) [1]	383188

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	3	2	0	1

Recommended Action(s):	Replace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

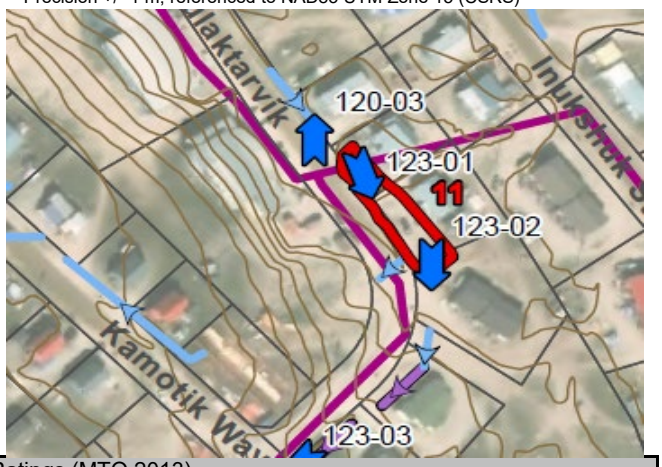
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-01
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Low and high points unknown	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7615023
Easting (m) [1]	383284

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	0	0	0

Recommended Action(s):	Survey to determine culvert orientation	Priority:	Low

Upstream View

Upstream Culvert End

Downstream View

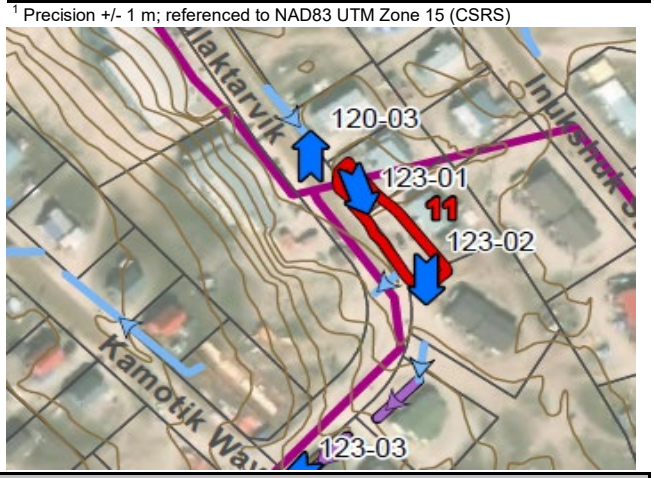
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-02
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	0
	Downstream	50
Other Comments	None	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7614988
Easting (m) [1]	383306

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	1	0	1

Recommended Action(s):	None	Priority:	Medium

Upstream View

Upstream Culvert End

Downstream View

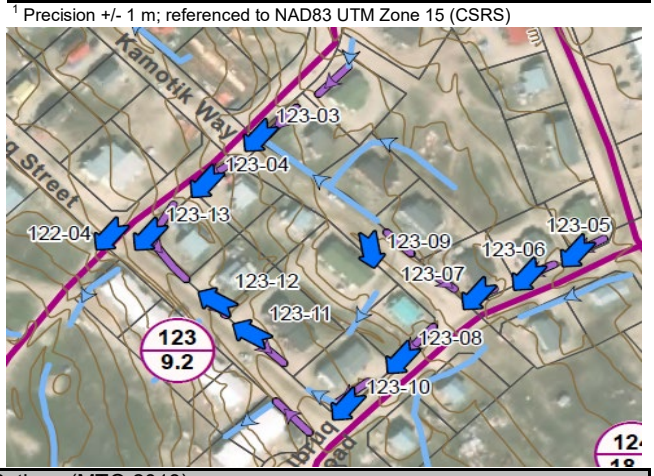
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-03
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	50
Other Comments	Upstream and downstream end crushed	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7614913
Easting (m) [1]	383258

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	1	0	1

Recommended Action(s):	Replace culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

