GOVERNMENT OF NUNAVUT

Naujaat Wastewater Treatment Facility

Pre-Design Report

June 2022– 21-2233

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Attention: Mr. Ashwani Sharma

Naujaat Wastewater Treatment Facility – Pre-Design Report

Please find attached an electronic copy of the Pre-Design Report for the Naujaat Wastewater Treatment Facility (WWTF), located in the Hamlet of Naujaat, Nunavut. This document is intended as an initial overview of the proposed design options to optimize the layout of the site in addressing the Hamlet needs.

Please contact the undersigned if you have any questions or concerns with regards to this submission.

Sincerely,

DILLON CONSULTING LIMITED

Keith Barnes

Keith Barnes, P. Eng.
Project Manager

CP:bg

Our file: 21-2233

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1.0 Introduction

Dillon Consulting Limited (Dillon) has been retained by the Department of Community and Government Services (CGS), Government of Nunavut (GN) to provide architectural and engineering services for an upgraded Wastewater Treatment Facility (WWTF) in Naujaat, Nunavut.

The intent of the project is to provide the Hamlet of Naujaat with a new seasonal discharge sewage lagoon and wetland treatment area (WTA) that meets or exceeds applicable environmental and regulatory guidelines and regulations, with capacity to the year 2043. This report presents the preliminary design for the lagoon including: design considerations, option development, climate change impacts, conceptual design options, schematic design alternatives, required site investigations and recommendations.

The project has progressed through conceptual, schematic and preliminary design. The project team has selected a site located east of the existing wetland, identified as "Sub-Option 3A" in the memo submitted to the GN on April 13, 2022 titled *Naujaat WWTF – Option 3: 10 Month vs. 12 Month Capacity – R1*, and presented in Appendix D. The lagoon will be constructed with a 4.5 metres (m) liquid depth and a 12 month storage capacity to meet the requirements of the CSA W203:19 design guidelines (*Planning, design, operation, and maintenance of wastewater treatment in northern communities using lagoon and wetland systems*). The location of the proposed footprint is shown in Figure 1 below.

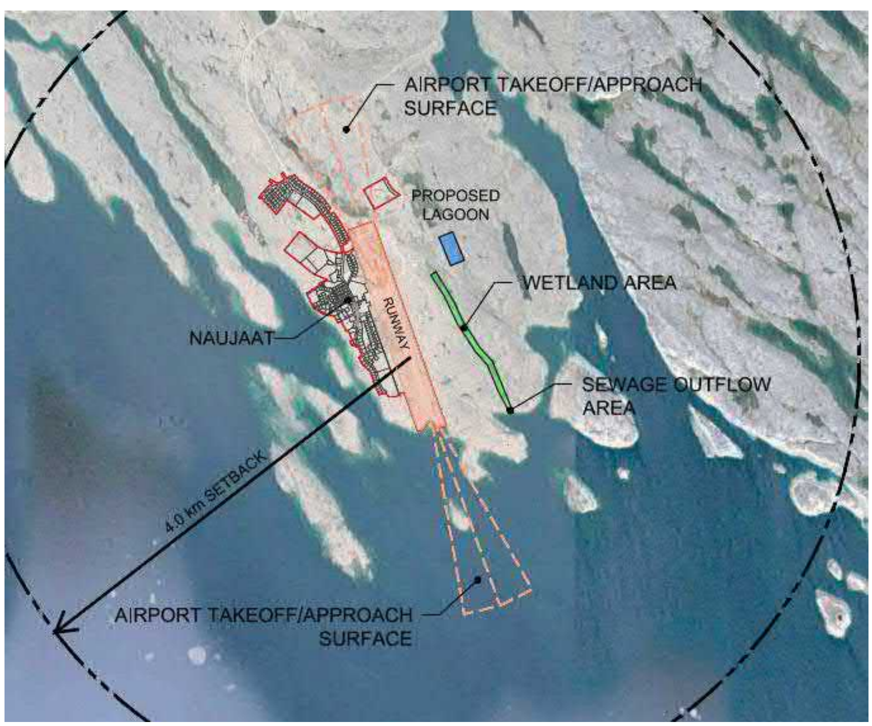

Figure 1: Selected Lagoon Footprint – Sub-Option 3B

1.1 Background

Naujaat is located on the northern shore of Repulse Bay, which is on the south shore of the Rae Isthmus. The local topography is extremely rugged, with very little soil covering ridges of the bedrock. Silty sands and gravel constitute the limited soils present, and the local vegetation consists of mosses, lichens and sedge meadows. The community is within the continuous permafrost zone and permafrost created landforms are visible.

All sewage generated by the community is collected and transported by Hamlet trucks to the sewage disposal facility. Naujaat currently utilizes a sewage disposal facility located 400 m from the northeast edge of the airport runway. The sewage disposal facility is located in a valley, south of the old solid waste disposal site. At this location, sewage trucks offload from a discharge area located on the west side of the valley. Sewage collects in the valley at a natural depression which acts as a primary treatment cell, and flows approximately 1,400 m through a series of wetlands and surface water bodies before entering Hudson Bay. This system does not meet present day best practices for disposal and treatment of wastewater in Nunavut and exposes the municipality to non-compliance with their Hamlet water license.

1.2 Previous Studies

Dillon reviewed the studies completed by the CWRS of Dalhousie University in 2017 titled *Wetland Treatment Area Study in Naujaat, Nunavut*. The purpose of the study was to assess the treatment performance of the existing WTA in Naujaat and to validate the wetland performance model to assess if additional treatment could be achieved in the WTA.

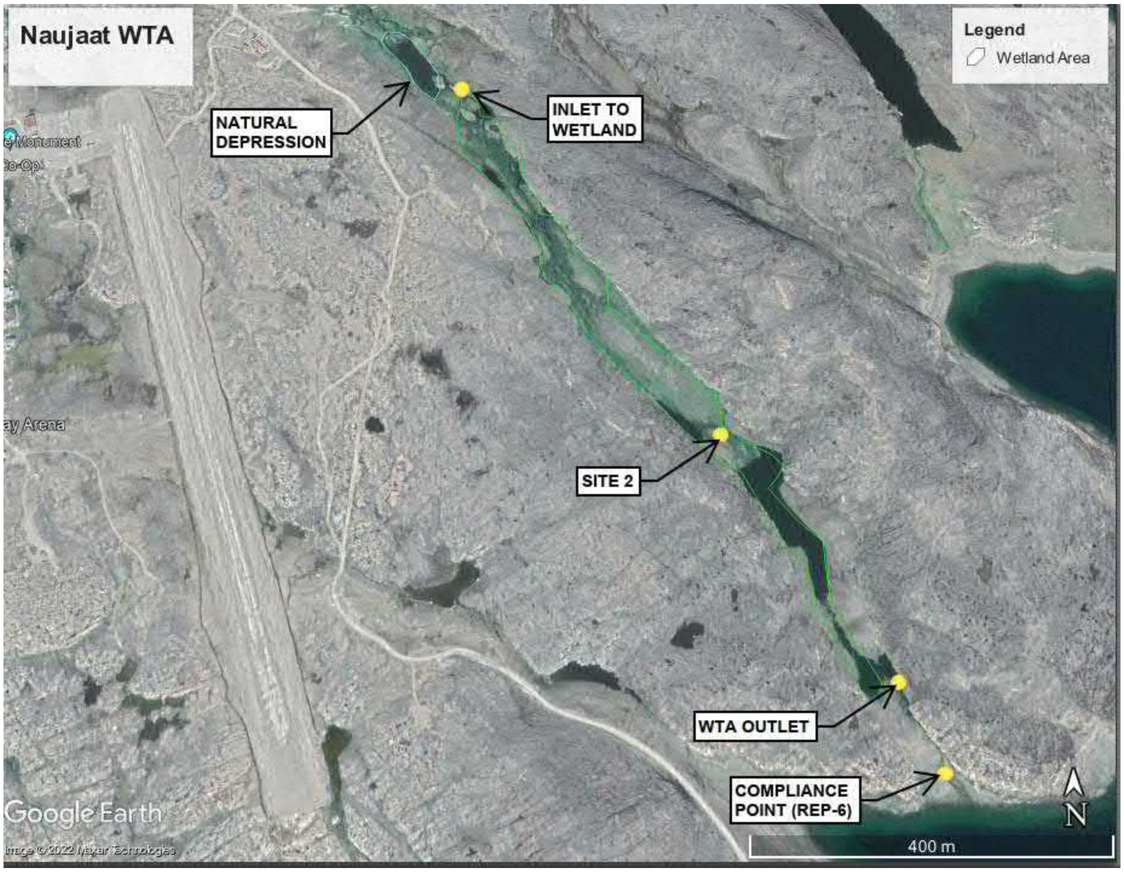

Figure 2: Map of Sampling Locations in WTA at Naujaat Referenced from 2017 CWRS Study

The wetland assessment involved the collection of samples at key locations in the WTA, shown in Figure 2, and analysis for the following parameters: $cBOD_5$, TSS, volatile suspended solids (VSS), *E. coli*, total nitrogen (TN), total ammonia nitrogen (TAN), unionized ammonia nitrogen (NH_3-N) and total phosphorus (TP). Two (2) rounds of treatment performance samples were taken during two (2) trips to Naujaat for a total of four (4) sample events. An average of eight (8) samples were collected for each round of sampling, including samples within the WTA and raw sewage. The inlet to the WTA is described as the discharge from the natural depression, where raw wastewater is collected prior to discharge into the wetland.

Figure 3: Natural Depression Upstream of the WTA

The summary of water quality results from the 2017 CWRS study and the treatment performance of the WTA are presented in Table 1. The CWRS noted that concentration reductions were observed for all parameters as the effluent travelled through the WTA. Significant concentration reductions were also observed when comparing the raw wastewater to the effluent from the natural depression (i.e., inlet to the WTA), indicating that treatment occurs within the natural depression.

The water quality results indicated 70 to 90% reductions in $cBOD_5$ and 80 to 90% reductions in TSS across the natural depression. The CWRS noted that for all sampling events, the wetland effluent met the guidelines outlined in the water license (3BM-REM1520). The regulatory compliance point (REP-6) is located in close proximity downstream of the wetland outlet as shown on Figure 2. Concentrations observed at the regulatory compliance point were generally similar to those observed at the WTA outlet.

Table 1: Summary of Water Quality Results from 2017 CWRS Study

	Raw		Inlet to WTA		Site 2 (intermediary point)		WTA Outlet		Compliance Point (REP-6)	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
$cBOD_5$ (*mg/L*)	411	510	35.6	125	9.2	37	17	24	17.5	20
TSS (*mg/L*)	217	434	44	64	3	26	9	43	15	37.3

	Raw		Inlet to WTA		Site 2 (intermediary point)		WTA Outlet		Compliance Point (REP-6)	
E. Coli *(CFU/ 100 mL)*	1.1E+06	1.7E+07	2.6E+05	1.7E+06	9.3E+01	8.0E+05	9.0E+00	1.0E+05	2.3E+01	1.0E+04
NH_3-N *(mg/L)*	0.91	3.48	0.37	1.16	0.09	0.25	0.08	1.94	3.47	3.47

1.3 Regulatory Issues

EXP Services Incorporated (EXP) completed a wetland assessment in 2012 which concluded that the wetland area would not be able to successfully treat wastewater from the community under future loadings and recommended that a new sewage lagoon be constructed at the front end of the wetland for pre-treatment and retention purposes.

There were additional requirements identified by the Nunavut Water Board (NWB) in the previous water license 3BM-REM1520 dated April 9, 2015. Under this license, the NWB identified conditions to be addressed by the Hamlet of Naujaat which included:

- Establish effluent performance parameters for the facility;
- Effluent parameters to be measured at site REP-6, which is defined as the final discharge point of the sewage system;
- The lagoons should have a freeboard of at least 1 m, or as recommended by a qualified geotechnical engineer and as approved by the NWB in writing, for all dams, dykes or other structure intended to contain, withhold, divert or retain water or wastes; and
- Sewage Disposal Facility is to be maintained and operated, to the satisfaction of an Inspector in such a manner as to prevent structural failure.

EXP also released a report in 2020 titled *Naujaat Sewage Lagoon Upgrade* which was submitted to the NWB in March 2020. The report addressed additional requirements identified by the NWB as part of the previous water license. The report also proposed updated effluent quality objectives specifically for Carbonaceous Biochemical Oxygen Demand ($cBOD_5$) and Total Suspended Solids (TSS) as recommended by the Centre for Water Resources Studies (CWRS) of Dalhousie University in 2017.

At present, it is misleading that the existing WTA appears to be in-compliance with effluent requirements stated in the current water license:

- Over-winter wastewater discharge to the WTA is frozen in place until the spring freshet conveys it to the marine water body; and

- Due to lack of controlled discharge in the summer months, wastewater is conveyed to the marine body alongside runoff from the spring melt. This results in dilution of samples, as it is discussed in the 2017 CWRS study.

With the proposed lagoon and WTA, 12 months of wastewater will be stored until being discharged during the August/September months. This results in treatment processes that occur in the lagoon and WTA, due to the misleading nature of the existing sampling regime, may result in effluent that appears to degrade in quality at the compliance point. An increase in the effluent parameter limits at the compliance point is needed due to this change in operation as presented in Table 2, we understand this is currently being discussed between the GN and the NWB.

Research was completed by Dalhousie University in 2017 at the Naujaat sewage disposal site and recommendations were made to increase the effluent limits. Based on the results of the research, the GN is currently in discussions with Environment and Climate Change Canada (ECCC) regarding the implementation of technology-based effluent limits. As such, the GN will be requesting an amendment to the Naujaat Municipal Water License (3BM-NAU2126) that is in line with these technology based effluent parameters. The GN intends to increase effluent quality limits at the compliance point for a lagoon/wetland system discharging into a well flushed environment, such as the case in Naujaat. The existing and proposed parameters for a lagoon/wetland passive treatment system are shown in Table 2.

Table 2: Existing and Proposed License Effluent Limits at Compliance Point

Parameter	Existing Limit	Proposed Limit
pH	Between 6 and 9	No change
$cBOD_5$	80 mg/L	100 mg/L
TSS	70 mg/L	120 mg/L
Fecal Coliforms	1 x 10^6 CFU/100 mL	No change
Oil and Grease	No visible sheen	No change
NH_3	-	1.25 mg/L

EXP's report was submitted to the NWB in September 2020 and a new water license was issued on January 27, 2021, 3BM-NAU2116 with an understanding that a new upstream lagoon would be constructed to address non-compliance issues with wastewater treatment. Note that based on the revised lagoon location, a water license amendment will be required to approve the proposed development.

2.0 Design Considerations

The lagoon will be designed to meet the long term needs of Naujaat, as well as the regulatory requirements of the NWB water license. Design standards will be based on *Planning, design, operation, and maintenance of wastewater treatment in northern communities using lagoon and wetland systems* (CSA W203:19). As per direction by the GN, the lagoon will be designed for a 20 year design horizon, to the year 2043.

The lagoon will be designed with 12 months of storage as is specified in the CSA W203:19 design standard. The design intent was discussed and agreed upon with the GN during the meeting on April 22, 2022. This will allow spring freshet to recharge the wetland before the lagoon is discharged in August and September. The WTA is over 1 kilometre (km) in length and will provide further storage downstream of the lagoon.

2.1 Treatment Method

The treatment facility will be designed with a new upstream primary lagoon cell, existing downstream natural depression acting as a secondary treatment cell and existing downstream wetland. The primary cell will be designed as an anaerobic lagoon with an operating depth of 4.5 m, and will serve primarily to reduce suspended solids entering downstream environments. Design guidelines (CSA W203:19) classify a lagoon with a depth of 2 to 5 m as an anaerobic lagoon with a negligible amount of oxygen in the water column. Biological activity would be primarily limited to the sludge layer and in the upper zone of the water column during the summer where oxygen may be present.

2.1 Lagoon Cell and Berm Design

The following design criteria is assumed to be followed for the primary cell and berm design. This criteria will be revisited and confirmed once the geotechnical and granular studies are completed.

- Berms to be constructed with suitable granular material available locally;
- Berms must have, at maximum, an interior side slope of 3H:1V;
- Berms must have, at maximum, an exterior side slope of 3H:1V;
- Berms must have an impermeable liner keyed into a depth suitable to ensure no seepage;
- Berm shall allow for maintenance vehicle access on top of the berms (i.e., heavy duty pickup or similar); and
- 1 m of freeboard.

2.2 Capacity Analysis

2.2.1 Population Projections and Wastewater Generation Rates

The historical population of Naujaat was referenced from 2021 Census Canada data. The average annual growth rate between the 2016 and 2021 censuses was 2.6%. The GN made the recommendation to proceed with the population growth rate of 2.6% during the project meeting on May 11, 2022. The population from 2021 was extrapolated to 2043 using the average population increase of 2.6% per year.

The sewage generation rate was calculated using standard design equations from CSA W203:19. The assumed residential water use (RWU) for a trucked water and sewage system is 90 litres per person per day (L/person/day). An allowance is made for non-residential water uses such as commercial, institutional and industrial demands. The total water use (TWU) per capita was estimated using the following equation:

$$TWU = RWU\ x\ [1.0 + (0.00023\ x\ population)]$$

The estimated annual wastewater generation to the year 2043 is presented in Table 3.

Table 3: Estimated Population and Wastewater Generation Rates 2023 to 2043

Year	Population	Total Water Use Per Capita (L/c/day)	Daily Wastewater Volume (L/d)	Annual Wastewater Generation (m^3)
2023	1,291	116.7	150,635	54,982
2028	1,470	120.4	177,098	64,641
2033	1,675	124.7	208,879	76,241
2038	1,909	129.5	247,207	90,231
2043	2,175	133.4	290,094	105,884

Dillon reviewed the historic per capita water usage for Naujaat between 2017 and 2021 and compared it to the estimated per capita wastewater generation over that same time period (where wastewater generation records were unavailable). The estimated per capita wastewater generation rates were noted to be within 10 to 15% of the historical per capita water usage volumes for the community. The values are presented in Table 4 below.

Table 4: Historic Per Capita Water Usage vs. Estimated Per Capita Wastewater Generation

Year	Historic Per Capita Water Usage (L/c/d)	Estimated Per Capita Wastewater Generation (L/c/d)
2017	97.3	113.0
2018	105.8	113.6
2019	96.9	114.2

Year	Historic Per Capita Water Usage (L/c/d)	Estimated Per Capita Wastewater Generation (L/c/d)
2020	101.3	114.9
2021	104.4	115.4

2.2.2 Sludge Accumulation

The lagoon will be sized to accommodate sludge accumulation for the 20 year design life of the treatment system. It is assumed that sludge will not be dredged from the lagoon during this period, as capacity will include sludge buildup till 2043. As referenced from CSA W203:19, a generation rate of 0.35 L/person/day will be considered to estimate sludge accumulation volumes. The annual sludge accumulation volumes is shown in Table 5. The approximate depth of sludge in 2043 is estimated at 194 millimetres (mm).

Table 5: Estimated Annual Sludge Accumulation to 2043

Year	Daily Sludge Generated (L/day)	Annual Sludge Generated (m^3)	Total Sludge Accumulation (m^3)	Approximate Avg. Sludge Depth (mm)
2023	452	165	165	7
2028	515	188	1,057	45
2033	586	214	2,073	89
2038	668	244	3,231	138
2043	761	278	4,551	194

2.2.3 Annual Precipitation and Evaporation

The lagoon will be sized to accommodate storage of precipitation for the 12 month storage period. Consideration for climate change has been included as part of the precipitation data analysis. Evaporation is not currently included as part of the lagoon sizing as it is expected to be minimal.

Historical precipitation data was referenced from Repulse Bay Airport from 1981 to 2010 to estimate an average annual precipitation volume in the area of the lagoon. Climate information for the Naujaat (formerly Repulse Bay) area was obtained from ECCC climate archives for the last climate normals period of 1981 to 2010. Dillon completed a climate change analysis of projected precipitation data between 2020 and 2050, as discussed in further detail in Section 4.2. A projected increase in precipitation volume of 13.5% was estimated to occur over 30 years between 2020 and 2050, and accounted for in the overall precipitation volume. The Naujaat (Repulse Bay) climate station has significant amounts of missing data records, and these years with significant amounts of missing data needed to be removed from the 30 year period given that their inclusion would introduce biases and errors into the long-term average. Only those years with sufficient temperature and precipitation data are included.

- Average annual precipitation (1981 to 2010) 331.2 mm;
- Annual precipitation with 13.5% allowance for climate change 358.47 mm;

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- Lagoon surface area at water level 30,780 m^2; and
- Annual precipitation volume captured by lagoon 11,034 m^3.

2.2.4 Runoff Estimate

The primary cell will be located in the upper valley of the existing wastewater treatment area, with the east slope of the valley sloping towards the proposed lagoon footprint. The WWTF design will incorporate a cut-off berm on the east valley to direct surface runoff away from the lagoon surface and maximize lagoon storage volume.

2.2.5 Lagoon Working Volume

The lagoon system will be sized to accommodate storage of wastewater, sludge accumulation and precipitation for a 12 month storage period.

- Annual wastewater generation to 2043 105,884 m^3;
- Annual sludge accumulation to 2043 4,551 m^3;
- Annual precipitation volume (snow and rain) captured by lagoon 11,034 m^3; and
- Lagoon design working volume 121,469 m^3.

2.3 Influent Loading Characteristics

The characteristics of sewage in a community are dependent on the type of collection system. The type of wastewater conveyance (piped, trucked or combination) and water usage in a municipality is considered when estimating influent wastewater quality. As referenced from CSA W203:19, the following influent loading criteria shown in Table 6 will be assumed for Naujaat based on a trucked wastewater system.

Table 6: Typical Raw Wastewater Quality for Trucked Wastewater System

Parameter	Typical Raw Wastewater Quality	Units	Source
$cBOD_5$	450	mg/L	CSA W203:19
TSS	400	mg/L	CSA W203:19
TAN	100	mg/L	CSA W203:19
TP	15	mg/L	CSA W203:19
E. coli	1×10^8	CFU/100 mL	CSA W203:19
TN	149	mg/L	CWRS Raw Sample Data
NH_3-N	3.48	mg/L	CWRS Raw Sample Data

2.4 Effluent Requirements Review

The GN's position, based on the research completed by the CWRS and ongoing discussions with NWB regarding wastewater regulations in the north, is that effluent quality limits for a lagoon/wetland discharging into a "well flushed" receiving environment should be a $cBOD_5$ of 100 mg/L and TSS of 120 mg/L. While the GN is pursuing updates to the water license to increase the Hamlet's $cBOD_5$ and TSS limits, Dillon has assumed that the current, more stringent effluent parameters will need to be met. The lagoon and WTA will be designed to achieve effluent quality that meets these limits.

As stated in the current license, all effluent discharged from the WWTF at Monitoring Program Station REP-6 (located at the final discharge from wetland area into Hudson Bay) shall not exceed the effluent quality standards shown in Table 7 below.

Table 7: Effluent Quality for Trucked Wastewater System

Parameter	Effluent Quality	Units
$cBOD_5$	80	mg/L
TSS	70	mg/L
NH_3-N	1.25	mg/L
pH	Between 6 and 9	-
Oil and Grease	No visible sheen	-
E. coli	1×10^6	CFU/100 mL

2.5 Lagoon System Kinetics

The overall level of treatment achieved by a lagoon system can be predicted using the following kinetic formula referenced from the *Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment and Disposal* (Atlantic Canada, 2006):

$$\frac{L_e}{L_i} = \frac{1}{1 + K_t T}$$

Where:

- L_e = Concentration of substrate ($cBOD_5$) in lagoon effluent (mg/L);
- L_i = Concentration of substrate ($cBOD_5$) in lagoon influent (mg/L);
- T = Residence time of sewage in lagoon (days); and
- K_t = kinetic rate constant for ($days^{-1}$) at temperature "t".

The kinetic rate constant, K_t varies according to temperature:

$$K_t = K_{20}\theta^{t-\theta}$$

Where:

- K_t = $CBOD_5$ kinetic rate constant ($days^{-1}$) at temperature "t";
- K_{20} = $CBOD_5$ kinetic rate constant ($days^{-1}$) at 20°C;
- θ = temperature coefficient; and
- t = temperature of lagoon contents during treatment season (^{0}C).

2.5.1 Primary Cell

Typical temperature coefficients (θ) as referenced from *Wastewater Engineering Fifth Edition* (Metcalf and Eddy, 2004) are generally 1.02 to 1.10. A typical value for θ of 1.035 was used in the preliminary sizing calculations based on Atlantic Canada Wastewater Guidelines (Atlantic Canada, 2006). Although typical values for K_{20} range from 0.04 to 0.06 $days^{-1}$ for anaerobic lagoon cells, a significantly lower value for K_{20} (6.7×10^{-3} $days^{-1}$) was assumed in this case, to be conservative and to coincide with referenced K_t values in CSA W203:19. This document presents K_t values which were measured at two (2) other Nunavut lagoon sites including Pond Inlet and Clyde River, where Clyde River is located closer to Naujaat.

It was noted that K_t values were an order of magnitude lower than those that would be used in standard design approaches for non-arctic systems. Accordingly, a conservative K_t was selected based on the lowest kinetic rate constant measured in Cell 1 at Clyde River, 4.3×10^{-3} $days^{-1}$ at an average temperature during the open water season of 7.2°C. The K_{20} for the Naujaat primary cell was adjusted at 7°C until a K_t value of 4.3×10^{-3} $days^{-1}$ was achieved (i.e., 6.7×10^{-3} $days^{-1}$).

The CSA W203:19 document states that K_t values were also computed at the Kugaaruk lagoon, which has a deep lagoon cell (greater than 4 m), similar to the proposed Naujaat lagoon design. This case study noted that there was a significant reduction of $cBOD_5$ between raw sewage and lagoon effluent, ranging from 57 to 62%, with a 5.4 m deep lagoon cell. It was also observed that there was no measureable decrease in $cBOD_5$ concentration between lagoon effluent at the beginning of the summer treatment season and at the end of the treatment season. The Kugaaruk lagoon demonstrated the benefits of a deeper lagoon cell, with respect to sequestration of contaminants in the sludge as it had the best water quality at the beginning of the summer when compared to Pond Inlet and Clyde River. This suggests that the majority of $cBOD_5$ removal occurred by settling rather than biological treatment, consistent with southern Canada septage receiving systems.

The Organic Loading Rate (OLR) and kinetic design parameters of the primary cell are summarized in Table 8 below. The OLR describes the daily loading rate of organic material per hectare (Ha) of lagoon surface area. While the CSA W203:19 guidelines classifies a "facultative lagoon cell" as having an operating water depth of 1 to 2 m, and an OLR of less than 22 kg cBOD/ha/d, the proposed primary cell will act as an anaerobic cell. Thus with a water depth of 4.5 m, the Naujaat primary cell will not be designed with an OLR less than 22 cBOD/ha/d. It is anticipated that the majority of treatment will occur in the downstream natural depression and wetland. Decant from the primary cell will also have a long path to travel down the wall of the valley where it will experience aeration prior to entering the downstream treatment system.

Table 8: Kinetic Design Parameters

Design Parameter	Value	Notes
ϴ	1.035	Atlantic Canada (2006), Metcalf & Eddy (2013))
K7	4.3 x 10^{-3} $days^{-1}$	CSA W203:19 (Clyde River Cell 1)
K20	6.7 x 10^{-3} $days^{-1}$	Calculated based on K_7 from CSA W203:19
OLR	37.8 kg $cBOD_5$/ha/d	

Although the lagoon cells will hold sewage for 12 months' time, the effective treatment time used in these calculations only accounts for the length of time sewage is estimated to be completely thawed for treatment during the summer months. Since freeze-up can vary and occur anytime from October to December, a range of 60 to 100 days of treatment was analyzed, as winter treatment is assumed to be negligible. The estimated effluent quality from the constructed primary lagoon cell was calculated for a variety of conservative temperatures and retention times and is presented in Table 9.

Table 9: Estimated Effluent $cBOD_5$ (L_e) from Primary Cell using Lagoon Kinetics

T (days)	K_{20} ($days^{-1}$)	ϴ	t (°C)	K_t[1] ($days^{-1}$)	L_i (mg/L)	L_e (mg/L)
100	6.7E-03	1.035	3	3.7E-03	450	328
100	6.7E-03	1.035	4	3.9E-03	450	325
100	6.7E-03	1.035	5	4.0E-03	450	321
100	6.7E-03	1.035	6	4.1E-03	450	318
100	6.7E-03	1.035	7	4.3E-03	450	315
80	6.7E-03	1.035	3	3.7E-03	450	347
80	6.7E-03	1.035	4	3.9E-03	450	344
80	6.7E-03	1.035	5	4.0E-03	450	341
80	6.7E-03	1.035	6	4.1E-03	450	338
80	6.7E-03	1.035	7	4.3E-03	450	335
60	6.7E-03	1.035	3	3.7E-03	450	368
60	6.7E-03	1.035	4	3.9E-03	450	365
60	6.7E-03	1.035	5	4.0E-03	450	363
60	6.7E-03	1.035	6	4.1E-03	450	360
60	6.7E-03	1.035	7	4.3E-03	450	358

Notes:

[1] K_{20} value was adjusted until a K_t value of 4.3 x 10^{-3} was achieved at 7 °C.

The lagoon will perform under primarily anaerobic conditions at an operating depth of 4.5 m. The primary cell will act as an upstream treatment cell, with minimal biological removal. It's expected that

$cBOD_5$ and TSS will be removed in the primary lagoon cell by settling, while the downstream natural depression (secondary treatment) and WTA will be designed to remove remaining $cBOD_5$, TSS, pathogens, nitrogen compounds, phosphorus, grease and oil to acceptable limits before the treated effluent enters the ocean.

2.5.2 Natural Depression (Secondary Treatment)

As described in Section 1.2, the CWRS completed water sampling to compare water quality of raw sewage and water quality downstream of the natural depression (CWRS, 2017). The study concluded that treatment occurred across the natural depression, where water samples showed 70 to 90% reductions in $cBOD_5$ and 80 to 90% reductions in TSS. It is believed that the natural depression is less than 2.5 m in depth and assumed to act as a facultative lagoon cell for the purposes of design.

The treatment capability of the natural depression was modelled as a shallow lagoon and estimated using first order kinetics, where a typical value for θ of 1.035 was used and a K_{20} value of 0.14 $days^{-1}$, as is typical for facultative lagoon cells. The K_{20} value of 0.14 $days^{-1}$ was validated as a reasonable value assuming a retention time of 30 days, based on the documented removal of $cBOD_5$ at the natural depression, measured during the 2017 CWRS study.

There is no data for the retention time of the depression, but it is assumed that the natural depression has a retention time of 30 days or less, therefore a sensitivity analysis was performed, shown in Table 10, ranging from 10 to 30 days. The influent $cBOD_5$ (L_i) was taken as the highest effluent $cBOD_5$ loading (368 mg/L) discharged from the primary cell.

Table 10: Prediction of Effluent $CBOD_5$ from Natural Depression using Lagoon Kinetics

T (days)	K_{20} ($days^{-1}$)	θ	t (°C)	K_t ($days^{-1}$)	L_i (mg/L)	L_e (mg/L)
30	0.14	1.035	3	7.8E-02	368	110
30	0.14	1.035	4	8.1E-02	368	107
30	0.14	1.035	5	8.4E-02	368	105
30	0.14	1.035	6	8.6E-02	368	102
30	0.14	1.035	7	9.0E-02	368	100
20	0.14	1.035	3	7.8E-02	368	144
20	0.14	1.035	4	8.1E-02	368	141
20	0.14	1.035	5	8.4E-02	368	138
20	0.14	1.035	6	8.6E-02	368	135
20	0.14	1.035	7	9.0E-02	368	132
10	0.14	1.035	3	7.8E-02	368	207
10	0.14	1.035	4	8.1E-02	368	203
10	0.14	1.035	5	8.4E-02	368	200
10	0.14	1.035	6	8.6E-02	368	197
10	0.14	1.035	7	9.0E-02	368	194

Based on the range of effluent quality from the natural depression, the WTA will be designed to handle a variety of $cBOD_5$ concentrations ranging from 100 to 200 mg/L. The estimated concentrations of TSS, TAN, NH_3-N, TP, TN and fecal coliforms summarized in Table 11 below are the expected effluent quality expected from the primary cell entering the natural depression, and the natural depression entering the WTA.

Table 11: Estimated Design Effluent Quality at Inlet to WTA

Parameter	Units	Primary Cell Effluent	Natural Depression Effluent	Reference
$cBOD_5$	mg/L	368	200	Kinetic Calculations
TSS	mg/L	25-50	< 30	CSA W203.19, Table D.1, D.2
TAN	mg/L	100	100	CSA W203.19, Table D.1
NH_3-N	mg/L	3.48	3.48	CWRS, 2017
TP	mg/L	10.5-12	10.5-12	CSA W203.19, Table D.1
TN	mg/L	149	149	CWRS, 2017
Fecal Coliforms	CFU/100 mL	$1.0x10^5 – 1.0x10^6$	$1.0x10^5 – 1.0x10^6$	CSA W203.19, Table D.1

CSA W203:19 Table D.1 states that a deep lagoon (> 2.5 m in depth) will typically show 0% removal of TAN. For conservative purposes, it is assumed that 0% removal of TAN, NH_3-N and TN will occur within the primary cell and natural depression, and that treatment of nitrogen compounds will occur in the WTA. Results from the 2017 CWRS study showed that removal of nitrogen compounds did occur across natural depression, although it isn't clear if this is due to biological treatment or dilution.

2.6 Wetlands Assessment

In consideration of the data available in Dalhousie University's *Wetland Treatment Area Study in Naujaat, Nunavut* (CWRS, 2017), an additional wetland field assessment was not recommended to be completed by Dillon as part of this study. The existing wetland treatment area was identified as the preferred location because:

- Extensive research had previously been conducted throughout the wetland;
- Vegetation throughout the wetland was established;
- Overburden was noted to be shallow with bedrock outcrops, suggesting that subsurface flow would not significantly impact freshwater fish habitat or drinking water sources; and
- Relocation considerations, such as additional siting exercises, geotechnical investigations, public consultation and the introduction of contaminants to a new location, and reclamation of the current treatment area would not be required as part of the design process.

The modified TIS model outlined in the Dalhousie University study was used to gain a better understanding of the treatment performance of the WTA following primary and secondary treatment through the lagoon system, described in Section 2.5, and to help provide recommendations on potential wetland modifications that may be used to improve treatment. The modified TIS model was validated by Hayward and Jamieson (2015) for performance modeling of surface and subsurface flow wetlands in the North (CSA W203.19).

While Dillon recognizes that due to the nature of treatment, no model can accurately predict the continuing performance of a wetland. Each wetland is as different and unique as its environment and the biological culture that it supports; this assessment is intended to provide valuable information regarding the potential for contaminant fate and transport throughout the WTA according to pre-design conditions.

2.6.1 Modified Tanks-In-Series Model

The modified TIS model is based on a conventional TIS chemical reactor model, and uses a series of completely mixed tanks with equivalent retention times to hydraulically represent the study wetland. The model utilizes a general mass balance, rearranged by Hayward and Jamieson (2015), to solve for the contaminant concentrations leaving each wetland cell. External hydrologic contributions from the surrounding watershed are cumulatively added along the length of the wetland.

$$C_{out} = \frac{\left(\frac{Q_{in}}{Q_{out}}\right) C_{in} + \left(\frac{\frac{Q_{ws}}{N}}{Q_{out}}\right) C^* + \frac{k\tau C^*}{Nd}}{1 + \frac{\tau}{Nd}(I + \alpha ET + k)}$$

Where:

- C_{in} = Concentration into tank 'N' (CFU/100 mL);
- C^* = Background concentration (CFU/100 mL);
- Q_{out} = Flow out of tank 'N' (m^3/d);
- Q_{in} = Flow into tank 'N' (m^3/d);
- Q_{ws} = External hydrologic contribution into the wetland segment (m^3/d);
- N = Number of tanks;
- k = First order areal rate constant (m/d);
- d_w = Water depth (m);
- I = Infiltration (m);
- ET = Evapotranspiration (m); and
- α = Transpiration Fraction.

To represent the WTA, a model consisting of four (4) wetland cells, each with a series of three (3) completely mixed tanks, was developed. The modelled wetland cells correspond with the treatment areas between sampling locations (sites) outlined in the Dalhousie University study; the model s and sampling sites are shown in Figure 4 below. The model representing the WTA (36,486 m^2) consists of the following cells:

- Inlet to Site 3: 12,690 m^2;
- Site 3 to Site 2: 12,078 m^2;
- Site 2 to Site 1: 9,064 m^2; and
- Site 1 to Outlet: 2,654 m^2.

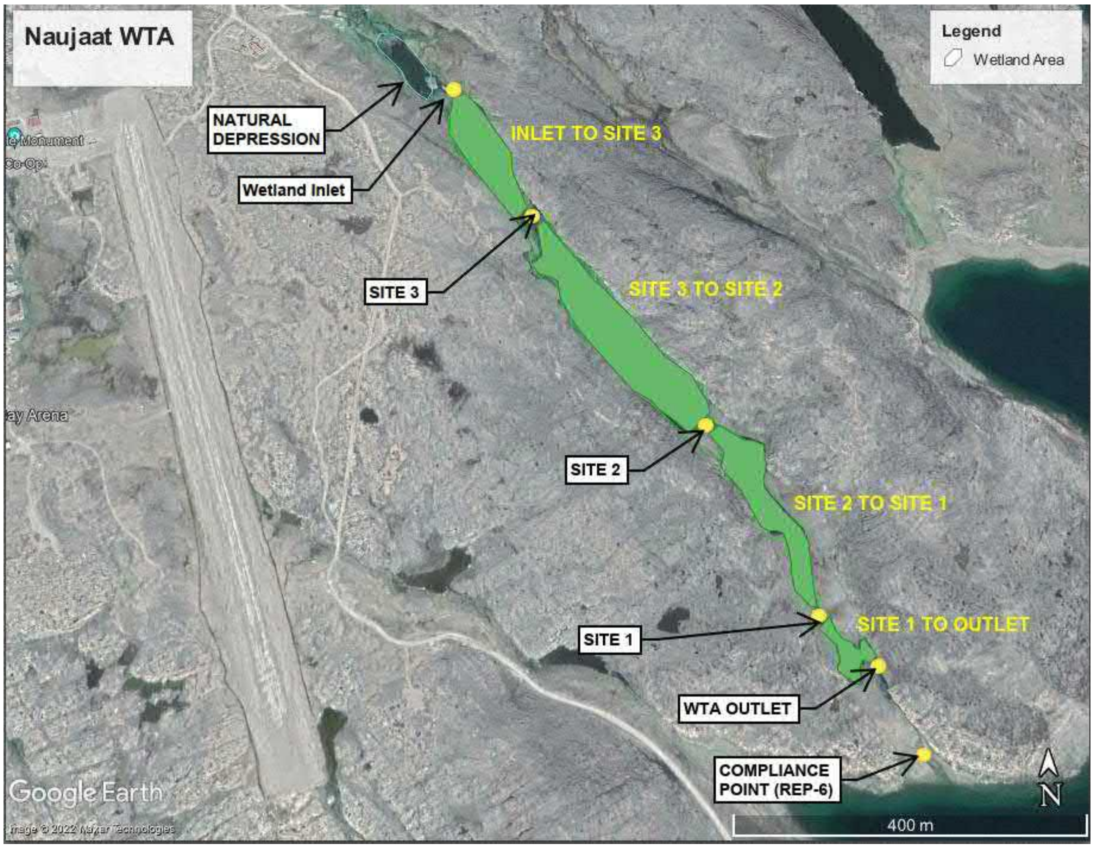


Figure 4: Model Cells and Sampling Sites

2.6.2 Assumptions

To initiate the model, a number of assumptions regarding the WTA were applied. The assumptions are as follows:

- External hydrologic contributions to the WTA from watershed runoff (Q_{WS}) were assumed to equal the flowrates recorded at each site in August 2016 (CWRS, 2017); these flows did not account for annual variations or climate change impacts;
- Hydraulic retention times were assumed to be equal to the nominal retention times calculated within the model, following the methodology discussed in the Dalhousie Study (CWRS, 2017);

- Water depths throughout the WTA were assumed to range from 0.08 m to 0.23 m, based on depths measured during the 2016 treatment season; water depth will vary with flow;
- Average daily evapotranspiration was assumed equal to the potential evapotranspiration calculated for an average value of 1.0 mm/day; climate projections are discussed further in **Section 4.0**;
- Average daily precipitation was assumed equal to the average monthly precipitation projected for Naujaat in 2050 for July (31.2 mm) and August (52.0 mm) for an average of 1.3 mm/day; climate projections are discussed further in **Section 4.0**;
- The transpiration factor was assumed to equal 0.5 as suggested by the Dalhousie University study (CWRS, 2017);
- Infiltration was assumed to be negligible based on site characteristics, as suggested by the Dalhousie University study (CWRS, 2017); and
- Wastewater loading of the WTA was assumed to occur during the acceptable treatment season, when air temperatures are above 5°C; the treatment season begins with the disappearance of snow, beginning of plant growth, and ends with the appearance of ice, plant die-off or dormancy, and temperatures below 5°C. Within this climatological window, wetland plants and microbiota assist nutrient removal processes along with physical removal processes.

2.6.3 Areal Rate Constants

Site-specific areal rate constants derived by Dalhousie University were compared to values suggested by literature for treatment wetlands (Kadlec & Knight, 1996), as shown in Table 12.

Table 12: Comparison of Areal Rate Constants at 20°C

Parameter	Unit	Kadlec & Knight (1996)	Dalhousie University (2016)
$CBOD_5$	m/year	34	98
TSS	m/year	1,000	-
TAN	m/year	20	66
NH_3-N	m/year	18	-
TP	m/year	12	-
TN	m/year	22	22
Fecal coliforms	m/year	103	146

Notes:
*Areal rate constants from Kadlec & Knight (1996) were applied to the TIS model as they proved most conservative.

The rate constants presented by Kadlec & Knight (1996) were applied to the model as they were more conservative when compared to the rate constants derived by Dalhousie University (CWRS, 2017). Parameter specific temperature correction factors were used to adjust the rate constants to the lowest suggested temperature during the treatment period (5°C) following the equation discussed in Section 2.5. Parameter specific temperature correction factors are included in Table 13.

Table 13: Temperature Correction Factors

Parameter	Value	Source
$CBOD_5$	1.012	Kadlec and Reddy (2001)
TSS	1	Removal not influenced by temperature
TAN	1.053	Kadlec and Wallace (2009)
NH_3-N	1.053	Kadlec and Wallace (2009)
TP	0.986	Kadlec and Wallace (2009); Kadlec and Reddy (2001)
TN	1.030	Kadlec and Wallace (2009)
Fecal coliforms	1.070	Chapra (1997); Boutilier et al. (2009)

2.6.4 Loading Characteristics

Influent loading characteristics of the wetland treatment area corresponded with the contaminant concentrations leaving the natural depression outlined in Table 11. Background water concentrations were set to equal the highest contaminant concentrations measured in the reference wetland throughout the 2016 treatment season (CWRS, 2017). The influent (C_{in}) and background water ($C*$) concentrations applied to the wetland model are included in Table 14.

Table 14: Wetland Loading Characteristics

Parameter	Units	WTA Inlet Concentration	Background Water Concentration
$CBOD_5$	mg/L	200	6.4
TSS	mg/L	30	7
TAN	mg/L	100	0.04
NH_3-N	mg/L	3.48	0
TP	mg/L	12	0.08
TN	mg/L	149	0.71
Fecal coliforms	CFU/100 mL	$1.0x10^6$	21.3

2.6.5 Loading Scenarios

An appropriate management strategy for wetland treatment areas is to avoid wastewater treatment during spring freshet when runoff from the watershed results in increased flows through the treatment area that provide dilution but not treatment. Further, a controlled decant scenario is desirable to avoid a large spring flow of lagoon wastewater, which may potentially contain large volumes of frozen wastewater and have insufficient detention for treatment. Therefore, a continuous discharge of wastewater into the wetland which is slowly decanted throughout the summer months is preferable. For the purpose of this assessment, the total lagoon volume (100,000 m^3) disbursed over the following three (3) decant scenarios has been compared:

- 14-day decant = approximately 7,000 m^3/day;
- 30-day decant = approximately 3,300 m^3/day; and
- 60-day decant = approximately 1,600 m^3/day.