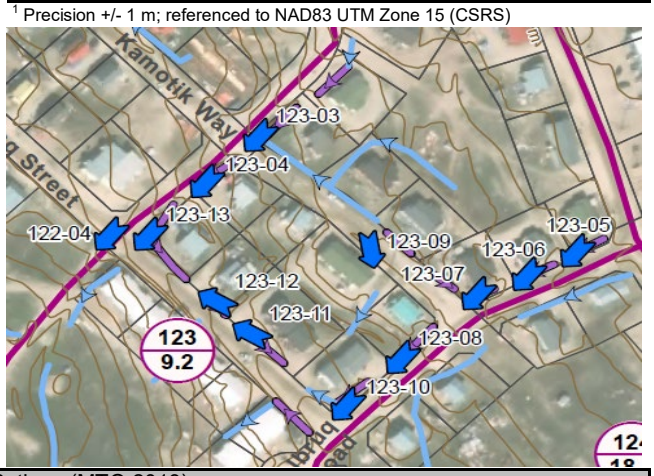
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-04
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Na
	Downstream	Na
Infill Depth (mm)	Upstream	400
	Downstream	400
Other Comments	Both ends buried. Shallow overburden. Flow occurs over the culvert. Ponding upstream	

Culvert Location	
Street	Tulaktarvik Way
Northing (m) [1]	7614889
Easting (m) [1]	383233

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	0

Recommended Action(s):	Replace culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

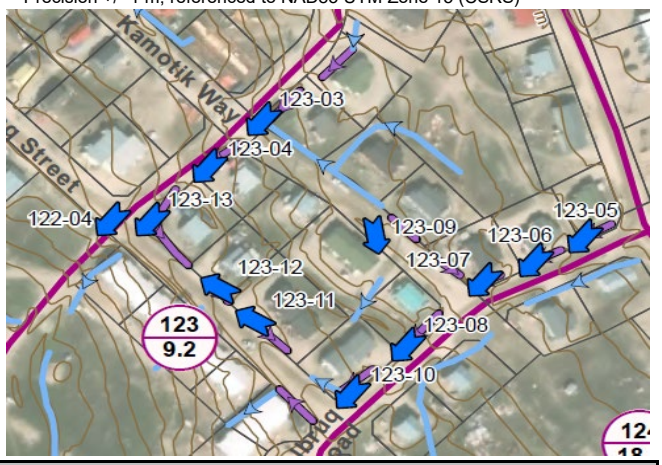
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-05
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	300
	Downstream	150
Other Comments	Upstream end almost buried	

Culvert Location	
Street	Ibruq Road
Northing (m) [1]	7614852
Easting (m) [1]	383409

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	0	2

Recommended Action(s):	Replace culvert at a lower elevation, improve upstream conveyance	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

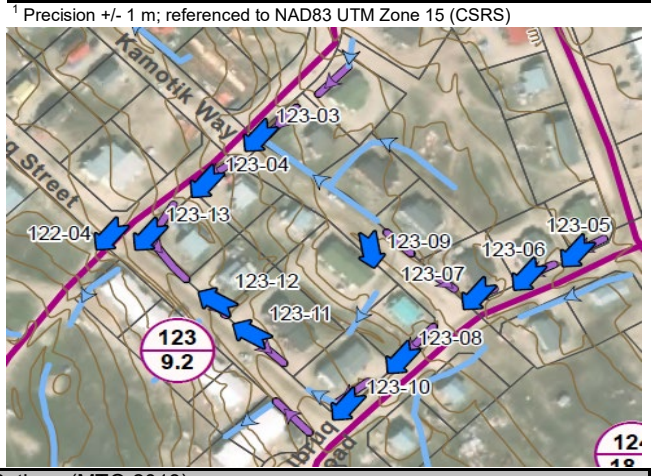
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-06
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	50
Other Comments	Upstream ponding. Ditch not well defined. Upstream invert too high.Debris in culvert	

Culvert Location	
Street	Ibruq Road
Northing (m) [1]	7614839
Easting (m) [1]	383386

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	1	0	2

Recommended Action(s):	Regrade ditch	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