The study completed by EXP in 2018 titled *Recommendations for the Development of Nunavut Municipal Wastewater Management Standards* concluded that a lagoon discharge rate of less than 2,500 m^3/day would be necessary in achieving effluent $CBOD_5$ and TSS concentrations that comply with the effluent limits at the regulatory compliance point (REP-6). According to EXP's conclusions and the proposed lagoon volume, a 60-day decant scenario would be required for a lagoon discharge rate of less than 2,500 m^3/day. A graphical comparison of Dillon's model results at the wetland outlet was completed to access each of the decant scenarios considered. Figure 5 shows the graphical comparison of contaminant concentrations at the compliance point, including both the existing and proposed water license criteria.

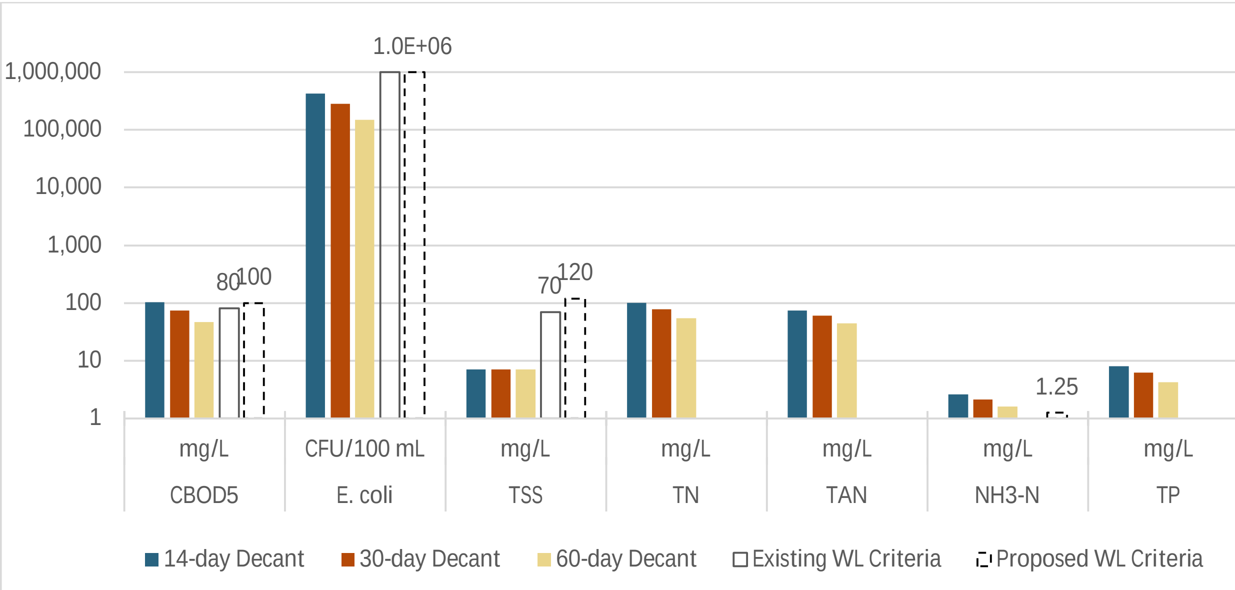


Figure 5: Treatment Performance Comparison based on Decant Period (dashed black box represents water license criteria)

Figure 5 demonstrates that following primary and secondary treatment, the WTA should be capable of reducing $CBOD_5$ and TSS to concentrations below those outlined on the water license, when a 30- or 60-decant period is considered (and in accordance with the assumptions outlined in Sections 2.6.2 through 2.6.4). NH_3-N appeared to be the critical parameter, with modelled concentrations at the WTA outlet exceeding the criteria set by the water license for the regulatory compliance point (REP-6) for all decant periods. Wetland modifications should be considered to provide flow attenuation and improve overall treatment performance, as discussed in Section 2.6.6 below. Modelled contaminant concentrations throughout the treatment process are included in Table 15.

Table 15: Modelled Contaminant Concentrations

Parameter	Units	Typical Raw Wastewater Quality	Primary Cell Effluent	Natural Depression Effluent	WTA Effluent by Decant Scenario		
					14-day	30-day	60-day
$cBOD_5$	mg/L	450	368	200	103	74	46
TSS	mg/L	400	25-50	<30	7	7	7
TAN	mg/L	100	100	100	73	60	43
TP	mg/L	15	12	12	8	6	4
E. coli	CFU/100 mL	1.0×10^8	1.0×10^6	1.0×10^6	4.2×10^5	2.8×10^5	1.5×10^5
TN	mg/L	149	149	149	99	78	54
NH_3-N	mg/L	3.48	3.48	3.48	2.6	2	2

It is noted that the prediction of *E. coli* removal across the lagoon and WTA is dependent on specific site conditions including retention time, settling rates and temperature. The effluent *E. coli* concentrations are expected to be at or below effluent limits at the regulatory compliance point (REP-6). Measured *E. coli* concentrations presented in the 2017 CWRS study show that *E. coli* concentrations were consistently lower than the NWB water license requirements of 1×10^6 CFU/100 mL at REP-6.

Further, variations in hydraulic retention time and other model parameters, such as an increased wetland treatment area or external hydrologic contributions, will impact the treatment performance of the WTA.

2.6.6 Wetland Modifications

While the model demonstrates that a longer decant period will improve the treatment performance of the WTA, NH_3-N concentrations at the wetland outlet may still exceed criteria suggested by the water license at the compliance point (REP-6). Wetland modifications should be considered to improve overall treatment performance throughout the natural wetland area. Figure 6 shows seven (7) potential locations for berms, not all may be needed but all would be useful in assisting with attenuation.

Modifying the WTA through the addition of flow diversion and attenuation devices could be used to increase hydraulic retention, prevent hydraulic scouring and disperse liquid more widely. Flow attenuation devices enhance wetland treatment performance and can be as simple as coarse rock berms placed across flow paths in strategic locations.

Flow attenuation devices require annual maintenance to provide optimal performance and treatment. Examples of annual maintenance activities include the following:

- Re-grade attenuation devices as required;
- Repair cuts and channels in attenuation devices with pit run or larger rock;
- Address water velocities by installing additional attenuation dams and/or silt fences as appropriate;

- Add rock to Scree slopes as required; and,
- Address channeling throughout the wetland with attenuation dams and/or silt fences.

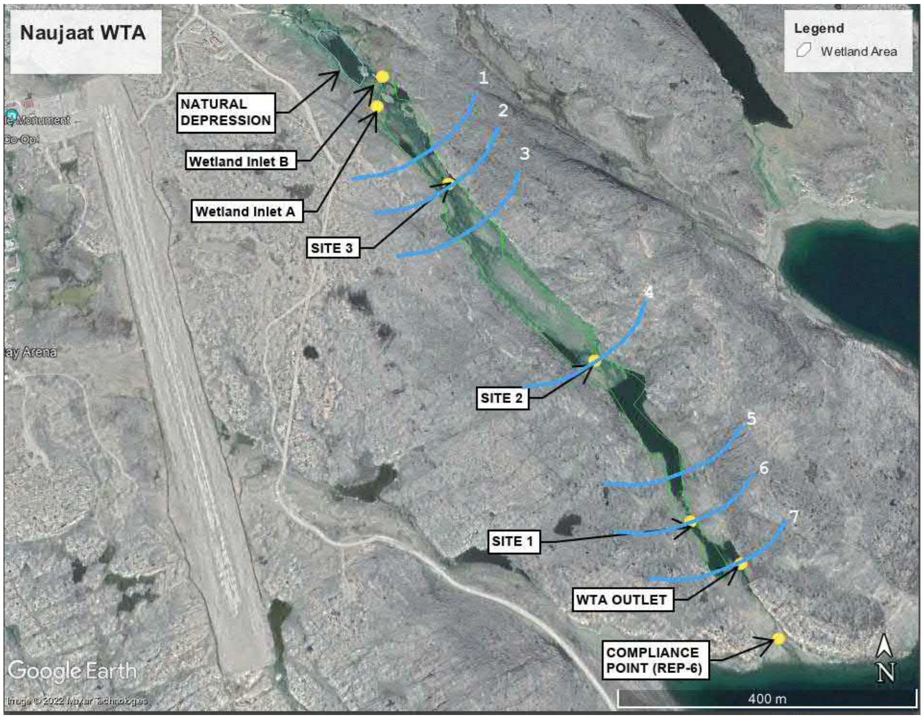


Figure 6: Wetland Flow Attenuation Berms

3.0 Site Infrastructure

3.1 Liner System

Geomembrane liners have been proven to be successful for use in Arctic environments as impermeable membranes. They are highly durable, resistant to the intense stresses of weather extremes and resilient to chemicals that are typically found in municipal wastewater. A suitable liner will be specified for use at the Naujaat WWTF, taking into consideration cold crack, installation slack to accommodate future settlement, brittleness failure and low-temperature impact. As with any lining system, the materials must be installed properly, following the manufacturer's guidelines to ensure the overall integrity of the system is maintained.

Dillon looked into several liner options that are available on the market for extreme weather applications: reinforced polyethylene (RPE), high density polyethylene (HDPE), linear low-density polyethylene (LLDPE), geosynthetic clay liner (GCL) and bituminous geomembrane (BGM). Low density polyethylene (LDPE) was not included within the options as LLDPE has improved tensile strength and resistance of harsh environments over the LDPE. Pros and cons of each liner options are described below:

- RPE geomembranes will retain flexibility at extremely low temperatures but are most commonly used for seepage control applications opposed to impermeable applications. The RPE geomembranes have UV resistance but only for short term exposed use and are recommended to include backfill over the liner.
- HDPE geomembranes have a high tensile strength, puncture resistance and are highly durable in extreme weather conditions. HDPE geomembranes have proven to be successful for use in Arctic environments as impermeable membranes and do not require a layer of backfill over the liner after installation.
- LLDPE geomembranes are able to be exposed to the environments similar to an HDPE geomembranes (no backfill required) but due to the low density of the geomembrane and reduced UV resistance in comparison to an HDPE liner, has a reduced warranty when exposed.
- GCL and coated GCL alternatives provide an impermeable liner and are typically the easiest to install compared to the other provided options. Although in order for either of the GCL options to work as designed, backfill is required to provide a confining pressure to the liner. This would require a minimum of 150 mm of backfill to be compacted over the GCL. The required backfill could potentially cause problems once municipal wastewater is added to the lagoon as the backfill layer could deteriorate, causing the backfill material to be also removed during the yearly decant process and reduce the available storage capacity. The GCL alternatives have high transportation costs due to the weight of the clay liner.
- BGM's are another alternative that are simple to install as they only require propane to seam the impermeable layers together. BGM's are typically more expensive per square meter with respect to

any of the other options but the BGM's do not require a 150 mm base layer of sand underneath the geomembrane.

HDPE, RPE and LLDPE are the typically toughest to install as they require a specialized crew for the installation. Backfill is recommended to be provided over RPE, LLDPE, GCL and coated GCL which would require a layer of rip-rap on the inside face of berms and will lead to complications with desludging of the lagoon in the future. A sand layer is required underneath RPE, LLDPE and HDPE liners, meaning that the underdrain system will be embedded in sand and may clog over time. A GCL or BGM liner can be placed on a rougher surface such as a screened stone allowing for improved drainage conditions.

Of the alternative liner options investigated, Dillon recommends an HDPE Liner (80 mil). HDPE liners are used frequently in northern Canada and provide cost savings compared to other types of liners. An RPE liner could also be considered as it is more puncture resistant than HDPE, can withstand very low temperatures and is highly resistant to chemicals. A liner such as RPE, which has fewer proven installations in Nunavut, may introduce additional risk to the project.

3.2 Inlet Structure

As identified in CSA W203:19, the inlet structure will include a discharge chute, constructed from a section of corrugated steel pipe and secured on the inside berm of the lagoon over a gabion mat to protect the berm from erosion. A parking pad above the discharge chute will be levelled and identified by guide posts (bollards). The discharge chute will extend through the fence so that the truck operator does not have to open a gate to discharge the truck contents.

3.3 Outlet Structure and Decant Plan

The lagoon outlet structure will consist of a metal chute secured over a gabion mat at the downstream end of the lagoon as shown in Figure 7. A pumping system powered by generator has been identified by the GN and NWB as the preferred decant operation at the facility. This method of decanting will require operations staff to install, maintain and remove pumps each year. During decanting, the pumps will need to be checked on a regular basis (daily). The benefit to pumping effluent is that it is relatively easy to repair or replace the pump if there is a failure, and allows the operator to control rate of discharge to ensure optimal wetland performance. A permanent dispersion pipe downstream of the pumping system will be constructed at the edge of the cliff to the valley and will be used to evenly disperse the effluent over the wetland. The operator will need to connect a hose from the pump discharge to the dispersion pipe during the decant operation.

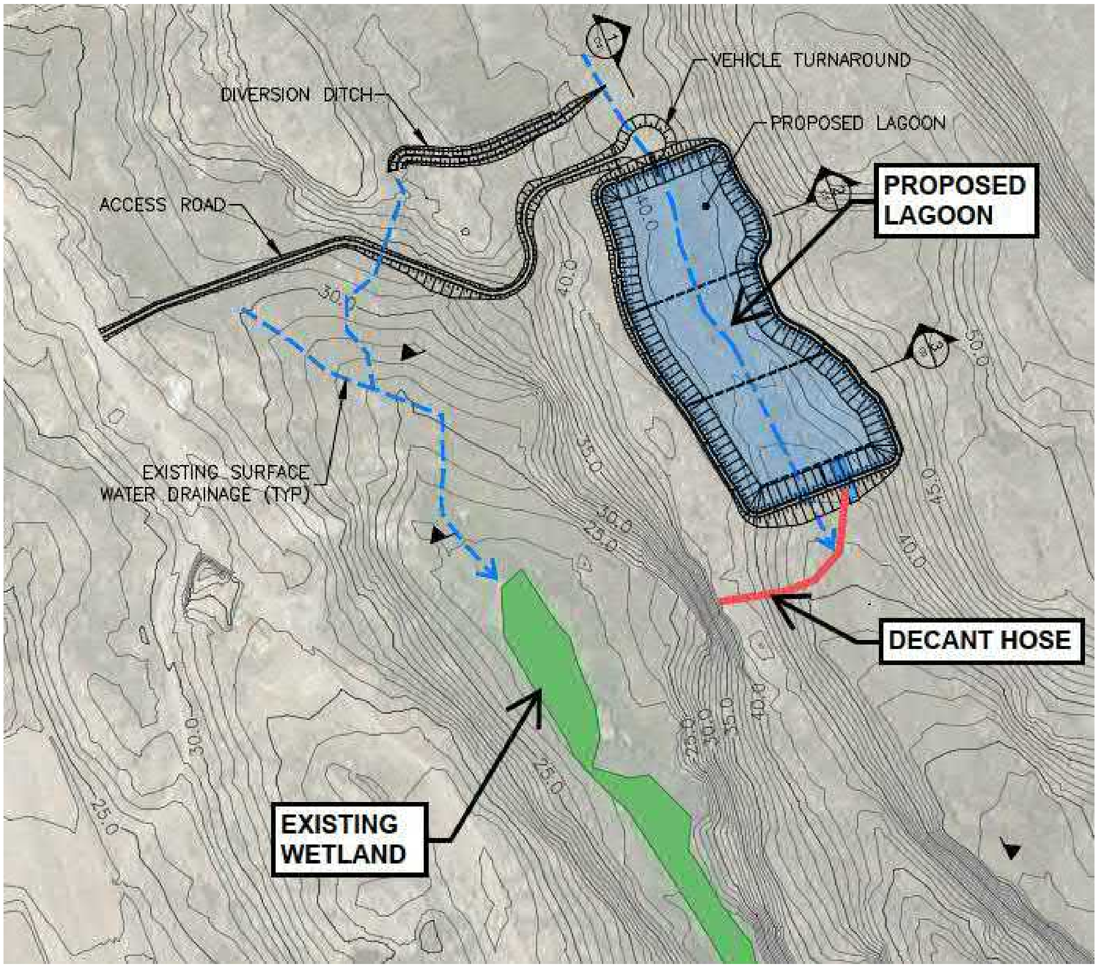


Figure 7: Proposed Lagoon, Decant Hose and Existing Wetland

3.4 Emergency Overflow Channel

An emergency overflow channel will be included in the lagoon berm design. This will consist of a shallow, open channel located just below the top of the berm. The channel will be protected from erosion and is intended to divert effluent to a specified release point that minimizes impacts on downstream infrastructure and receiving environments. The channel will have shallow side slopes to allow for vehicle traffic. This recommendation will be revisited during detailed design and following review by the geotechnical engineer.

3.5 Drainage/Venting System

Gas formation under the liner is unusual but can occur when a liner is placed over a surface previously covered with decomposable material. Biogas formation will also readily form if even minor amounts of wastewater effluent flow through small pin holes or imperfect seams occurring during construction or during operation. Biogas pockets may lead to the creation of large gas bubbles under the liner, which results in "whale backs", shown in Figure 8, extending beyond the surface of liquid in HDPE lined cell and risks damage to the liner. Hydraulic uplift potential must also be considered in areas where the excavated cell or portions of the excavated cell are at a depth where a phreatic surface of groundwater is present or piezometric pressures are present.

Figure 8: Example of "whale backs" as referenced from CSA W203:19

To mitigate this risk, the liner base will be installed over 150 mm sand which will allow for the movement of trapped water and air underneath the liner. A piped vent will be installed to promote passive ventilation and will be large enough to allow the introduction of a submersible pump should water accumulation become a problem. The vent pipe will consist of a 250 mm pipe extending from underneath the liner along the height of the berm and will daylight at the south end of the lagoon.

3.6 Access Road

The construction of the lagoon will require an access road from north of the site. The access road must meet the following conditions:

- The access road width will be 4 m;
- The maximum grade will be 5%;
- Road side delineators will be install to assist in snow clearing; and
- Side slopes of the road will be governed by the stability of the granular material used for the road construction. Geotechnical recommendation will be used to determine the minimum side slope. For safety reasons, a minimum slope of 3:1 will also govern.

3.7 Truck Pad and Turnaround Circle

The truck turning access pad will need to be constructed north of the lagoon berm to allow for gravity discharge from the truck into the lagoon. The location of the pad must provide for a cost effective construction that balances earthworks and allows for safe operation of the truck in winter conditions. The truck pad will have the following elements:

- A turning radius of 17.5 m;
- 3:1 (H:V) side slopes;
- Discharge culvert at discharge location;
- Stop logs at the discharge location to give the truck driver a physical indicator to stop the truck;
- Delineators along the edge of the truck pad to indicate the edge of the embankment in winter conditions; and
- The side slopes of the truck pad will be protected against erosion with a layer of granular material. The erosion protection will have a minimum gradation of a 50 mm minus material. Coarser material may be used if economically available.

3.8 Signage

Proper site fencing and gates as required is recommended around the facility. The lagoon should be provided with a suitable fence placed at the top of the berm with a locked access gate. The truck discharge into the primary cell will be designed to penetrate through the site fence to allow for sewage truck operators to access the site and discharge into the lagoon without requiring to operate the access gate.

It is recommended that warning signs be placed along the perimeter of the site and at least one (1) per side in local languages to designate the nature of facility, the risk to human health and advise against trespassing. Signs should also be posted at appropriately spaced intervals along the perimeter of the proposed WTA area and at the final discharge compliance point of the sewage treatment facility.

3.9 Upstream Flow Diversion

All upstream runoff will be diverted around the lagoon footprint using ditches and directed towards the valley and existing wetland. Culverts will be designed to handle spring freshet and prevent any washout of the access road. A factor of safety will be applied to the sizing of ditching and culverts to account for future climate change conditions and changing precipitation patterns for the lifespan of the sewage treatment system.

4.0 Climate Change Impacts

4.1 Climate Change Implication on Design and Operations

The changing climate is expected to result in some benefits and risks for passive wastewater treatment systems that store wastewater for seasonal discharge. With ongoing climate warming, it is likely that the wastewater stored in the lagoon can be discharged and treated over a longer ice-free season in the future. A longer ice-free season eventually could support the lowering of water levels in the lagoon by late summer and perhaps allow for increased winter wastewater storage. But, the timing of these changes will remain uncertain. The warming of lagoon waters and treatment performance will depend on the lagoon's sizing and depth. The challenge will be to ensure that the lagoon and WTA is suitably sized to store the wastewater plus any additional future precipitation and evaporation, while accommodating sewage long enough for adequate treatment. Ongoing climate warming likely will also support additional and different vegetation in the tundra wetland. Where needed, these and other changes will be considered through climate analysis and analogues (i.e. systems in climates similar to those projected for Naujaat at the end of the next couple of decades). A variety of climate variables and indices can be tailored for ice formation, permafrost active layer thawing, treatment performance and vegetation shifts, among others.

The system's lifetime risks from permafrost warming, deepening active layers, implications for containment, stability of berms and the wetland's hydraulic retention times for treatment will need to be considered. Risks over time from changes to precipitation and evaporation will be incorporated. For example, the best practices in the CSA standard, W203:19, on "*Planning, design, operation, and maintenance of wastewater treatment in northern communities using lagoon and wetland systems*" recommends the use of "conservative" values of precipitation and evaporation in the storage calculations (i.e., a 20-year return period maximum precipitation and a 20-year return minimum evaporation).). The lagoon and WTA will be sized to accommodate average precipitation volumes as referenced from 30 year historical precipitation data, with an allowance for climate change. This volume is considered reasonably conservative, and increasing the size of the lagoon by 10-20% is likely not warranted for a rainfall event that will occur once or twice over the lifespan of the treatment system. In those rare rainfall events, the lagoon freeboard will accommodate the additional precipitation so that there is limited impact to Hamlet operations. The W203:19 standard also recommends that hydraulic or retention structures in the wetland consider the flows expected for an extreme 100-year return period rainfall event and its impacts on the entire wetland watershed. We will use our hydrological and climate expertise to assess these current and potential future conditions.

4.2 Future Temperature and Precipitation Analysis

Climate information for the Naujaat (formerly Repulse Bay) area was obtained from ECCC climate archives for the last climate normals period of 1981 to 2010. The Naujaat (Repulse Bay) climate station has significant amounts of missing data records, and these years with significant amounts of missing data needed to be removed from the 30 year period given that their inclusion would introduce biases and errors into the long-term average. Only those years with sufficient temperature and precipitation data are included.

The mean annual temperature in the period for Naujaat was -12.1°C, with the months of June through September having average temperatures above freezing. As shown in Figure 9, the coldest month on average is February (average temperature of -31.4°C), while the warmest month is July with an average temperature of 8.8°C.

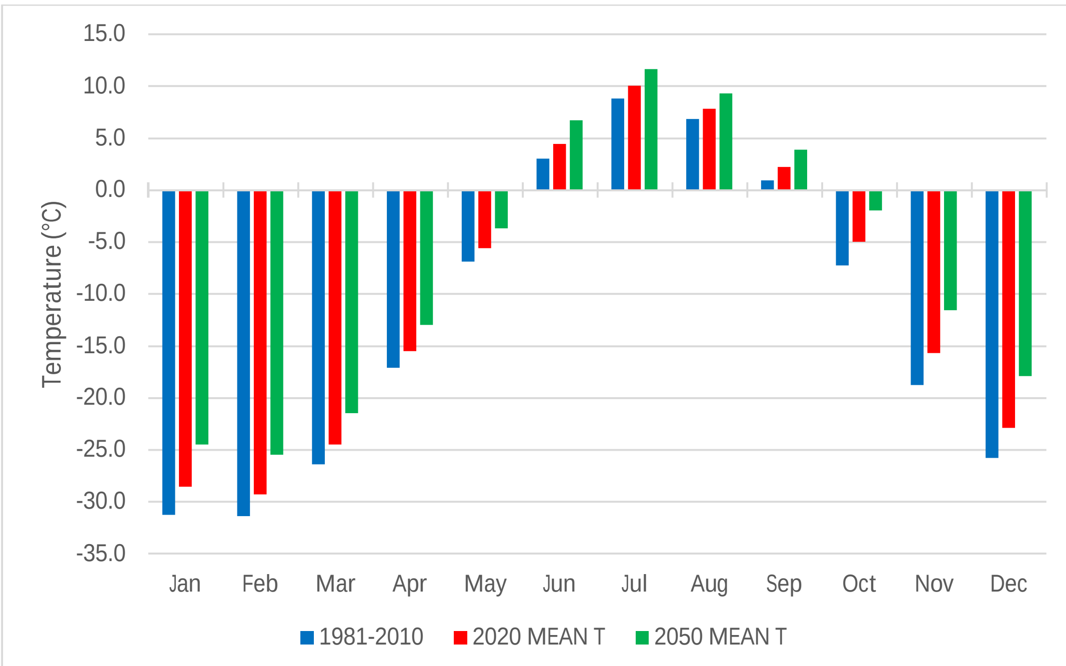


Figure 9: Historical (1981 to 2010) and Projected (2041 to 2070) Mean Monthly Temperature

As shown in Figure 10, the mean annual temperature trend for the period of 1981 to 2010 indicates increases over time, with warming during this period of data available from approximately -13°C to -11°C, considering the linear trend line presented in the figure below. This is consistent with the warming noted for many locations in Canada's north.

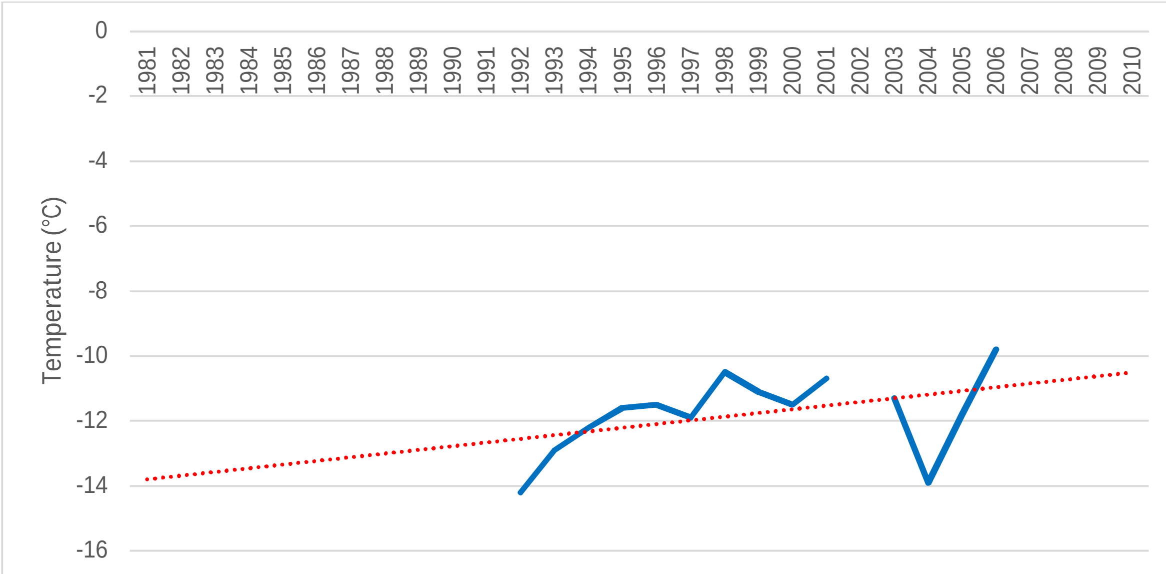


Figure 10: Historical Mean Annual Temperature 1981-2010

Projections were obtained on a monthly and annual basis from the Dillon Climate Analytical System from an ensemble of 35 Global Climate Models for this location. All model projections were obtained and averaged to provide the projected change going forward for two (2) time periods (2020s = 2011 to 2040) and (2050s = 2041 to 2070). All projections were based on the IPCC AR5 climate change model series using a conservative assumption or scenario where Greenhouse Gas (GHG) emissions are assumed to increase with continued burning of fossil fuels. This GHG assumption is known as the "business as usual" Representative Concentration Pathway or RCP8.5. In the past, this has been the emissions pathway closest to replicating actual observations of GHG concentrations in the atmosphere. According to this projection, the mean annual temperature will increase to -10.2°C (+1.9°C) in the 2020s and then to -7.3°C (+4.8°C) by the 2050s – a continuing warming trend from the historical record. The monthly changes in mean temperature can be seen in Figure 9 above, with the greatest warming occurring in the autumn and winter seasons.

Precipitation at Naujaat averages 311.3 mm per year, including both rain and snow. Approximately two-thirds (2/3) of the precipitation at this location falls as snow historically (215.4 cm of snow, 123.8 mm of rain). The breakdown of monthly precipitation by type is shown in Figure 11 below, where the green bars indicate rainfall, the blue bars represent equivalent snowfall totals and the black bars represent precipitation totals.

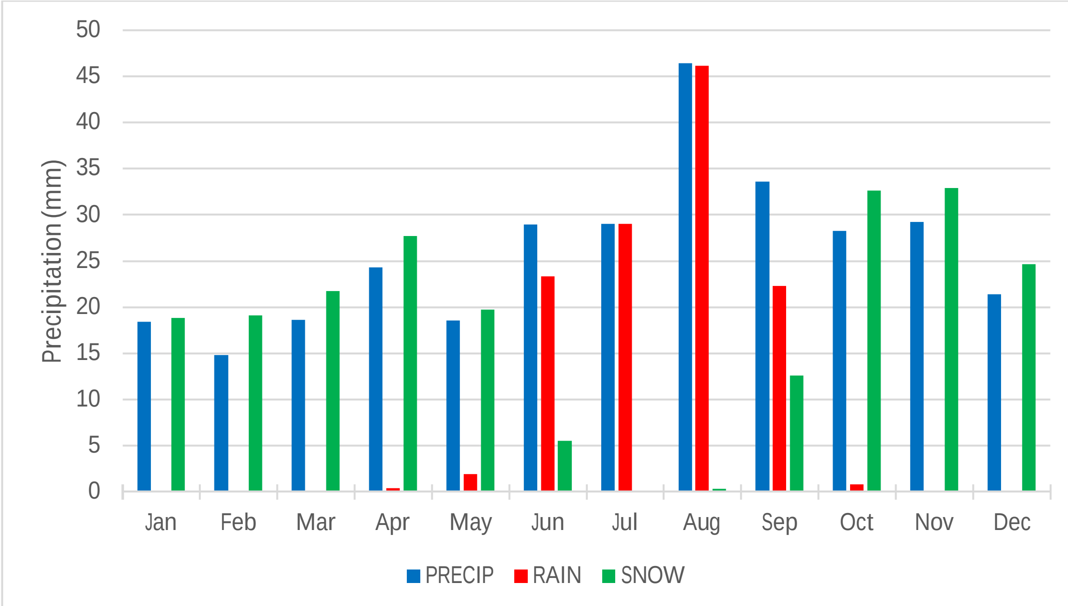


Figure 11: Historical Monthly Mean Precipitation Data 1981-2010

Historically the wettest months are in the summer, while the driest months are found in the winter season. Rain is the significant precipitation type historically between June and September, while snow predominates in all other months.

As shown in Figure 12, the trend in precipitation has been increasing during the 1981 to 2010 period from an average of approximately 325 mm to 350 mm for the period of available data, as seen in the linear trend in the figure below. For the available data, note that there is considerable year to year variability in the annual precipitation totals.

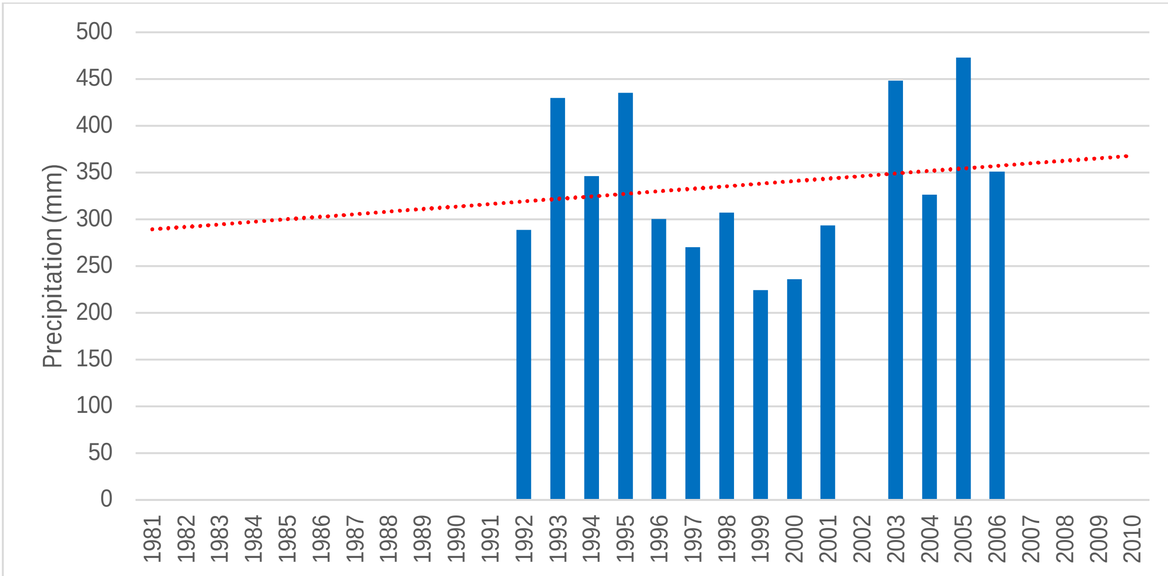


Figure 12: Historical Annual Mean Precipitation Data 1981-2010

Projections of precipitation using the same ensemble of climate models and using the Dillon Climate Analytical System show a continued increase in precipitation going forward for Naujaat. With associated increased warming, the proportion of rain versus snow is also expected to increase, but snow will still predominate in the colder months by far. The projected change in precipitation by month is shown below. All months show increased precipitation but the increases are the least for the summer months of June-July-August. The largest increase in precipitation by the 2020s is found in the autumn (+8.3% in 2020s) and winter (+11.1%) months, when snow predominates. Even greater increases are projected by the 2050s period. Projected mean monthly precipitation is shown in Figure 13 below.

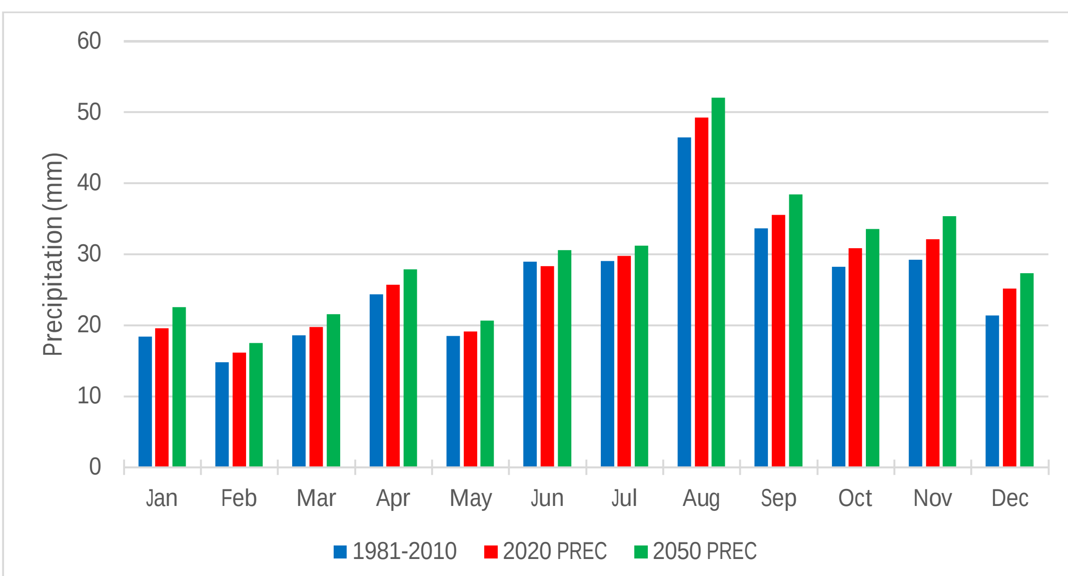


Figure 13: Projected Mean Monthly Precipitation to 2041-2070

Based on limited available rainfall Intensity-Duration-Frequency (IDF) data, the 25 year return period values of the 24-hour extreme rainfall in an area that includes Coral Harbour and Hall Beach ranges from 34 to 40 mm, *with current Naujaat values likely over 35 mm of rainfall* (25 year return period of 24 hour extreme rainfall). By the 2040s, it is estimated that the 25 year return period extreme rainfall events in the Naujaat area *could increase to values from 40 to 45 mm*. Further south, the 25 year return period values for the Rankin Inlet and Baker Lake climate stations range from 55 to 60 mm.

5.0 Site Selection and Conceptual Design Alternatives

Dillon conducted a desktop review of background documents provided by the GN, for the proposed WWTF. The reviewed documents included:

- Topographic maps;
- Geotechnical investigations and previous design drawings;
- Design reports by EXP Services; and
- Design review reports by Wood Environment & Infrastructure Solutions.

Based on Dillon's desktop siting study taking into consideration the proximity to the existing wetland, required setbacks (water source, residential, airport zoning regulations, marine, etc.) and all other background data collected, a total of nine (9) conceptual concepts were evaluated, which includes the five (5) alternate designs provided by Wood in February 2021 as well as the originally proposed design provided by EXP in March 2020. The results of the study were presented in a ratings table with weighted rankings and updated site map. The options were evaluated based on six (6) categories including:

1. Containment;
2. Constructability;
3. Life cycle costing;
4. Climate change implications;
5. Potential regulatory acceptance; and
6. Ease of operation.

The results of the desktop review, ratings table and site map are presented in the memo *Naujaat WWTF – Weighted Factor Analysis* (August 4, 2021) attached in Appendix A.

The conceptual designs presented in this memo included the following options:

- Option 1: Fully lined single cell lagoon over former landfill site;
- Option 2: Fully lined two (2) cell lagoon with each cell having capacity for six months of effluent storage;
- Option 3: Fully lined single cell lagoon located to the northeast of the existing discharge location;
- Option 4: EXP's original design adapted to include single cell lagoon with 12 months storage located in valley. A geosynthetic clay liner (GCL) with the use of thermosiphons would be used for containment;
- Option 5: EXP's original design with fully lined single cell lagoon located in valley;
- Option 6: EXP's design with liner extended into bedrock trench. The liner would be installed below the upstream face of the lagoon berm and anchored into the crest;

- Option 7: EXP design with an insulated liner;
- Option 8: Containment berm across valley with upstream flow diversion; and
- Option 9: Containment berm across valley with upstream flow containment.

Dillon met with the GN project team on August 11, 2021 and four (4) options were chosen to move forward into the schematic design stage. The major concerns from the GN revolved around proximity of Options 1 and 2 to the former solid waste site and the location of Options 4, 5, 6 and 7 in the valley where berms would be constructed above standing water. The GN also eliminated all options from consideration without a fully lined containment system. It was important that a lagoon was selected that allowed for upstream diversion of runoff to prevent dilution of wastewater in the pre-treatment cell. Option 8 and 9 had the lowest capital costs, so it was decided that one of these options should be included in the schematic design process and compared to the other fully lined lagoon options. Based on this discussion, the following options were carried forward into schematic design:

- Option 1 (modified) – Hybrid option between Option 1 and 3: Fully lined single cell lagoon located away from the existing solid waste site;
- Option 3: Fully lined lagoon located to the northeast of the existing discharge location, at the top of the valley;
- Option 5: EXP's original design with fully lined single cell lagoon located in the valley; and
- Option 8: Containment berm across valley with upstream flow diversion.

6.0 Schematic Design Recommendations

Dillon completed schematic design drawings for five (5) lagoon footprint options. The schematic design drawings include the following:

- Site plan of the development showing locations of the proposed lagoon, berm, approach road and truck turn area;
- Total volume, working volume, sludge allowance and freeboard;
- Cross sections;
- Contours developed from DEM data and associated elevations of berms, lagoon bed and access road;
- Material volumes including HDPE piping, liner, cut/fill, granular and sand; and
- Air vent and anchor trench details.

The following five (5) options were carried forward in the schematic design process:

- *Option 1* – Fully Lined Single Cell Lagoon north of Former Landfill, Hybrid of Option 1 and 3;
- *Option 3* – Single Cell Lagoon North of Existing Wastewater Disposal Site;
- *Option 5* – (Wood) EXP Design with Fully Lined Lagoon;
- *Option 8* – (Wood) Containment Berm Across Valley (Upstream Flow Diversion); and
- *Option 1A* – Fully Lined Single Cell Lagoon north of Option 1 Footprint.

6.1 Site Selection Trip

Charlie Pogue of Dillon and David Browne of the GN attended a site visit to Naujaat on September 21 to 23, 2021 to complete initial site reconnaissance and investigate the four (4) schematic design locations to determine the feasibility of each design. In discussion with Naujaat officials, Dillon gathered local knowledge of the proposed locations and developed an understanding of the municipalities operating procedures, concerns and objectives. This included any concerns related to land and marine activities such as travel, recreation and/or harvesting that may be impacted by the project. From the site visit, Dillon and GN staff identified a fifth schematic design for consideration located north of Option 1. The following option was considered as part of the schematic design analysis:

- *Option 1A* – Fully Lined Single Cell Lagoon north of Option 1 Footprint.

Based on visual inspection of the five (5) schematic design alternatives during the site visit, Dillon provided an estimate of the bedrock blasting required, which was provided to Altus and included as part of the Class 'D' cost estimates. It was assumed that all excavated material would be hauled away, while fill for lagoon berms would come from the quarry site located 8 to 10 km away, with material that only requires screening.

- Option 1: 50 to 70% blasting required;

- Option 1A: 30 to 50% blasting required;
- Option 3: 50 to 70% blasting required;
- Option 5: 30 to 50% blasting required; and
- Option 8: 0 to 20% blasting required.

6.2 Summary of Schematic Design Alternatives

Dillon updated the weighted factor analysis from the conceptual design phase of the project looking at Options 1, 1A, 3, 5 and 8. A memo was prepared titled *Alternative Schematic Design Options*, submitted on October 12, 2021 which included the comparison matrix, weighted factor analysis, schematic design drawings and cost estimate. The memo and associated documents are attached for reference in Appendix B.

It was noted that while Option 1A was the preferred location for the lagoon from a construction perspective, it was located closest to the airport runway. The GN approached officials from Nunavut Airports, under the Department of Economic Development and Transportation to access the location of Option 1A in terms of hazards to the airport runway and the potential for bird strikes. There were concerns raised for the potential elevated risk of bird strikes at this location including:

- Proximity to glide path of planes landing and takeoff;
- Elevation of berm with respect to the runway (approximately 11 m difference); and
- Existing runway length is quite short already presenting landing challenges.

From the beginning of the conceptual design phase, the GN was concerned with Option 5 and 8 involving construction of the lagoon berms directly in the valley over standing water. Based on risks associated with construction and stability of the lagoon berms over time, it was determined that Options 5 and 8 should be eliminated from the evaluation.

Based on the concerns raised in regards to Option 1A, 5 and 8, the GN determined Option 3 was the preferred location, with lowest risk to airport operations and was chosen as the preferred lagoon location. The constraint mapping, access road and lagoon footprint figures are attached in Appendix C. This location is located west of the existing wastewater disposal site and is located furthest from the airport runway, with the lowest risk for bird strikes out of the options presented during the schematic design stage. The following items will need to be considered during detailed design at the location of Option 3:

- Long discharge path of effluent over lagoon berm and into the valley;
- Construction of access road across difficult terrain to the lagoon site;
- Consideration of upstream flow diversion under access road and in vicinity of lagoon berms; and
- Construction of liner against east wall of upper valley, where blasting/shaping of rock will be required to protect the liner integrity.

The GN provided an email to Dillon on October 28, 2021 with a decision to proceed with Option 3.

6.2.1 10 Month Capacity vs. 12 Month Capacity Lagoon

After submission of the draft Pre-Design Report in December 2021, the GN asked that Dillon investigate the difference in cost between a ten (10) month capacity and a 12 month capacity lagoon at the location of Option 3. Dillon looked at three (3) different lagoon configurations including:

- Sub-Option 3A: 10 month capacity lagoon cell with a depth of 3 m;
- Sub-Option 3B: 12 month capacity lagoon cell with a depth of 4.5 m; and
- Sub-Option 3C: 10 month capacity lagoon cell with a depth of 4.5 m.