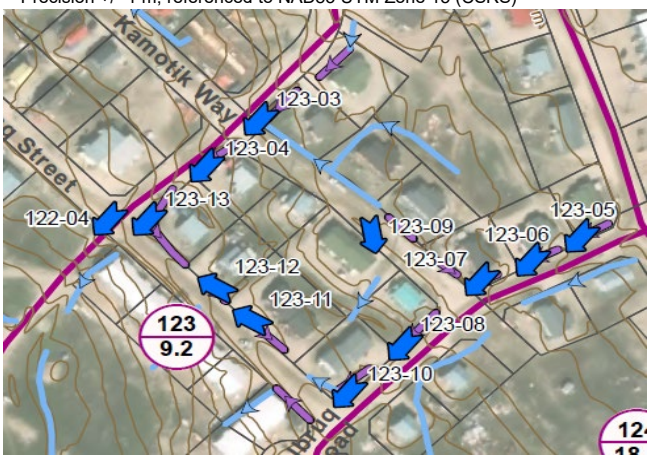
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-07
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	Yes
Infill Depth (mm)	Upstream	50
	Downstream	0
Other Comments	None	

Culvert Location	
Street	Ibruq Road
Northing (m) [1]	7614829
Easting (m) [1]	383362

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	3	1	0	0

Recommended Action(s):	Replace culvert, ends crushed	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

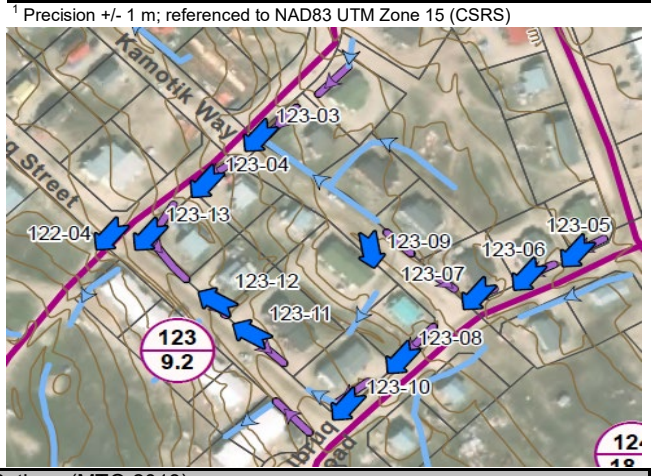
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-08
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		500
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	350
Other Comments	None	

Culvert Location	
Street	Ibruq Road
Northing (m) [1]	7614795
Easting (m) [1]	383326

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	0	0

Recommended Action(s):	None	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

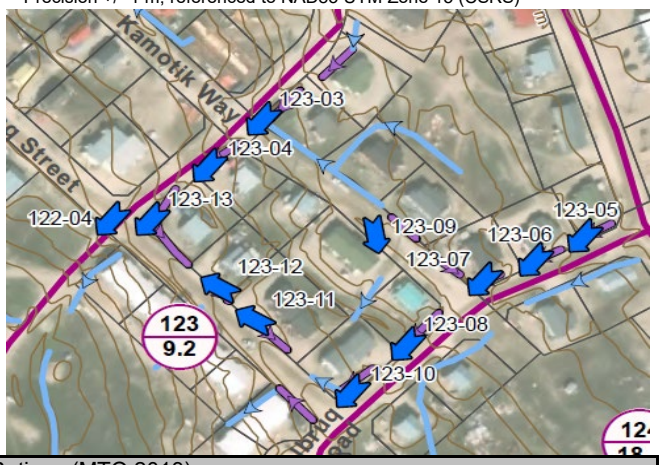
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-09
Type		Entrance
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	150
	Downstream	0
Other Comments	Shallow overburden. No proper ditch to convey flow.	