On April 22, 2022 the GN provided instruction to Dillon to proceed with Sub-Option 3B with a 12 month capacity lagoon cell and a depth of 4.5m. Further details of the analysis is summarized in the memo found in Appendix D.

7.0 Required Site Investigations

The following site investigations are required to move the project into detailed design based on the selection of Option 3.

7.1 Investigations by Canadrill

Dillon will subcontract Canadrill to perform a topographic survey and geotechnical investigation at the location of Option 3. Canadrill will also complete a granular assessment during their time in Naujaat.

7.1.1 Topographic Survey

The topographic survey is required and will be completed by one (1) field surveyor from the Canadrill team who will conduct the survey, establishing control points adjacent to the site which can be used at a later date to control development of the site(s). The control points will be related to the existing survey control site benchmark shown on the proposed schematic drawings. The surveyor will use a Leica VIVA GPS Receiver with a base station located near the survey to provide consistent and accurate data. The resulting field data will be compiled and the processed data will be developed into CAD format.

7.1.2 Geotechnical Investigation

The geotechnical field program is required and will be supervised/carried out by a field engineer from Canadrill experienced with northern geotechnical air-track drilling, permafrost soils and northern borrow source development on a full-time basis.

All borehole/test pit/hand auger locations and the extent of any observed bedrock outcrops will be located/delineated using a commercial grade handheld GPS device. Test location elevations will be determined in the office based on location and existing topography.

The goal of the investigation is to verify depth to bedrock and the extent of any ice-rich soils present, as well as evaluate the quality/permeability of any near surface bedrock as much as practical. Several deep boreholes are required to either confirm areas of thick overburden or evaluate the extent of seasonal thaw/groundwater flow through shallow bedrock. Deeper than anticipated active layer thicknesses can be indicative of heavy seasonal drainage flowing through areas of a site and provide an estimated depth for pervious or sound bedrock. Test pits alone have potential to encounter premature refusal on frozen ground without exposing bedrock, making them inconclusive and offer little in the way of ground temperature data; however, test pits are a very quick and useful way to further evaluate near surface soils in support of roadway design, and to expose near surface bedrock for more detailed evaluation/coring. Therefore, the combination of drilling and test pitting is preferred and will be performed.

7.1.3 Granular Assessment

The granular assessment is required and will be completed by Canadrill. It is known that the community currently derives fill material from local borrow sources previously identified within 10 km of the community footprint. It is understood from the site visit and conversations with the Naujaat SAO that several previously identified borrow sources remained untouched as of 2017; however, it cannot be estimated how many of these deposits were actually of good quality, or which remain available for the project. Canadrill will thoroughly review all available information related to past, present and future borrow sources/quarries of the community to verify areas identified/used. They will conduct phone interviews with local Hamlet staff and/or contractors in an attempt to determine the current status of these identified sources of material prior to the field program.

During the field program, Canadrill will carry out site visits to discuss/observe any material sources, crushing equipment (if present), quality, anticipated schedule(s) and quantity with those responsible for obtaining/providing the material. It is understood that the quantity and quality of these deposits was previously estimated based on preliminary shallow hand dug samples and ground penetrating radar. Representative samples would be obtained and sent south as described below for further classification and laboratory testing (moisture content and gradation).

Any previous areas/evidence of local blasting and crushing operations will be identified and logged via photographs and GPS coordinates, as well as any potentially suitable large bedrock outcrops/ridges near existing roadways, which may represent a good source for alternative production of granular materials if practical.

7.2 Phase I Environmental Site Assessment (ESA)

A phase I ESA will be required at the site of Option 3 and will be completed without a site visit. Dillon will gather background information on the selected WWTF site through review of available documentation and photos from Dillon’s previous site visit on September 21 to 23, 2021. This information includes reviewing available information provided by GN CGS, speaking with available community officials and utilizing Environmental Risk Information Services (ERIS). Dillon will contact the Naujaat SAO to provide knowledge regarding the historical uses of the site.

ERIS will be contacted and retained to conduct a search of databases for information on the site and surrounding area (250 m radius) and will obtain aerial photographs of the site from the extensive collection at the National Aerial Photography Library (i.e., one (1) aerial photo per decade, if available).

7.3 Snow and Wind Analysis

Gradient Wind has been hired as a sub-consultant to perform snow and wind analysis of the WWTF site. The principal tool in both studies is 3D computer modelling based on computational fluid dynamics (CFD) to assess snow drifting and odour dispersion from the lagoon. The snow drift and accumulation study would estimate the drift sizes and locations that may cause operational problems for site access, and recommend snow clearing operations or snow storage areas as may be required.

7.4 Airport Bird Hazard Risk Assessment

A bird hazard assessment is required as a component of the regulatory submission application. Dillon will complete this task in accordance with Transport Canada's 2004 *Airport Bird Hazard Risk Assessment Process Manual*. This process is well-established in Canada and identifies site-specific hazards affecting the collision risk potential between birds and aircraft. The approach evaluates three risk elements:

1. Aircraft-related elements;
2. Bird species-related elements; and
3. Land use-related elements by hazardous species.

To complete the bird hazard risk assessment, confirmation of bird use in the area near the airport will be required with specific attention to the current landfill as a predictive case study for the proposed project. To do so, Dillon will complete a desktop background review of available information to determine the potential bird species presence based on known occurrence records and species ranges. Information provided by local community members and airport personnel will also be used to characterize bird use in the area. Additionally, a request for information will be sent to Transport Canada for historical bird strike data for the airport.

Using the information gathered for the site, predictions of the incremental risk associated with the proposed project will be completed. The predicted incremental risk will account for reductions in bird collision risk through application of mitigation measures, as outlined in Transport Canada's *Wildlife Control Procedures Manual (TP1150)* and their guide titled *Sharing the Skies: An Aviation Industry Guide to the Management of Wildlife Hazards (TP13549)*.

The bird hazard risk assessment report will provide an evaluation of the selected site in relation to airport flight path information, aircraft types and risk to be included as part of the regulatory submission to Transport Canada.

7.5 Wetland Field Assessment

As discussed in Section 2.6, a review of Dalhousie University's *Wetland Treatment Area Study in Naujaat, Nunavut* (CWRS, 2017) was completed to evaluate the need for additional data collection through a wetland field assessment. The CWRS collected site-specific data during the 2016 treatment season (June to September), through multiple sampling events, and focused on the following methodology:

- Watershed and wetland delineation;
- Discharge measurements;
- Tracer studies;
- Vegetation and wildlife characterization;
- Water quality samples;
- Treatment performance assessment;
- Rate constant derivation;
- Model development for the application and assessment of two (2) potential decanting options; and
- Community consultation.

In consideration of the available data, no additional wetland field assessment is recommended by Dillon at this time.

8.0 Recommendations

Dillon recommends proceeding to detailed design with Option 3, a single cell lagoon located north of the existing wastewater disposal site. Based on the concerns raised in regards to Options 1A, 5 and 8, the GN determined Option 3 was the preferred lagoon location, with lowest risk to airport operations. This location is located west of the existing wastewater disposal site in the valley and is located furthest from the airport runway, with the lowest risk for bird strikes out of the options presented during the schematic design stage. The following items will need to be considered during detailed design at the location of Option 3:

- Long discharge path of effluent over lagoon berm and into the valley;
- Construction of access road across difficult terrain to the lagoon site;
- Consideration of upstream flow diversion under access road and in vicinity of lagoon berms; and
- Construction of liner against east wall of upper valley, where blasting/shaping of rock will be required to protect the liner integrity.

The following site investigations will be required at the site of Option 3 prior to the project moving into detailed design.

- Topographic survey;
- Geotechnical assessment;
- Granular assessment;
- Phase I ESA (desktop assessment);
- Snow and wind analysis; and
- Airport bird hazard risk assessment.

Appendix A

Weighted Factor Analysis Memo

Memo

DILLON CONSULTING

To: Ashwani Sharma, Project Manager

From: Keith Barnes, Project Manager

cc: Roberto Woisky, Wayne Thistle, David Brown, Sarah Collins

Date: August 4, 2021

Subject: Naujaat WWTF – Weighted Factor Analysis

Our File: 21-2233

Dillon has completed our weighted factor analysis of the 9 preliminary options previously discussed on July 19, 2021. The analysis helped to narrow the options down to 3 preferred to move forward with schematic design. The three preferred options for schematic design are:

- Option 1: Fully Lined Single Cell Lagoon over Former Landfill
- Option 3: Single Cell Lagoon North of Existing Site
- Option 5: (Wood) Exp Design with Fully Lined Lagoon

Based on the new increased lagoon capacity required in relation to the previous submission, solely on population increases over 20 years, and our understanding that 9 month holding capacity was accepted by the regulators, we suggest moving forward with Schematic Designs of Options 1, 3 and 5 with a holding capacity of 9 months.

We are still looking into the pros and cons of an exfiltration berm. Once we have more information, it will pass it along for the GN’s review. We have not considered exfiltration in the evaluation to date.

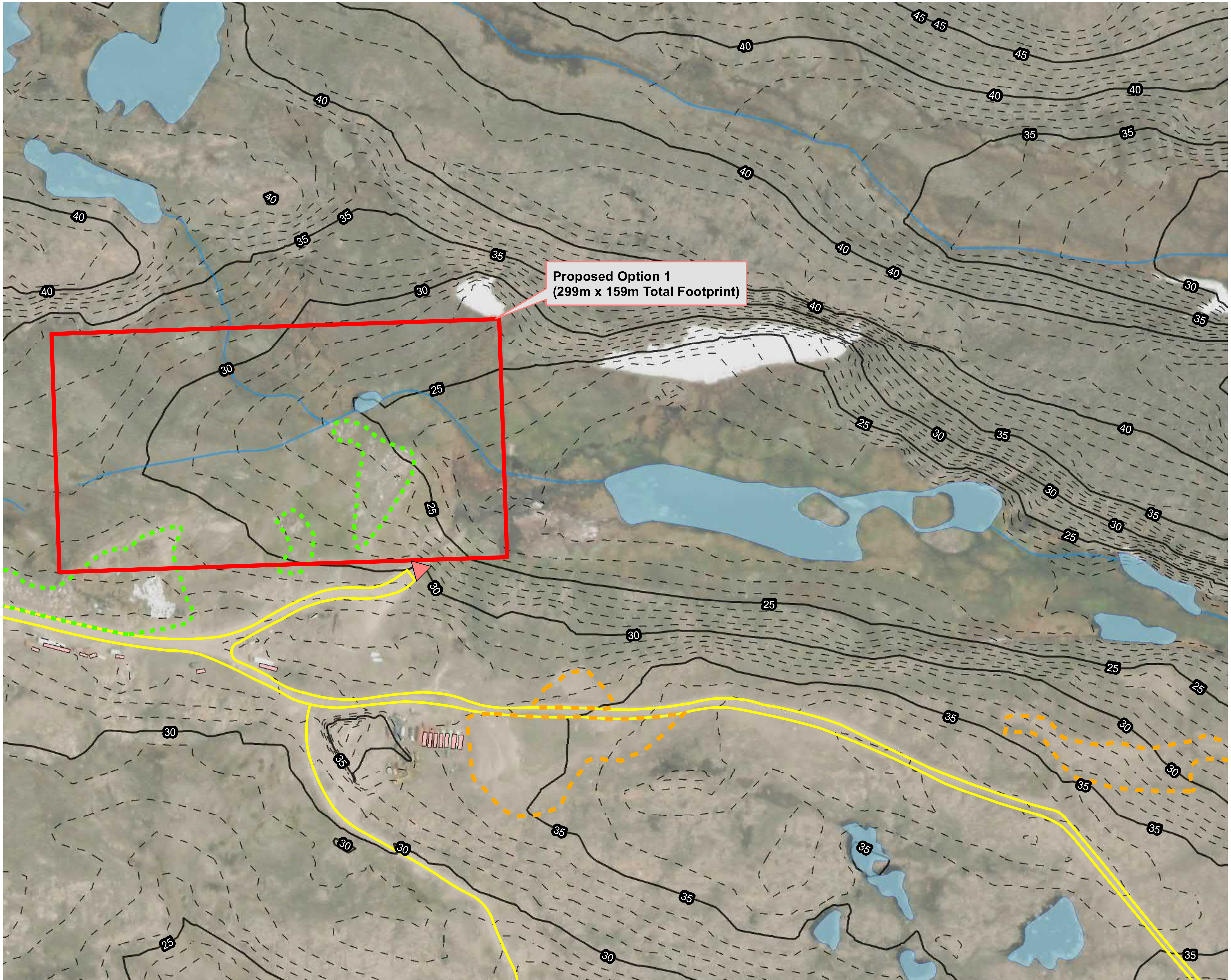
Please review our weighted assessment of the options as we would like to set up conference call to confirm the GN's acceptance of our review prior to Dillon moving forward with the conceptual design.

21-2233 - Naujaat WWTF

21-2233 Naujaat WWTF - Summary Table of Conceptual Designs

Option	Description
1 - Fully Lined Single Cell Lagoon over Former Landfill	Option 1 (footprint shown in Figure 1) is a fully lined single cell lagoon located on top of the former landfill which allows for reuse of the former site. The geosynthetic liner provides a fully contained lagoon from the old landfill site underneath. The liner would be anchored to the top of the berm, preventing the requirement of anchoring to bedrock or permafrost. Due to the location being over the former landfill, there could be the potential for gas production under the liner. This would require venting piping under the liner to mitigate having gas build-up under the liner. Thaw settlement could also cause potential berm stability issues. Desludging of the lagoon would require the lagoon to be taken offline during this process and other means of discharging would need to be explored, including discharging directly into the wetland during this time. Flow from the upstream catchment area would be able to be diverted and not contribute to the lagoon volume.
2 - Two 6 Month Retention Lagoon	Option 2 (footprint and alignment shown in Figure 2) is a fully lined two-cell lagoon with each having the capacity for six months of effleunt storage. The two cells are proposed to be fully lined as they are located over the former landfill. The two cells allow for desludging to occur in once cell while allowing the other cell to continue to be operational during the process. Similar to Option 1, due to the location being over the former landfill, there could be the potential for gas production under the liner. This would require venting piping under the liner to mitigate having gas build-up under the liner. Thaw settlement could cause potential berm stability issues. Flow from the upstream catchment area would be able to be diverted and not contribute to the lagoon volume.
3 - Single Cell Lagoon North of Existing Site	Option 3 (footprint and approximate location shown in Figure 3) is a single cell lagoon located to the northeast of the exisitng discharge location. The location allows for the exisitng catchment area flows to remain in their exisitng paths without the need of flow diversions prior to construction. Option 3 has not been previously investigated, therefore, in order to recommend containment requirements additonal investigations would be required prior to a recommendation. Desludging of the lagoon would require the lagoon to be taken offline during this process and other means of discharging would need to be explored, including discharging directly into the wetland during this time from the existing location. Depending on furthing investigations of the site, the blasted material from the site can contribute to the required granualr material for the base of the lagoon flooe and the berms.
4 - Exp Original Design	Option 4 - Exp's original design has been adapted to include 12 months opposed to 9 months to meet the compliance requirements. The original design consists of a storage lagoon within the valley, directly downstream of the existing discharge location. Using the existing topography to its advantage, the containment on the east side of the lagoon is achieved by using the existing bedrock as a natural berm, reducing the cost and granluar for the construction of the berms. A geosynthetic clay liner (GCL) with the use of thermosiphons is proposed to eliminate seepage from the lagoon. Based on this proposed methodology, additonal geothermal analysis would be required to determine the location of the thermosiphon. The proposed design, as well as options 5, 6, and 7 using the same footprint, require flow diversion of the updtream catchment area prior to construction. With the present location being within an exisitng wetland there is the potential for the design to be constructed over a talik or pond, requiring dewatering below the lagoon floor. During the desluding of the proposed lagoon, other means of discharging during this time would need to be explored, inlcuding discharging directly into the wetland during this time. Based on the location of the proposed lagoon the temporary discharge during the desludging would need to be diverted through a channel to not potentially erode the toe of the southwest berm.

5 - (Wood) Exp Design with Fully Lined Lagoon	*Design [* Option 5*] is to retain the presently proposed sewage lagoon berm design and alignment. The low-permeability liner would be installed below the upstream face of the lagoon berm and anchored into the crest. Rather than anchoring the liner into permafrost below the upstream toe of the constructed berm, the liner would extend horizontally across the lagoon base and up the rock slope along the easterly limit.* *Bedding layers would be placed below the liner across the base of the lagoon an against the rock slope. Protection layer(s) would also be required on top of the liner.* *Settlement will occur over time as the permafrost thaws below the lagoon. Folded/slack liner will be incorporated into the liner layout plan to accommodate this settlement.*
6 - (Wood) Exp Design with Liner Extended into Bedrock Trench	*Design [* Option 6*] is to retain the presently proposed sewage lagoon berm design and alignment. The low-permeability liner would be installed below the upstream face of the lagoon berm and anchored into the crest. The liner would extend near vertically below the upstream toe of the constructed berm, into a cut-off trench excavated into sound bedrock. The cutoff trench would be backfilled with clay and/or grout.* *The upper layer of the bedrock can be weathered or fractured. The level of weathering and fracturing decreases quickly with depth. It is expected that cutting into bedrock to approximately 1 m will meet containment criteria.* *Settlement will occur over time as the permafrost thaws below the lagoon. Folded/slack liner will be incorporated into the liner layout plan on the berm slope to accommodate soil settlement over the lagoon impoundment.*
7 - (Wood) Exp Design With an Insualted Liner	*Design [* Option 7*] is to retain the presently proposed sewage lagoon berm design and alignment. The low-permeability liner would be installed below the upstream face of the lagoon berm and anchored into the crest. The liner would extend near vertically below the upstream toe of the constructed berm, a minimum of 2 m below original ground and 1 m into permafrost.* *The low-permeability liner would be insulated, with the insulation integral to the liner. Settlement will occur over time as the permafrost thaws below the lagoon, although the thaw rate will be delayed. Folded/slack liner will be incorporated into the liner layout plan to accommodate this settlement. No thermosiphon will be installed during the original construction.*
8 - (Wood) Containment Berm Across Valley (Upstream Flow Diversion)	*Design [* Option 8*] is to construct a containment berm across a narrow portion of the valley, south of where the present sewage lagoon is located. A conceptual sketch is shown in Figure [* 5*]. The presently proposed sewage lagoon berm design and geometry would be maintained, having a liner keyed into permafrost and a thermosiphon installation. The length of berm construction required is significantly shorter than the presently proposed design, with containment chiefly achieved by the valley walls.*
9 - (Wood) Containment Berm Across Valley (Upstream Flow Containment)	*Design [* Option 9*] is the same as [* Option 8*], except that the catchment area flows upstream of the truck discharge area would be directed into the lagoon and discharge through the decanting system.* *Assessment would be required to confirm the hydrological aspects of the system (storage requirements, water balance) and wetland treatment efficiency.*



HAMLET OF NAUJAAT

CONCEPTUAL WWTF

CONCEPTUAL SITE LOCATIONS

FIGURE 1 - OPTION 1 (FULLY LINED SINGLE LAGOON NEAR LANDFILL)

- CONCEPTUAL SITE LOCATION
- EXISTING DISCHARGE LOCATION
- EXISTING DUMPSITE
- EXISTING QUARRY
- EXISTING ROADWAY/TRAIL
- EXISTING WATERBODY
- EXISTING WATERCOURSE
- EXISTING BUILDING FOOTPRINT
- MAJOR 5 METRE CONTOURS
- MINOR 1 METRE CONTOURS

0 25 50 100 m

SCALE 1:2,500

N

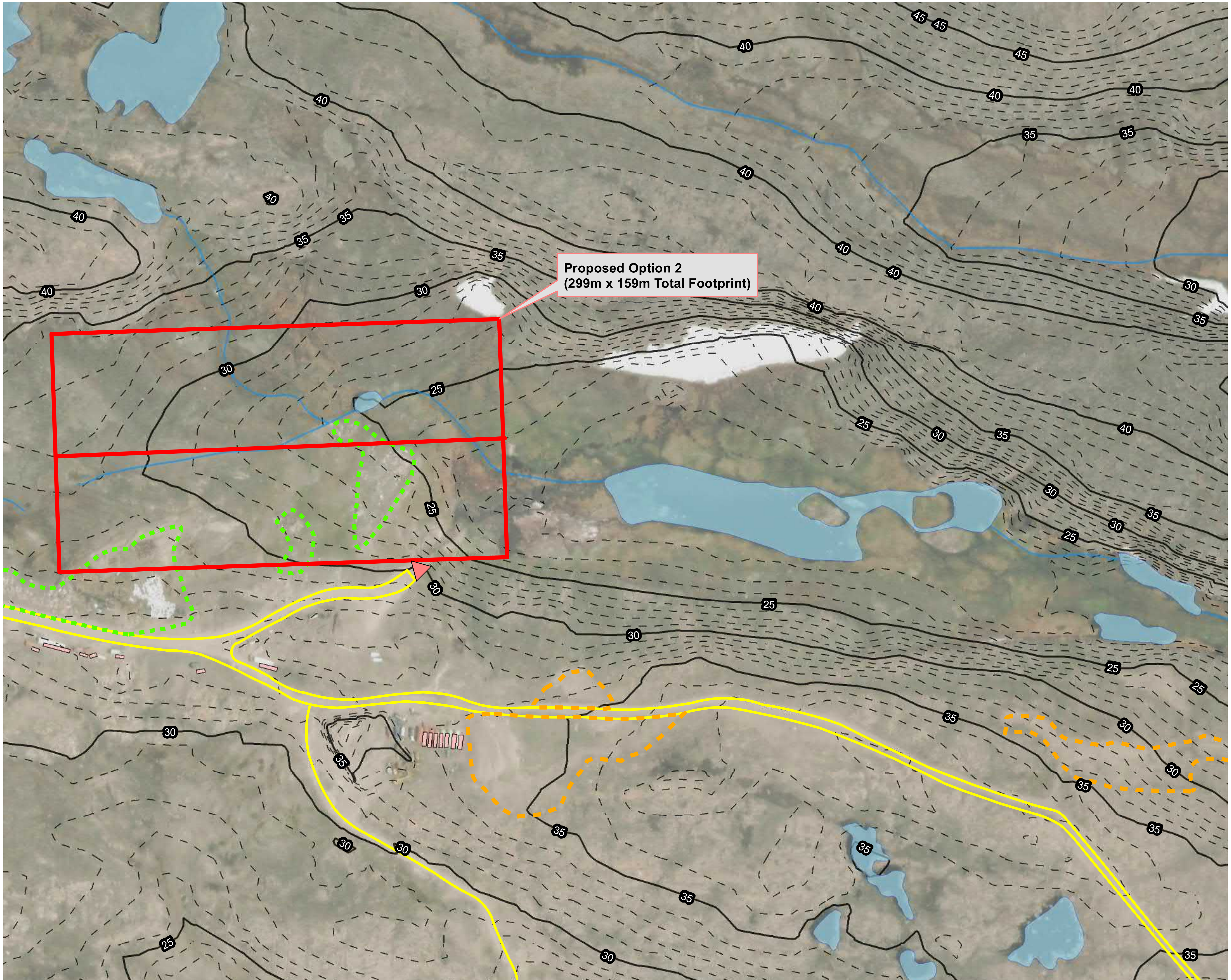
MAP DRAWING INFORMATION:
DATA PROVIDED BY DILLON CONSULTING LIMITED, ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