Culvert Location	
Street	Kamotik Way
Northing (m) [1]	7614852
Easting (m) [1]	383314

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	2

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

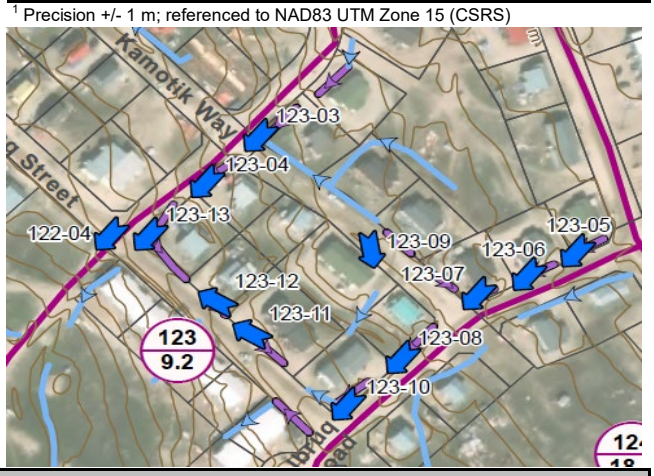
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-10
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		800
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	50
	Downstream	400
Other Comments	Partially blocked by ice downstream. Ponding upstream. Ditch not defined	

Culvert Location	
Street	Ibruq Road
Northing (m) [1]	7614771
Easting (m) [1]	383300

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	1	2	0	0

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

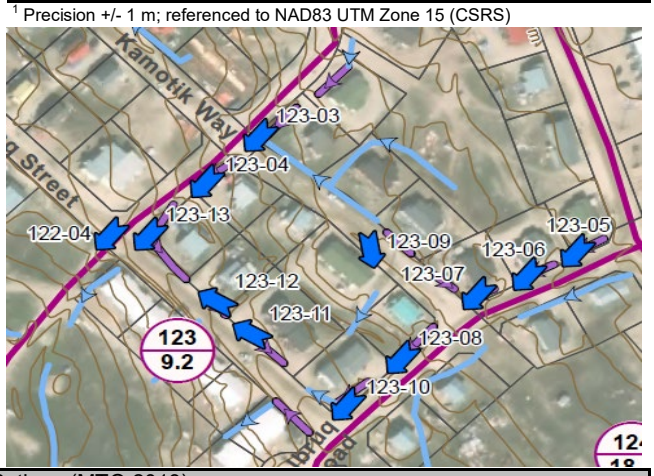
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-11
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Upstream almost buried and very crushed. Cant see inside	

Culvert Location	
Street	Hinaaq Street
Northing (m) [1]	7614813
Easting (m) [1]	383254

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	4	0	0	0

Recommended Action(s):	Repalce culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

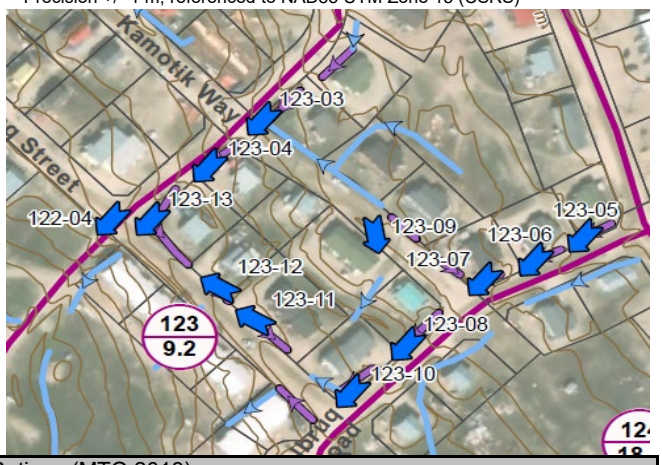
Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-12
Type		Entrance
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		400
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	100
	Downstream	250
Other Comments	Debris in front of upstream end	

Culvert Location	
Street	Hinaaq Street
Northing (m) [1]	7614830
Easting (m) [1]	383237

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	0	0

Recommended Action(s):	Clear rock	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

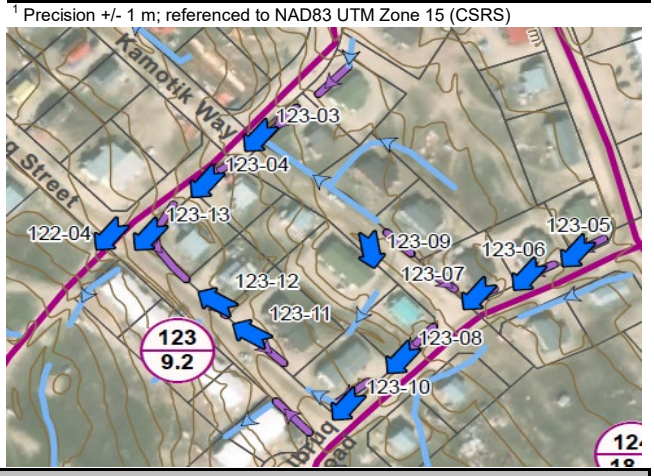
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		123-13
Type		Cross
Shape		Round
Material		CSP
Diameter or Dimensions (mm)		600
Marker Post Present		No
End Crushing	Upstream	Yes
	Downstream	No
Infill Depth (mm)	Upstream	0
	Downstream	0
Other Comments	Upstream invert high. Dont drain efficiently	

Culvert Location	
Street	Hinaaq Street
Northing (m) [1]	7614861
Easting (m) [1]	383206

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	2	2	1	0

Recommended Action(s):	Reinstall culvert at a lower elevation	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

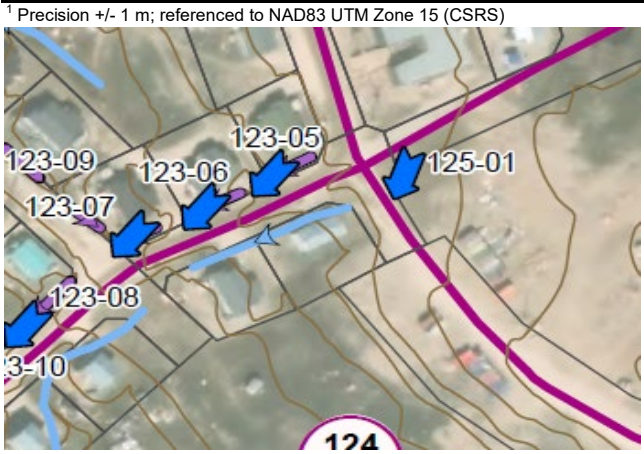
Downstream Culvert End

NOTE: Information presented on this sheet is representative of conditions in ***June 2022****. Current conditions may vary from what is provided on this sheet.*

Culvert Information		
Culvert ID		125-01
Type		Cross
Shape		Round
Material		PVC
Diameter or Dimensions (mm)		250
Marker Post Present		No
End Crushing	Upstream	No
	Downstream	No
Infill Depth (mm)	Upstream	200
	Downstream	0
Other Comments	Culvert inlet almost buried. Ponding upstream. No clear ditch to the culvert	

Culvert Location	
Street	Nuvu Road
Northing (m) [1]	7614852
Easting (m) [1]	383454

[1] Precision +/- 1 m; referenced to NAD83 UTM Zone 15 (CSRS)



Culvert Condition Ratings (MTO 2013)				
Barrel Material (0-4)	Shape (0-4)	Capacity (0-2)	Erosion and Scour (0-2)	US/DS Channel (0-2)
0	0	2	0	1

Recommended Action(s):	Flush culvert	Priority:	High

Upstream View

Upstream Culvert End

Downstream View

Downstream Culvert End

*NOTE: Information presented on this sheet is representative of conditions in **June 2022**. Current conditions may vary from what is provided on this sheet.*

SANDBAG DIKE CONSTRUCTION

***Disclaimer**: This document provides information that may be insufficient in addressing all your concerns about sandbag dike construction. We suggest you contact your local municipal authorities for additional information and guidance.*

SAFETY TIPS FOR LEADERS AND VOLUNTEER WORKERS

- Individuals with a medical condition that would make it dangerous for him/her to participate should avoid taking part.
- Register all persons involved and deliver the registration sheet to the community Emergency Coordinator.
- Wear protective gear such as steel toed boots, hat, safety glasses, gloves, sunscreen, etc.
- Ensure there are sufficient potable water and bathroom facilities. Take regular water breaks.
- Be attentive of large equipment moving in the area.
- Be aware of floodwater dangers:
  - Contamination
  - Varying water flow and strong undercurrents
  - Floating debris
- Adhere to proper sandbag handling technique:
  - Do not bend more than 20 degrees in any direction while handling sandbags.