MAP CREATED BY: BS
MAP CHECKED BY: JH
MAP PROJECTION: NAD 1983 UTM Zone 16N

FILE LOCATION: \\DILLON.CA\DILLON_DFS\CALGARY\CALGARY CAD\GIS

DILLON CONSULTING

PROJECT: 21-2233
STATUS: DRAFT
DATE: JULY 2021



HAMLET OF NAUJAAT

CONCEPTUAL WWTF

CONCEPTUAL SITE LOCATIONS

FIGURE 2 - OPTION 2 (TWO 6 MONTH RETENTION LAGOONS SEPERATED BY BERM OR CURTAIN)

CONCEPTUAL SITE LOCATION

EXISTING DISCHARGE LOCATION

EXISTING DUMPSITE

EXISTING QUARRY

EXISTING ROADWAY/TRAIL

EXISTING WATERBODY

EXISTING WATERCOURSE

EXISTING BUILDING FOOTPRINT

MAJOR 5 METRE CONTOURS

MINOR 1 METRE CONTOURS

0 25 50 100 m

SCALE 1:2,500

N

MAP DRAWING INFORMATION:
DATA PROVIDED BY DILLON CONSULTING LIMITED, ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

MAP CREATED BY: BS
MAP CHECKED BY: JH
MAP PROJECTION: NAD 1983 UTM Zone 16N

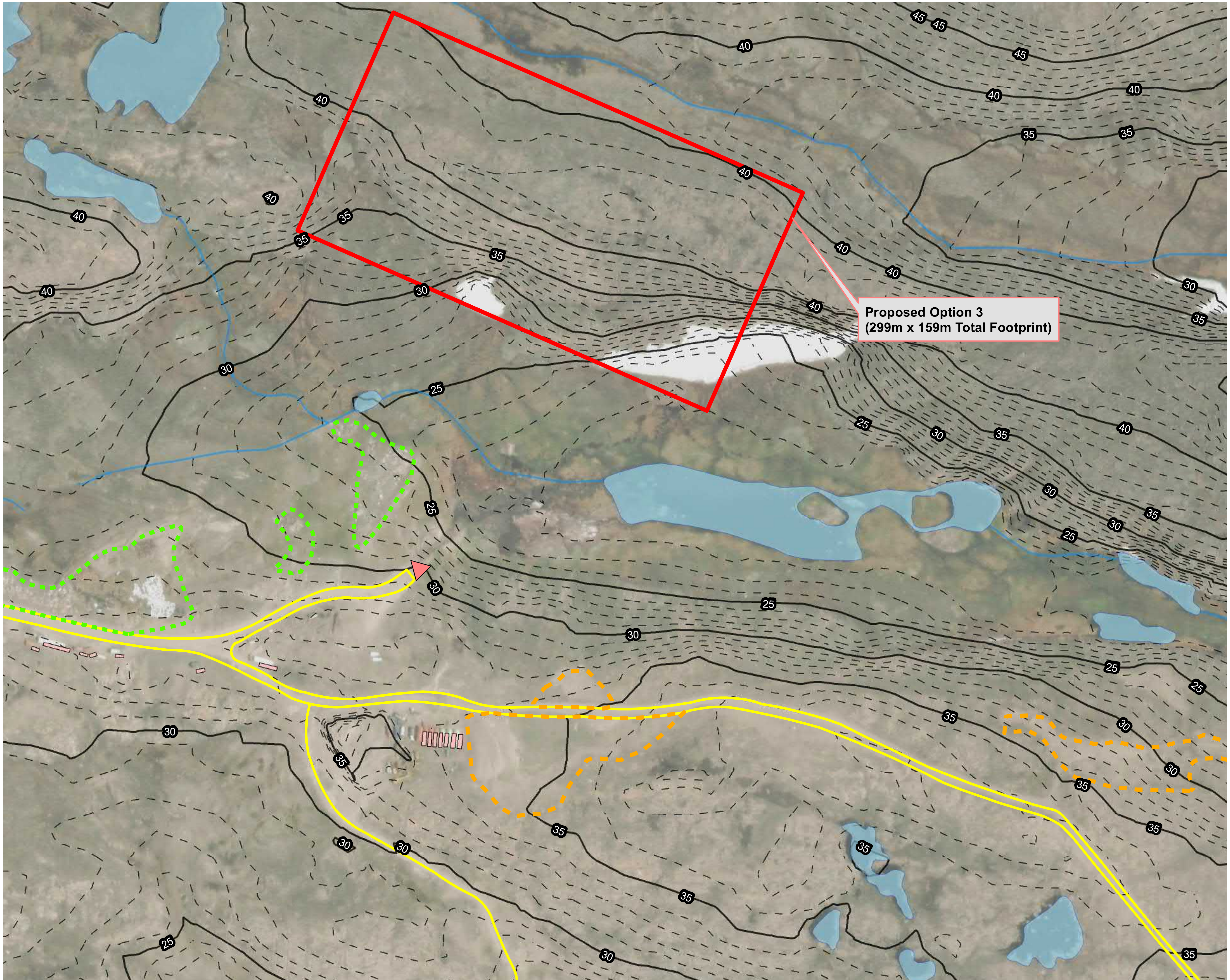
FILE LOCATION: \\DILLON.CA\DILLON_DFS\CALGARY\CALGARY CAD\GIS

DILLON CONSULTING

PROJECT: 21-2233

STATUS: DRAFT

DATE: JULY 2021



HAMLET OF NAUJAAT
CONCEPTUAL WWTF

CONCEPTUAL SITE LOCATIONS

FIGURE 3 - OPTION 3 (SINGLE CELL LAGOON)

CONCEPTUAL SITE LOCATION
EXISTING DISCHARGE LOCATION
EXISTING DUMPSITE
EXISTING QUARRY
EXISTING ROADWAY/TRAIL
EXISTING WATERBODY
EXISTING WATERCOURSE
EXISTING BUILDING FOOTPRINT
MAJOR 5 METRE CONTOURS
MINOR 1 METRE CONTOURS

0 25 50 100 m
SCALE 1:2,500

MAP DRAWING INFORMATION:
DATA PROVIDED BY DILLON CONSULTING LIMITED, ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

MAP CREATED BY: BS
MAP CHECKED BY: JH
MAP PROJECTION: NAD 1983 UTM Zone 16N

FILE LOCATION: \\DILLON.CA\DILLON_DFS\CALGARY\CALGARY CAD\GIS

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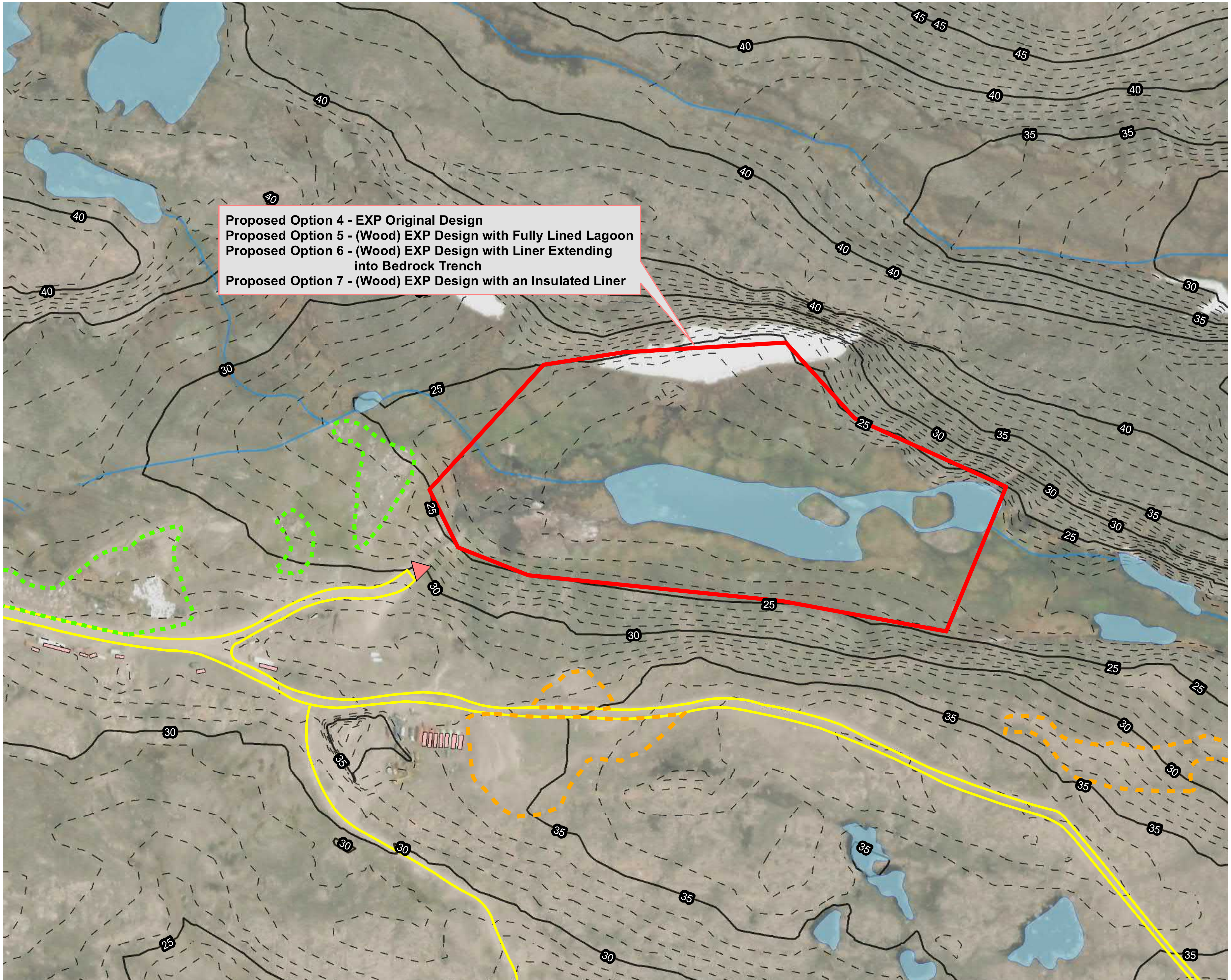
PROJECT: 21-2233
STATUS: DRAFT
DATE: JULY 2021

HAMLET OF NAUJAAT
CONCEPTUAL WWTF

CONCEPTUAL SITE LOCATIONS
FIGURE 4 - OPTION 4, OPTION 5, OPTION 6, & OPTION7



- CONCEPTUAL SITE LOCATION
- EXISTING DISCHARGE LOCATION
- EXISTING DUMPSITE
- EXISTING QUARRY
- EXISTING ROADWAY/TRAIL
- EXISTING WATERBODY
- EXISTING WATERCOURSE
- EXISTING BUILDING FOOTPRINT
- MAJOR 5 METRE CONTOURS
- MINOR 1 METRE CONTOURS

NOTE:
EXP AND WOOD DESIGNS ARE WITH AN INCREASED FOOTPRINT TO ACCOMMODATE THE 12 MONTH STORAGE REQUIREMENTS TO THE YEAR 2043.

0 25 50 100 m
SCALE 1:2,500

N

MAP DRAWING INFORMATION:
DATA PROVIDED BY DILLON CONSULTING LIMITED, ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

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FILE LOCATION: \\DILLON.CA\DILLON_DFS\CALGARY\CALGARY CAD\GIS

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PROJECT: 21-2233
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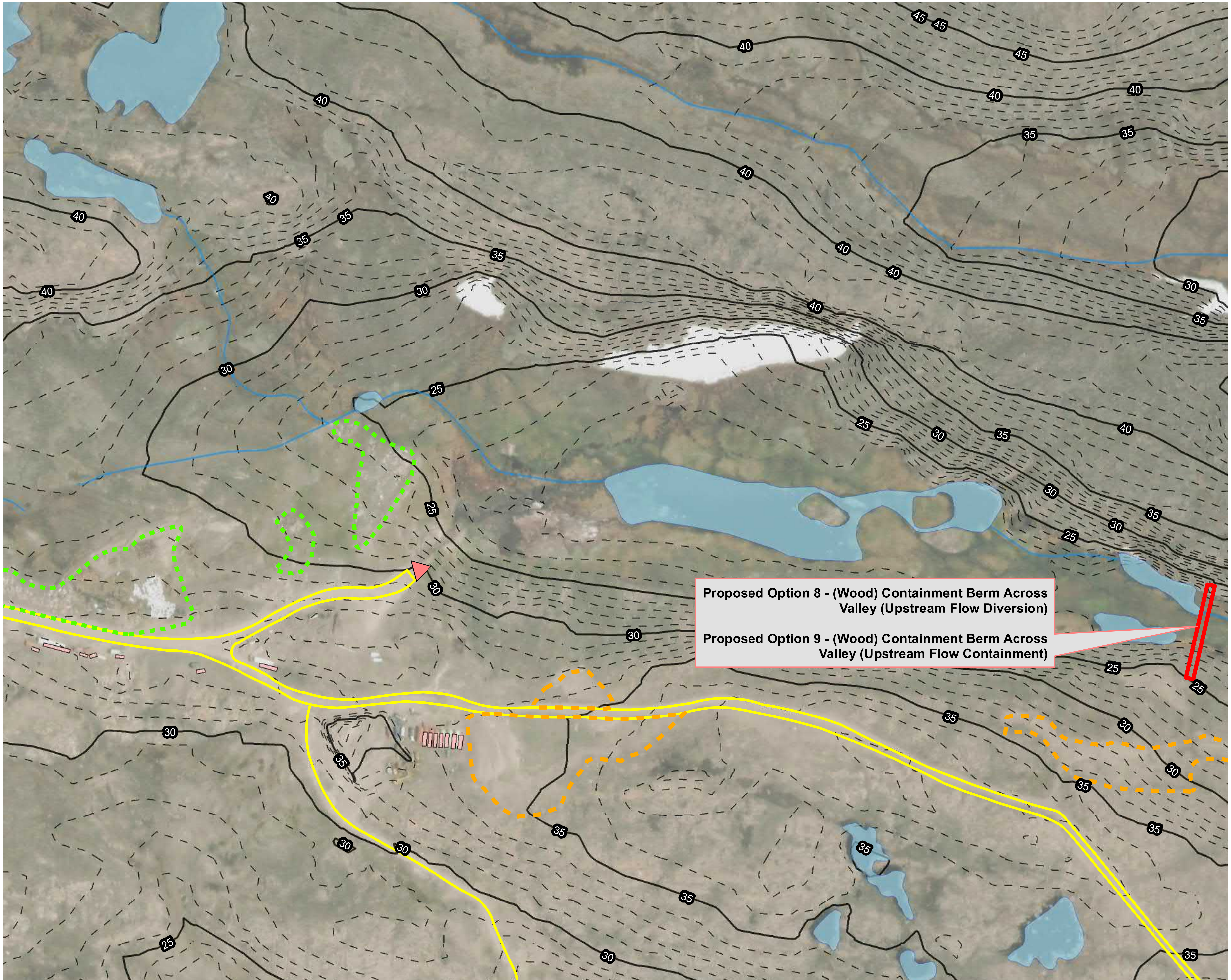
DATE: JULY 2021



HAMLET OF NAUJAAT

CONCEPTUAL WWTF

CONCEPTUAL SITE LOCATIONS

FIGURE 5 - OPTION 8 & OPTION 9

- CONCEPTUAL SITE LOCATION
- EXISTING DISCHARGE LOCATION
- EXISTING DUMPSITE
- EXISTING QUARRY
- EXISTING ROADWAY/TRAIL
- EXISTING WATERBODY
- EXISTING WATERCOURSE
- EXISTING BUILDING FOOTPRINT
- MAJOR 5 METRE CONTOURS
- MINOR 1 METRE CONTOURS

0 25 50 100 m

SCALE 1:2,500

N

MAP DRAWING INFORMATION:
DATA PROVIDED BY DILLON CONSULTING LIMITED,
ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS,
CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN,
AND THE GIS USER COMMUNITY

MAP CREATED BY: BS
MAP CHECKED BY: JH
MAP PROJECTION: NAD 1983 UTM Zone 16N

FILE LOCATION: \\DILLON.CA\DILLON_DFS\CALGARY\CALGARY CAD\GIS

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PROJECT: 21-2233

STATUS: DRAFT

DATE: JULY 2021

Appendix B

Schematic Design Memo

Memo

To: Ashwani Sharma, Project Manager

From: Keith Barnes, Project Manager

cc: Roberto Woisky, Wayne Thistle, David Brown, Sarah Collins

Date: October 12, 2021

Subject: Naujaat WWTF – Alternative Schematic Design Options R1

Our File: File #21-2233

1. Introduction

Dillon Consulting (Dillon) has completed schematic design drawings for five options as discussed with the Project Team on August 11, 2021. The following four options were carried forward from the weighted factor analysis:

- Schematic Design 1 (Option #1) – Fully Lined Single Cell Lagoon north of Former Landfill, Hybrid of Option #1 and #3
- Schematic Design 2 (Option #3) – Single Cell Lagoon North of Existing Wastewater Disposal Site
- Schematic Design 3 (Option #5) – (Wood) EXP Design with Fully Lined Lagoon
- Schematic Design 4 (Option #8) – (Wood) Containment Berm Across Valley (Upstream Flow Diversion)

Charlie Pogue of Dillon and David Browne of the Government of Nunavut (GN) attended a site visit to the Hamlet of Naujaat (Hamlet) on September 21-23, 2021 to complete initial site reconnaissance and investigate the four schematic design locations to determine the feasibility of each design. In discussion with Hamlet officials, Dillon gathered local knowledge of the proposed locations and developed an understanding of the Hamlet's operating procedures, concerns and objectives. This included any concerns related to land and marine activities such as travel, recreation and/or harvesting that may be impacted by the project. From the site visit, Dillon and GN staff identified a 5th schematic design for consideration located north of Option 1. The following option will be considered as part of the schematic design analysis:

- Schematic Design 5 (Option #1A) – Fully Lined Single Cell Lagoon north of Option #1 Footprint

2. Cost Estimates

Altus provided Class 'D' cost estimates (attached) for each of the five schematic design options. The assumptions for the cost estimate include:

- Option 1: 50-70% blasting required;
- Option 1A: 30-50% blasting required;
- Option 3: 50-70% blasting required;
- Option 5: 30-50% blasting required;
- Option 8: 0-20% blasting required; and,

- All excavated material will be hauled away, while fill for lagoon berms will come from quarry site located 8-10 km away, with material that only requires screening.

3. Extent of Wetland

The wetland extends approximately 1.5 km south from the existing wastewater disposal site. The water level appeared average to high during the site visit. Local operations staff noted that the community received a large volume of rainfall throughout the summer. There was emergent vegetation noted throughout the wetland along the valley floor towards the ocean in most locations.

4. Recommendations

Dillon updated the weighted factor analysis from the conceptual design phase of the project looking at Options 1, 1A, 3, 5 and 8. Based on the outcome of the weighted factor analysis and the site investigation, the recommended lagoon footprints are **Options 1A and 5**. If Option 1A is chosen as the preferred alternative, further investigations will be required to confirm suitability of this location.

The major discussion points relating to Option 1A include:

- Located in the flattest area of the proposed lagoon area, with minimal upfront flow diversion.
- It is suspected that less blasting of bed rock will be required at this location.
- Further investigations are required at this location including geotechnical assessment, bird hazard assessment and topographic survey.
- Delineation of solid waste area to be confirmed by geotechnical team. Visible waste site appears to be outside of lagoon footprint, need to confirm whether any waste is buried further west towards the proposed footprint.

The major discussion points relating to Option 5 include:

- Investigations have been completed at this location including geotechnical, bird hazard assessment and topographic survey meaning that detailed design could progress sooner than Option 1A.

- Confirm with geotechnical sub-consultant the implications of building berms in the valley on areas of standing water.

The comparison matrix, weighted factor analysis, schematic design drawings and cost estimate are attached for reference.

MUST protect the Public's Health	X
MUST protect the Environment	X
MUST meet the requirements of the Water License	X
MUST under normal operation, have little potential for catastrophic failure	X

Option 1 - Fully Lined Single Lagoon Near Landfill							
	Justification for Ranking	Score	Weight (%)	Weighted Score	Ranking (out of 10)	Weighted Ranking	Total Possible Score
Containment	- Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Constructability	- Runoff diversion required	5	12.5%	0.625	7.5	11.3	15
	- Fully lined lagoon	6	12.5%	0.750			
	- Dewatering not required	10	12.5%	1.250			
	- No thermosyphons required	10	12.5%	1.250			
	- Discharge to existing valley/wetland	10	12.5%	1.250			
	- 50-70% blasting required	4	12.5%	0.500			
	- Additional regulatory/site investigations required	5	12.5%	0.625			
	- No bypass of wastewater disposal required during construction	10	12.5%	1.250			
Life Cycle Cost	- Full HDPE liner system required - 4 constructed berms - Runoff diversion required	2	100%	2.0	2.0	5.0	25
Climate Change Implications	-Requires pumping	5	50%	2.5	7.5	3.8	5
	- Bypass of upstream flow	10	50%	5.0			
Potential Regulatory Acceptance	- Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Ease of Operation	- Requires pumping	5	50%	2.5	6.3	9.4	15
	- No thermosyphons	10	25%	2.5			
	- Fully lined, specialzied sludge removal	5	25%	1.3			
					Total	69.4	100

MUST protect the Public's Health	X
MUST protect the Environment	X
MUST meet the requirements of the Water License	X
MUST under normal operation, have little potential for catastrophic failure	X

Option 1A - Fully Lined Single Lagoon North of Option 1

	Justification for Ranking	Ranking	Weight (%)	Weighted Score	Ranking (out of 10)	Weighted Ranking	Total Possible Score
Containment	-Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Constructability	-Runoff diversion required	5	12.5%	0.6	7.8	11.6	15
	- Fully lined lagoon	6	12.5%	0.8			
	- Dewatering not required	10	12.5%	1.3			
	- No thermosyphons required	10	12.5%	1.3			
	- Discharge to existing valley/wetland	10	12.5%	1.3			
	- 30-50% blasting required	6	12.5%	0.8			
	- Additional regulatory/site investigations required	5	12.5%	0.6			
	- No bypass of wastewater disposal required during construction	10	12.5%	1.3			
Life Cycle Cost	- Full HDPE liner system required - 4 constructed berms - Runoff diversion required	3.1	100%	3.1	3.1	7.7	25
Climate Change Implications	-Requires pumping	5	50%	2.5	7.5	3.8	5
	- Bypass of upstream flow	10	50%	5.0			
Potential Regulatory Acceptance	- Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Ease of Operation	- Requires pumping	5	50%	2.5	6.3	9.4	15
	- No thermosyphons	10	25%	2.5			
	- Fully lined, specialzied sludge removal	5	25%	1.3			
					Total	72.5	100

MUST protect the Public's Health	X
MUST protect the Environment	X
MUST meet the requirements of the Water License	X
MUST under normal operation, have little potential for catastrophic failure	X

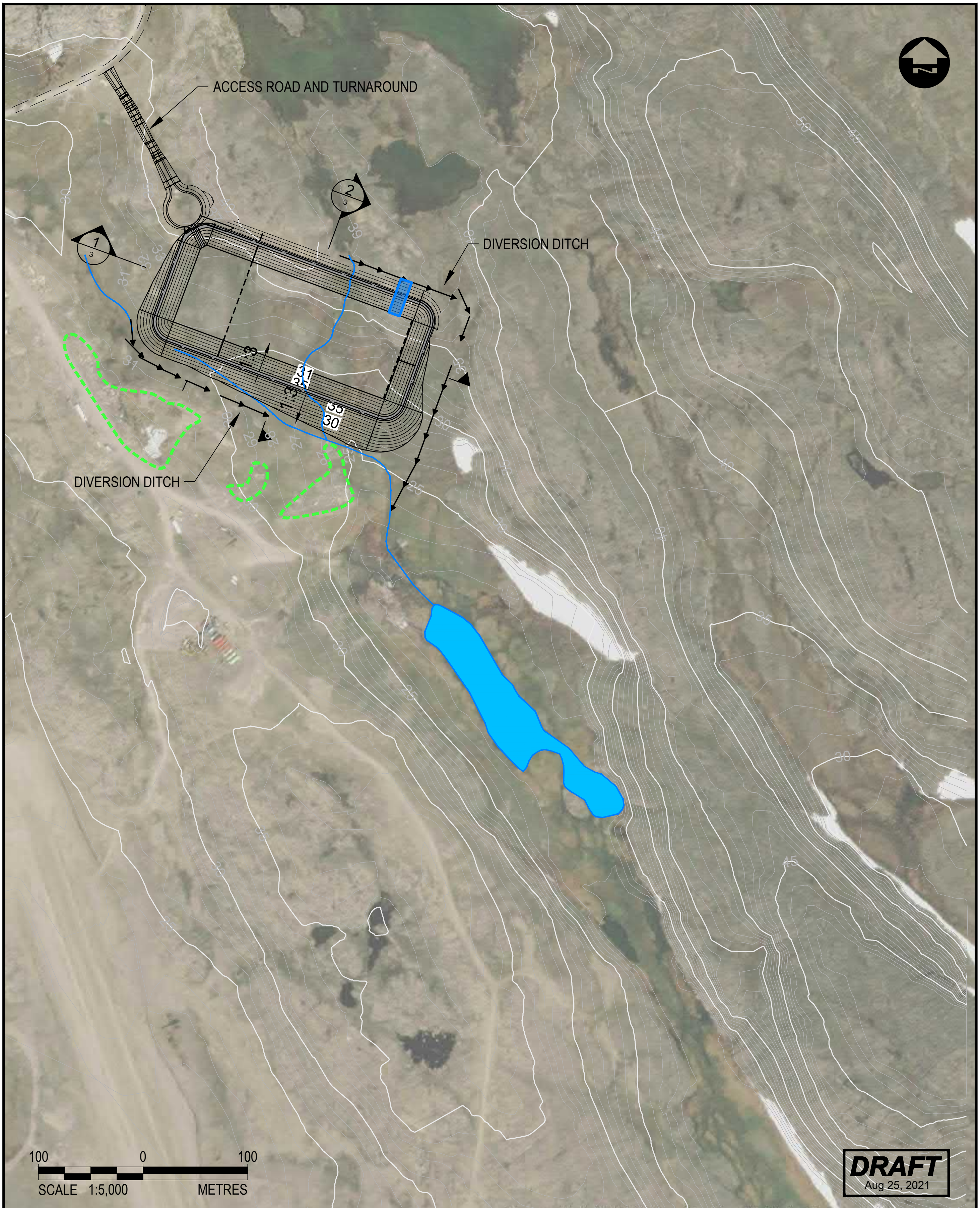
Option 3 - Single Cell Lagoon North of Existing Site							
	Justification for Ranking	Ranking	Weight (%)	Weighted Score	Ranking (out of 10)	Weighted Ranking	Total Possible Score
Containment	-Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Constructability	- Upstream flow diversion required	5	12.5%	0.6	6.4	9.6	15
	- Fully lined lagoon	6	12.5%	0.8			
	- Dewatering is required	6	12.5%	0.8			
	- No Thermosyphons	10	12.5%	1.3			
	- Discharge outside of existing valley/wetland	5	12.5%	0.6			
	- 50-70% blasting required	4	12.5%	0.5			
	- Additional regulatory/site investigations required	5	12.5%	0.6			
	- No bypass of wastewater disposal required during construction	10	12.5%	1.3			
Life Cycle Cost	- Limited information available on soil conditions (permafrost and bedrock) - Additional site development required - Full HDPE liner system required - Additional geotechnical and geothermal investigation required - Access road extension required	3.3	100%	3.3	3.3	8.2	25
Climate Change Implications	-Requires pumping	5	50%	2.5	7.5	3.8	5
	- Bypass of upstream flow	10	50%	5.0			
Potential Regulatory Acceptance	- Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Ease of Operation	- Requires pumping	5	50%	2.5	6.3	9.4	15
	- No thermosyphons	10	25%	2.5			
	- Fully lined, specialzied sludge removal	5	25%	1.3			
					Total	70.9	100

MUST protect the Public's Health	X
MUST protect the Environment	X
MUST meet the requirements of the Water License	X
MUST under normal operation, have little potential for catastrophic failure	X

Option 5 - (Wood) EXP Design with Fully Lined Lagoon							
	Justification for Ranking	Ranking	Weight (%)	Weighted Score	Ranking (out of 10)	Weighted Ranking	Total Possible Score
Containment	-Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Constructability	-Runoff diversion required	5	12.5%	0.6	7.0	10.5	15
	- Fully lined	6	12.5%	0.8			
	- Dewatering is required and berm constructed over standing water	4	12.5%	0.5			
	- No thermosyphons required	10	12.5%	1.3			
	- Discharge to existing valley/wetland	10	12.5%	1.3			
	- 30-50% blasting required	6	12.5%	0.8			
	- Additional regulatory/site investigations not required	10	12.5%	1.3			
	- Bypass of wastewater required during construction	5	12.5%	0.6			
Life Cycle Cost	- Full lined HDPE lagoon - Runoff diversion required - Berms only required on 3 sides	3.4	100%	3.4	3.4	8.5	25
Climate Change Implications	-Requires pumping	5	50%	2.5	7.5	3.8	5
	- Bypass of upstream runoff flow	10	50%	5.0			
Potential Regulatory Acceptance	- Fully lined lagoon	10	100%	10.0	10.0	20.0	20
Ease of Operation	- Requires pumping	5	50%	2.5	6.3	9.4	15
	- No thermosyphons	10	25%	2.5			
	- Fully lined, specialzied sludge removal	5	25%	1.3			
					Total	72.2	100

MUST protect the Public's Health	X
MUST protect the Environment	X
MUST meet the requirements of the Water License	X
MUST under normal operation, have little potential for catastrophic failure	X

Option 8 - (Wood) Containment Berm Across Valley (Upstream Flow Diversion)							
	Justification for Ranking	Ranking	Weight (%)	Weighted Score	Ranking (out of 10)	Weighted Ranking	Total Possible Score
Containment	- Lined berm, keyed into permafrost	5	100%	5.0	5.0	10.0	20
Constructability	- Flow diversion required	5	12.5%	0.6	6.9	10.3	15
	- Lined berm, keyed into permafrost	8	12.5%	1.0			
	- Dewatering required and berm constructed over standing water	4	12.5%	0.5			
	- Thermosyphons required	5	12.5%	0.6			
	- Discharge to existing valley/wetland	10	12.5%	1.3			
	- 0-20% blasting required	8	12.5%	1.0			
	- Additional regulatory/site investigations not required	10	12.5%	1.3			
	- Bypass of wastewater required during construction	5	12.5%	0.6			
Life Cycle Cost	- Small berm construction - 2nd least expensive option - Runoff flow diversion required	10	100%	10.0	10.0	25.0	25
Climate Change Implications	-Requires pumping	5	50%	2.5	7.5	3.8	5
	- Bypass of upstream runoff flow	10	50%	5.0			
Potential Regulatory Acceptance	- Containment berm only	4	100%	4.0	4.0	8.0	20
Ease of Operation	- Pumping required	5	50%	2.5	6.3	9.4	15
	- Thermosyphon inspections	5	25%	1.3			
	- Partially lined, local contractor sludge clean out	10	25%	2.5			
					Total	66.4	100



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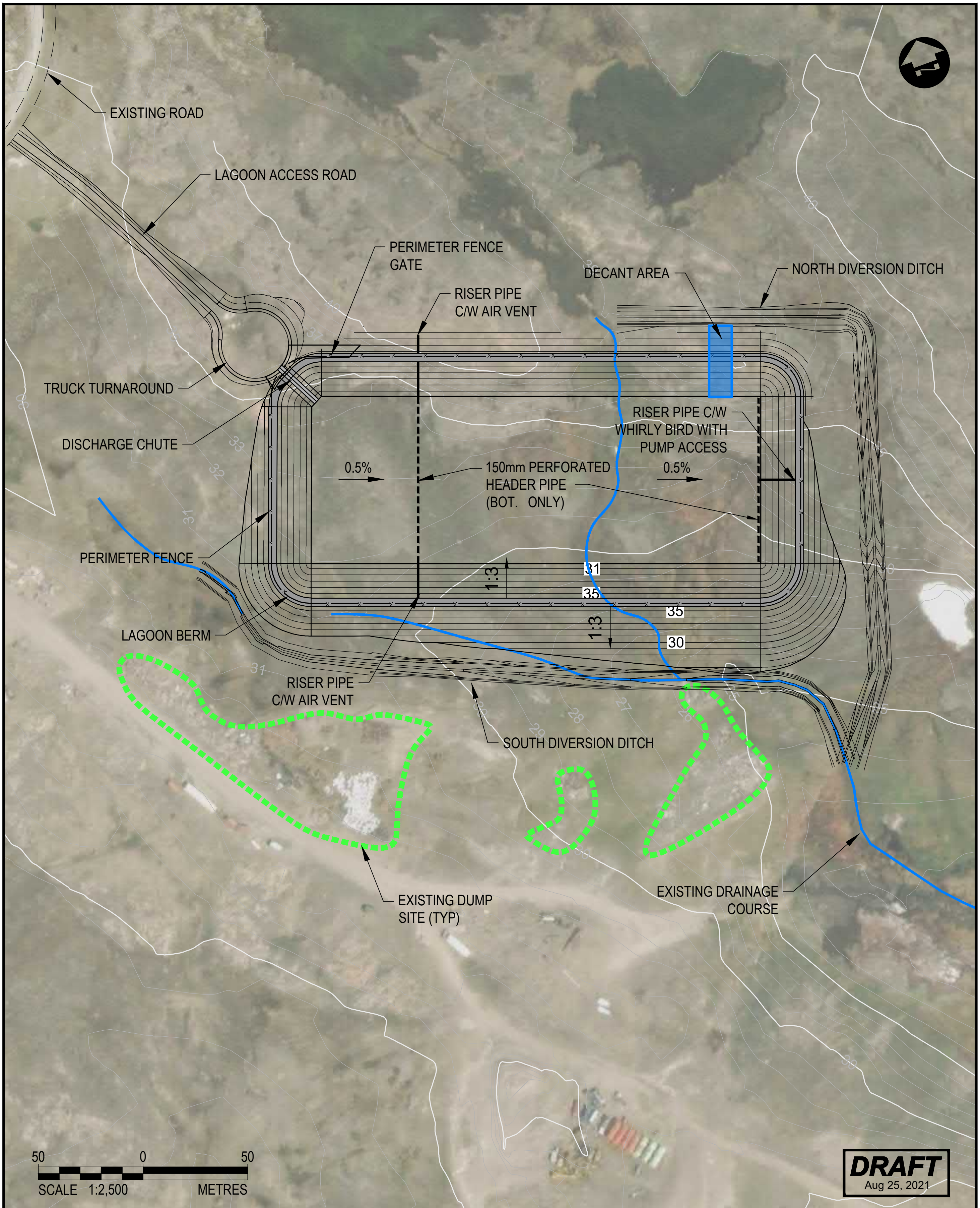
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **LAGOON SITE PLAN**

FIGURE NO. **1**

DATE **August 2021**



DILLON CONSULTING

DATE August 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**

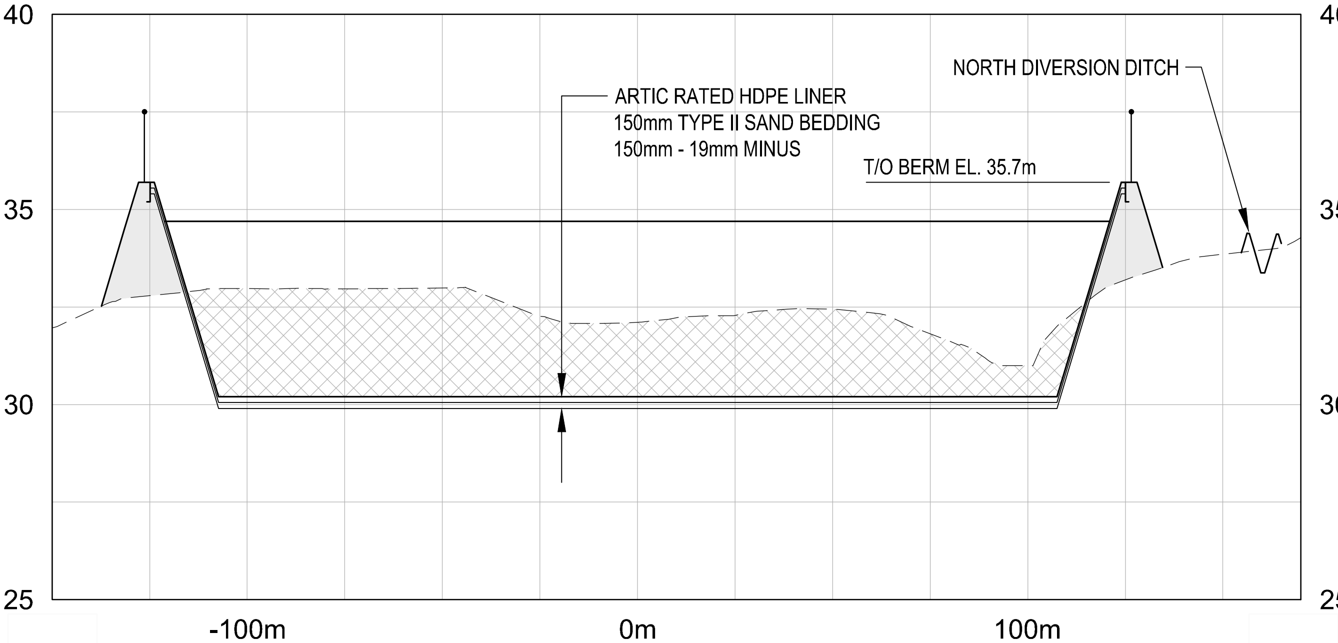
HAMLET OF NAUJAAT, NUNAVUT

TITLE

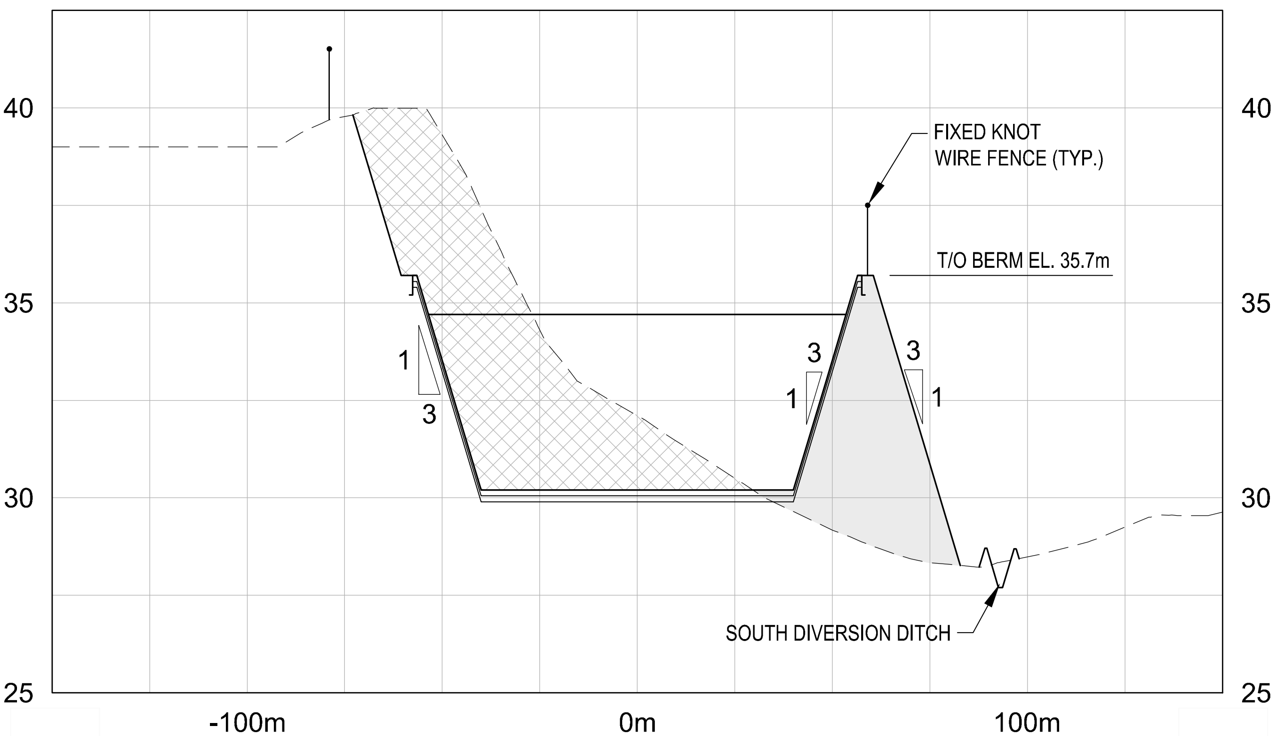
PROJECT NO. **21-2233**

FIGURE NO. **2**

FileName:c:\pw working directory\projects 2021\40skbldms55676\21223-02-site-opt1.dwg



1 SECTION
3 H 1:2000 V 1:200



2 SECTION
3 H 1:2000 V 1:200

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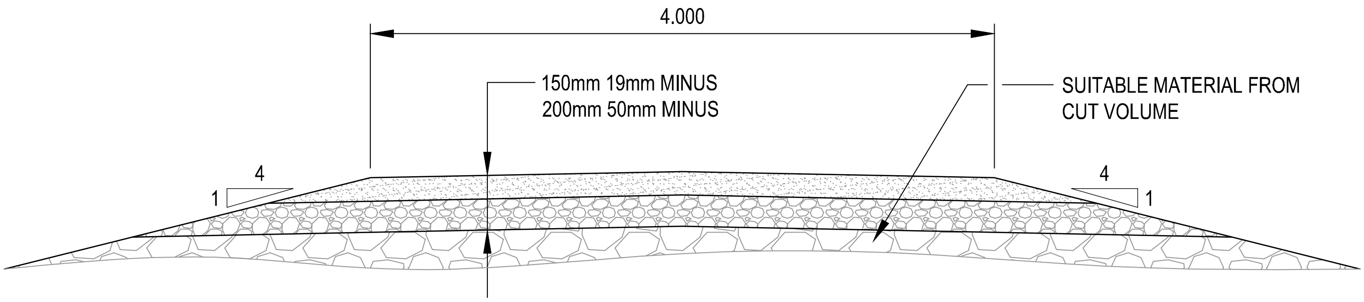
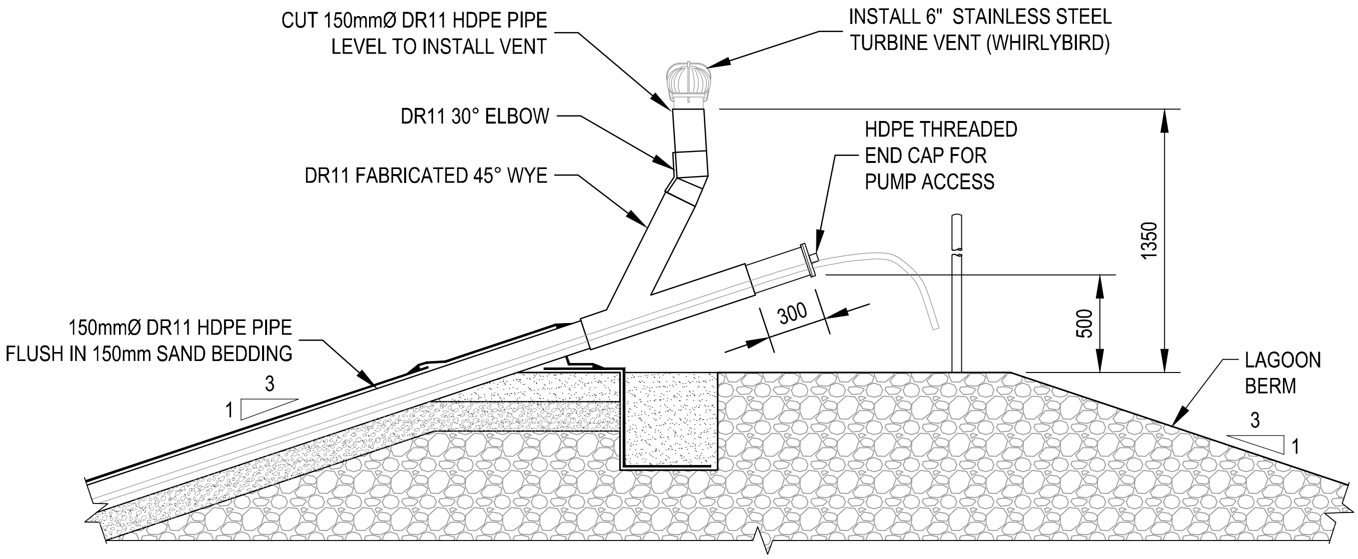
Aug 25, 2021