  - Keep heavy weights below shoulder height, above knees and close to the body. Limit reaching with arms when passing the sandbags.

  - Pivot feet and do not twist through the back while handling sandbags.
  - Do not throw sandbags.

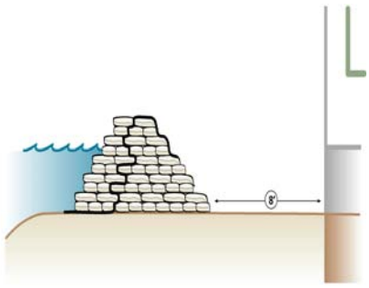
FILLING SANDBAGS

- Fill sandbag to half its capacity (no more than 40 lbs) with sand, clay or silt.
- Fold or tie the flap (tying or sewing is not necessary).
- Do not drag the bags (this could cause lower back injury and bag to weaken).
- When forming a line to pass sandbags, face each other and stand no more than one to two feet apart. If there are not enough people to form a continuous line, use a wheelbarrow to move sandbags.

BUILDING A SANDBAG DIKE

- Location:
  - Base area of dike should be clear of snow and ice.

- To avoid flood water moving under a dike, do not build a dike on porous land or on a septic field.
- The dike should be at least eight feet from building foundation. This prevents foundation damage and allows room for people and equipment to move. As well, this space allows more dike base width to be constructed should additional dike height be required.



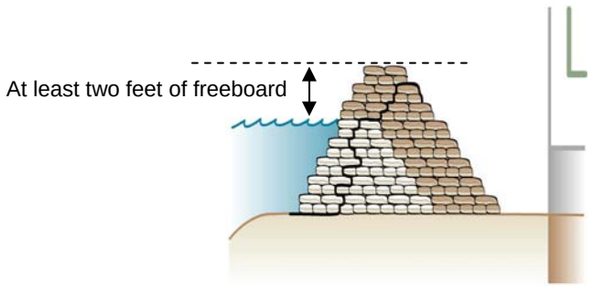
- To create a more secure dike, when possible, create a trench in the soil that is one sandbag deep by two sandbags wide.

- Construction:
  - Dike size:
    - Height: Sandbag dikes require at least two feet of freeboard. Freeboard is the area of the dike between the highest floodwater level and the top of the dike:

predicted floodwater rise above ground level + two feet of freeboard

= required dike height

For example, if floodwater is predicted to rise four feet above ground level, the required dike height is at least six feet. (4’ + 2’ of freeboard = 6’ high dike)

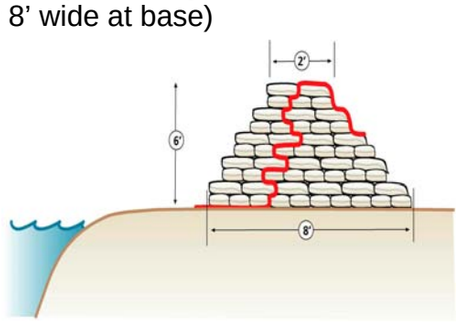


Sandbag dikes will compact when they get wet, which can reduce the available freeboard. The amount of compaction due to wetting increases with the size of the dike. Add at least five per cent to the required height of the dike to account for compaction. For example, add three to four inches for a six foot dike to account for compaction due to wetting.

- Width: The base of a sandbag dike is two feet wider than it’s required height:

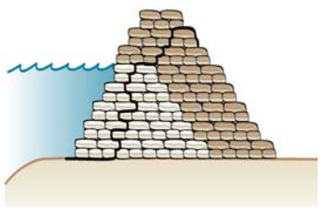
height* + two feet = *width at base

For example, a dike with a required height of six feet would have to be eight feet at its base. (6’ + 2’ = 8’ wide at base)

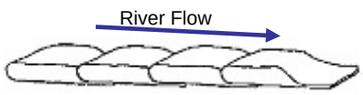


- Sandbag dikes must be at least two feet wide across the top of dike.
- Due to the high pressure water can exert, consult your local authority for additional advice for dikes higher than six feet.

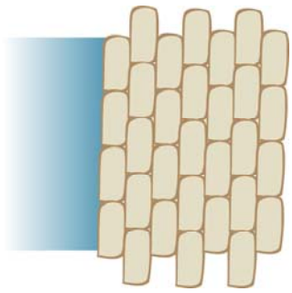
- Polyethylene sheets
  - Proper use and placement of polyethylene sheets is important to reduce the rate of water seeping through the dike. Use six mil polyethylene in three meter wide rolls on the river side of the dike. Have the polyethylene sheet protrude over the ground on the river side of the dike. Be careful not to puncture the polyethylene sheet. (The polyethylene sheet will be weaved between the courses of sandbags.)



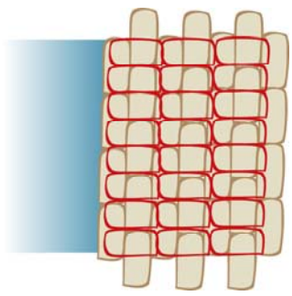
- First course/bottom layer:
  - Lay first course/bottom layer of bags parallel to river/water with the closed side of bag against river flow direction.
  - The filled portion of the second bag sits over the empty portion of the previously placed bag. This is known as lapping.



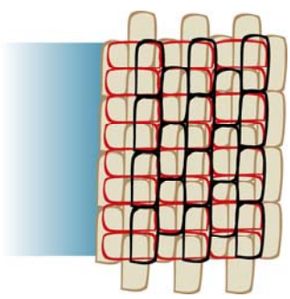
  - Drop the bags into place and tamp bags with feet to lodge them into place.
  - Offset the bags from the previous row in the same course to form a brick pattern.



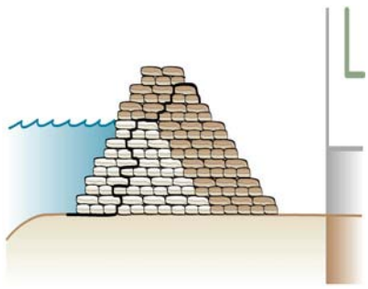
- Second and remaining courses:
  - Rotate bags 90 degrees when laying second course of sandbags. Keep seal side of bag towards water/river. Ensure sandbags are well packed against each other and firmly in place.



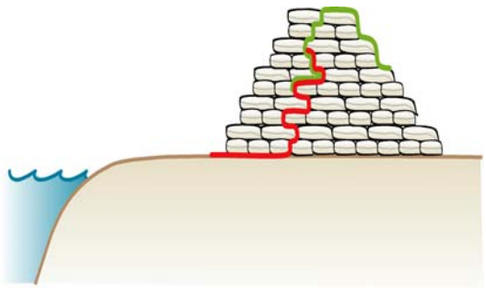
  - Change direction of bag from parallel to perpendicular to the river for each course of bags.
  - Every second course of sandbags should be set back a quarter (1/4) of a sandbag width, both on the river side and the land side of the dike, producing a step-like appearance.



- Weave the polyethylene sheet between the courses of sandbags as to have at least two layers of sandbags protecting the polyethylene sheet from debris punctures. Maximum depth of the polyethylene sheet should be three sandbags or a quarter (1/4) of the cross section of the dike, whichever is less.



- If more height of polyethylene sheet is required, make polyethylene sheets overlap at least two feet.



o No matter how well you build a dike, extreme water pressure may cause water to seep through the dike or bubble up through the ground. It is advisable to have pumps with sufficient fuel and oil readily available to last the duration of the flood event and an escape plan.

SANDBAG DIKE REMOVAL

- Sandbags should be removed with the same precautions as they were laid.
- Sand from sandbags should not be used for children's sand boxes or play areas, but could be used for landscaping purposes.

For further information or questions contact:

YOUR MUNICIPAL OFFICE OR **EMERGENCY MEASURES ORGANIZATION (EMO)**

1525 – 405 Broadway
Winnipeg, Manitoba R3C 3L6
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