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt1.dwg

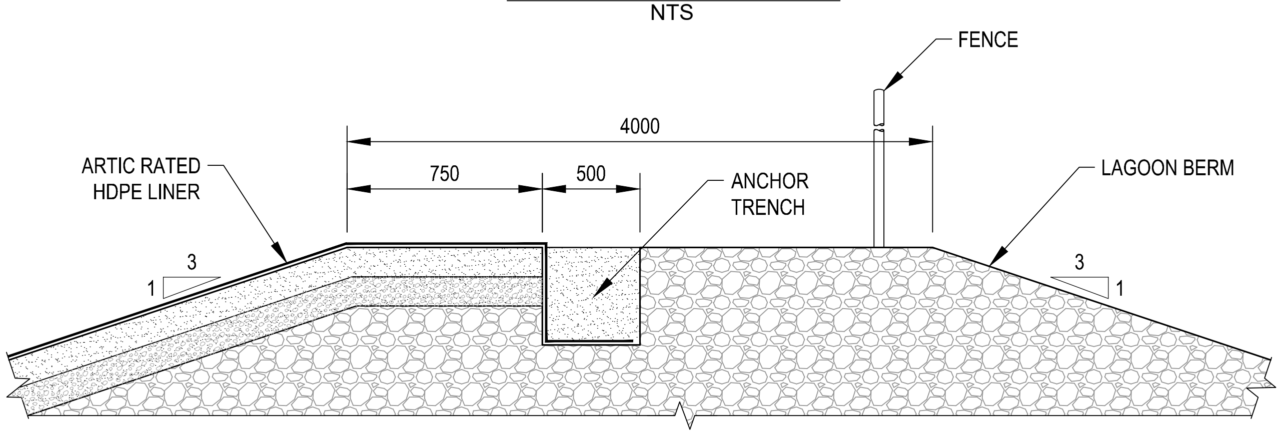
DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
DATE **August 2021**	TITLE **LAGOON SECTIONS**	FIGURE NO. **3**



ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



ANCHOR TRENCH DETAIL
NTS

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PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **DETAILS**

PROJECT NO. **21-2233**

FIGURE NO. **4**

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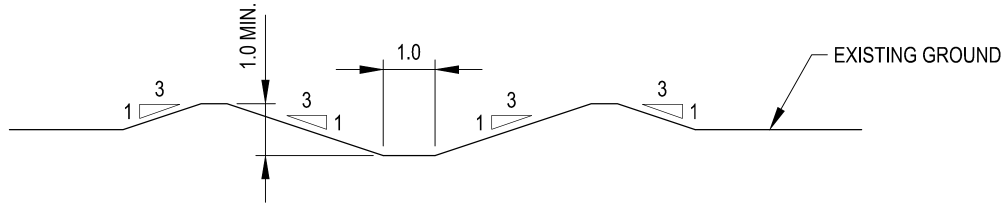
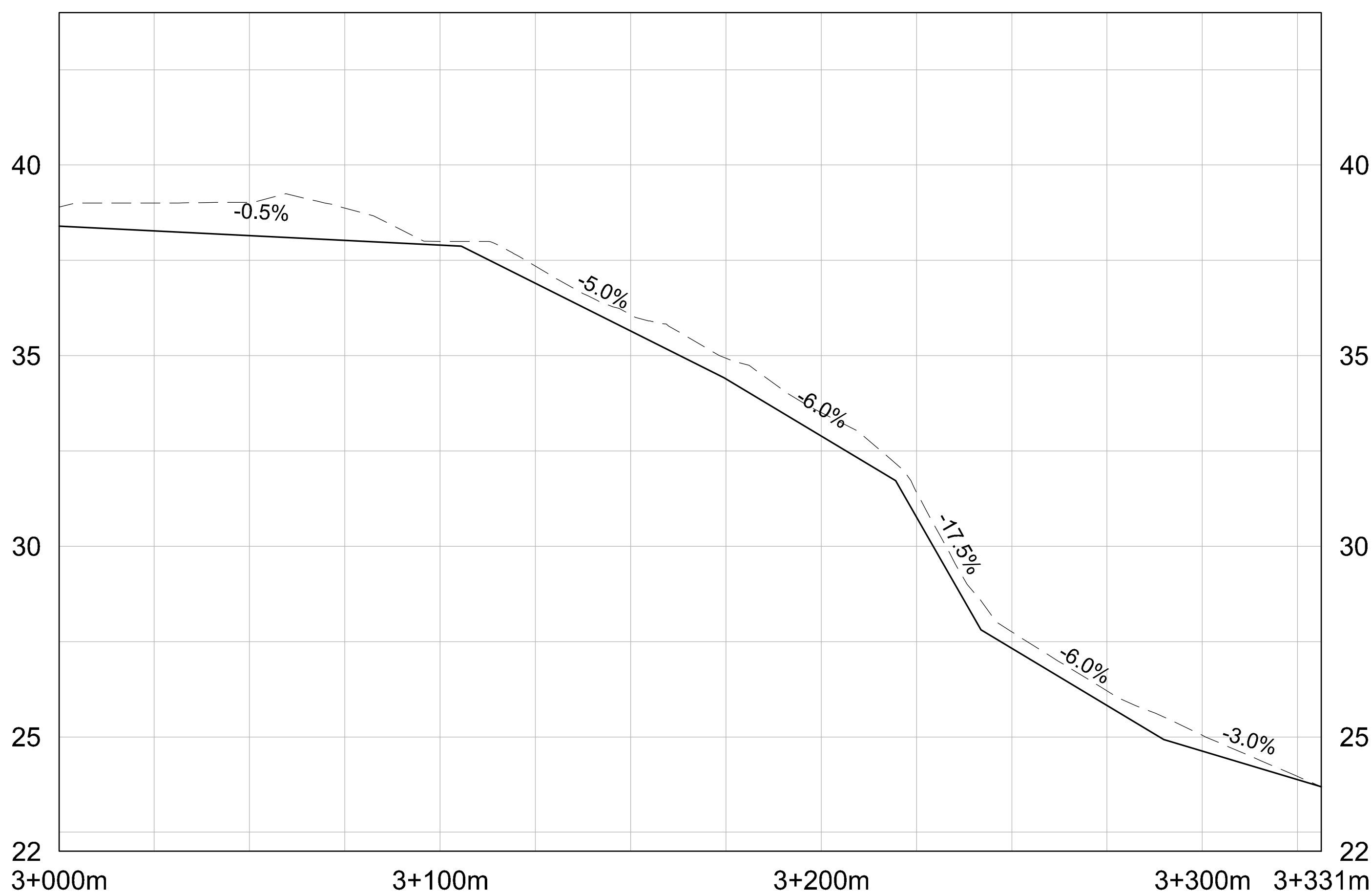


TYPICAL DIVERSION DITCH DETAIL
HOR: 1:2000 VER: 1:200



NORTH DIVERSION DITCH PROFILE
HOR: 1:2000 VER: 1:200

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FileName:c:\pw working directory\projects 2021\40skbldms55676\21223-02-site-opt1.dwg

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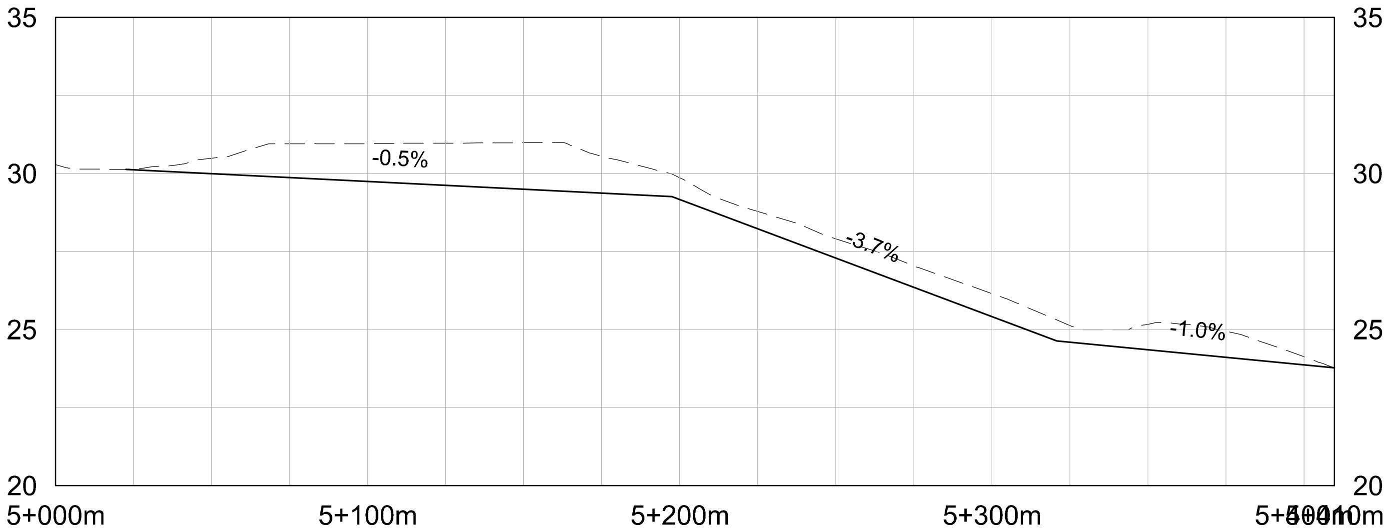
DATE **August 2021**	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
	TITLE **NORTH DIVERSION DITCH PROFILE**	FIGURE NO. **5**



SOUTH DIVERSION DITCH PROFILE

HOR: 1:2000 VER: 1:200

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Aug 25, 2021

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PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1** **HAMLET OF NAUJAAT, NUNAVUT**		PROJECT NO. **21-2233**
DATE **August 2021**	TITLE **SOUTH DIVERSION DITCH PROFILE**	FIGURE NO. **6**

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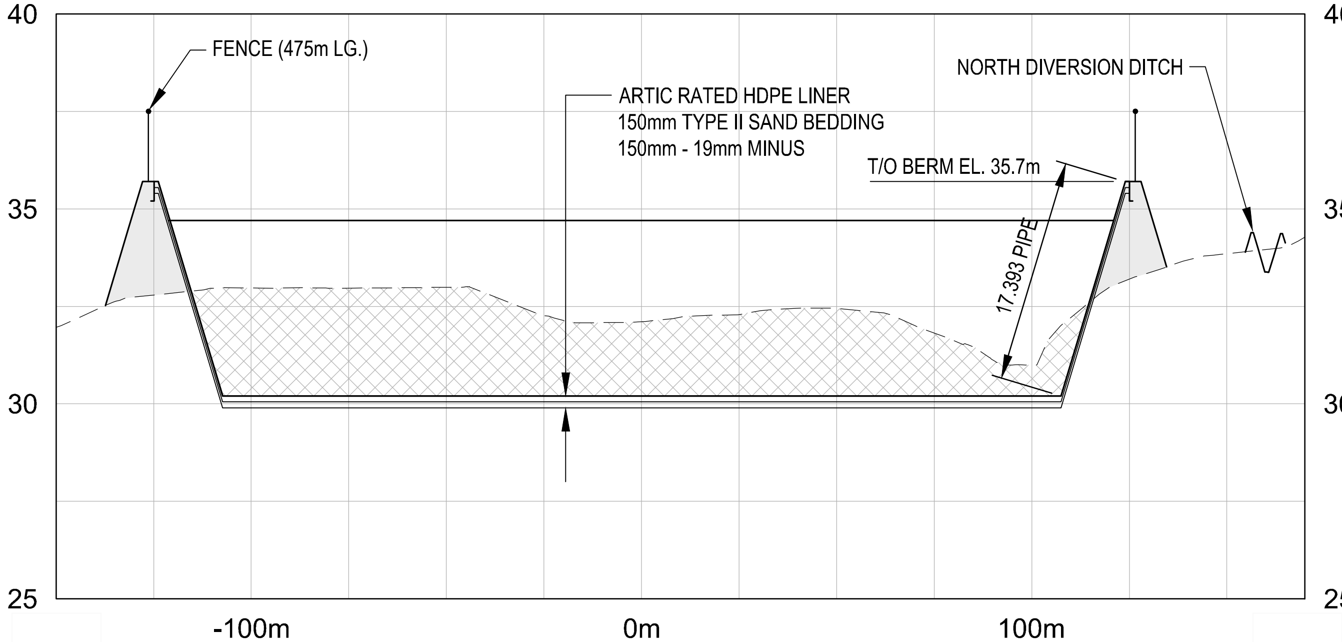
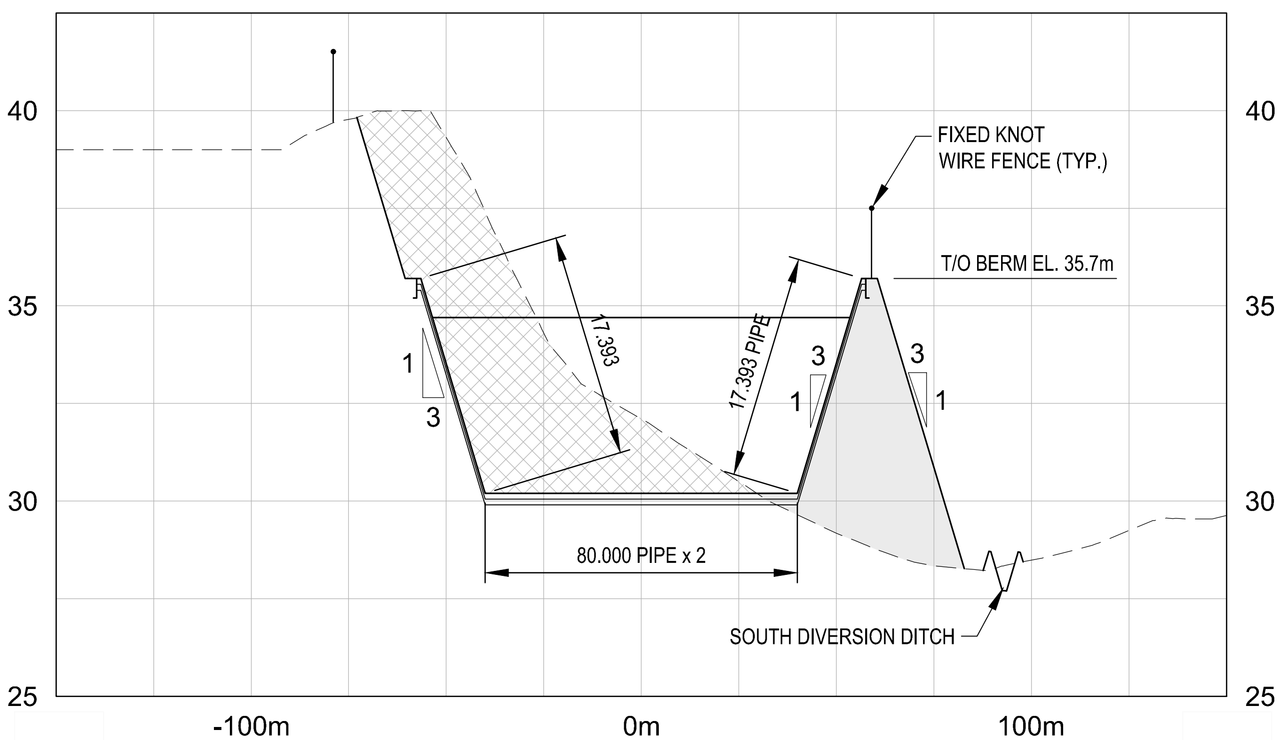


ARTIC RATED HDPE LINER:............................ 29,500m2
TYPE II SAND BEDDING: 29,500 x 0.15 .... 4,425m3
TYPE II 19mm MINUS...4,425m3

150mm HDPE PIPE (PERFORATED)............160m
150mm HDPE PIPE (SLOPES)........................65m
150mm HDPE PIPE (ABOVE T/O BERM)..........9m

LAGOON CUT.....................................70,100m3
LAGOON CONSTRUCTION FILL.......51,400m3
NET (CUT)...18,700m3



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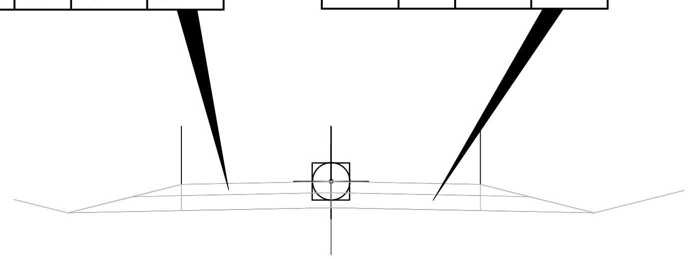
FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt1.dwg

DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **August 2021**	TITLE **QUANTITIES** **LAGOON SECTIONS**	FIGURE NO. **Q-1**

MATERIAL VOLUME PAVEMENT			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
5+000.00	0.70	0.00	0.00
5+020.00	0.70	13.96	13.96
5+030.00	0.70	6.98	20.93
5+035.00	0.70	3.49	24.42
5+040.00	0.70	3.49	27.91
5+060.00	0.70	13.96	41.87
5+080.00	0.70	13.96	55.83
5+100.00	0.70	13.96	69.78
5+105.00	0.70	3.49	73.27
5+110.00	0.70	3.49	76.76
5+115.00	0.70	3.49	80.25
5+120.00	0.70	3.49	83.74
5+125.00	0.70	3.49	87.23
5+130.00	0.00	1.74	88.97
5+135.00	0.00	0.00	88.97
5+140.00	0.00	0.00	88.97
5+160.00	0.00	0.00	88.97

MATERIAL VOLUME SUBBASE			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
5+000.00	1.23	0.00	0.00
5+020.00	1.23	24.70	24.70
5+030.00	1.23	12.35	37.04
5+035.00	1.23	6.17	43.22
5+040.00	1.23	6.17	49.39
5+060.00	1.23	24.70	74.09
5+080.00	1.23	24.70	98.78
5+100.00	1.23	24.70	123.48
5+105.00	1.23	6.17	129.65
5+110.00	1.23	6.17	135.83
5+115.00	1.23	6.17	142.00
5+120.00	1.23	6.17	148.17
5+125.00	1.23	6.17	154.35
5+130.00	0.00	3.09	157.43
5+135.00	0.00	0.00	157.43
5+140.00	0.00	0.00	157.43
5+160.00	0.00	0.00	157.43



20 0 20
SCALE 1:1,000 METRES

DRAFT
Aug 25, 2021

DILLON CONSULTING

DATE **August 2021**

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES**

FIGURE NO. **Q-2**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\21233-02-site-opt1.dwg

South Diversion Ditch Cut Fill
TOTAL VOLUME TABLE

STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
5+000	0.00	0.00	0.00	0.00	0.00	0.00
5+020	0.00	0.00	0.00	0.00	0.00	0.00
5+040	0.00	0.00	0.00	0.00	0.00	0.00
5+060	0.60	2.47	5.97	24.70	5.97	24.70
5+080	0.00	4.83	5.93	73.05	11.90	97.75
5+100	0.00	5.67	0.00	105.13	11.91	202.88
5+120	0.00	6.68	0.00	123.15	11.91	326.03
5+140	0.00	7.65	0.00	143.30	11.91	469.33
5+160	0.00	8.74	0.00	163.96	11.91	633.28
5+180	0.04	4.77	0.41	135.14	12.32	768.42
5+200	1.15	2.23	11.91	70.05	24.23	838.47
5+220	1.48	1.37	26.30	36.10	50.53	874.57
5+240	1.25	1.88	27.33	32.57	77.86	907.14
5+260	0.96	2.07	22.11	39.56	99.96	946.70
5+280	0.83	2.17	17.89	42.40	117.86	989.09
5+300	0.56	2.40	13.90	45.62	131.75	1034.71
5+320	0.64	2.15	11.98	45.50	143.73	1080.21
5+340	1.49	1.45	21.23	36.09	164.97	1116.30
5+360	0.35	3.70	18.19	51.76	183.15	1168.06
5+380	0.59	2.59	8.22	63.85	191.37	1231.91
5+400	4.02	0.48	45.85	30.70	237.22	1262.61

North Diversion Ditch Cut Fill
TOTAL VOLUME TABLE

STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+000	0.00	0.00	0.00	0.00	0.00	0.00
3+020	0.82	2.20	8.18	21.96	8.18	21.96
3+040	0.38	2.82	12.02	50.15	20.20	72.10
3+060	0.01	5.22	3.91	80.39	24.11	152.49
3+080	0.83	2.34	8.35	75.62	32.46	228.11
3+100	6.39	0.13	72.16	24.70	104.62	252.81
3+120	1.98	1.22	80.16	13.59	184.78	266.40
3+140	2.75	0.75	46.48	19.76	231.27	286.16
3+160	1.12	1.87	38.65	26.17	269.91	312.32
3+180	1.11	2.07	22.34	39.40	292.26	351.72
3+200	1.29	1.76	24.09	38.28	316.35	390.00
3+220	2.50	1.23	37.95	29.81	354.30	419.81
3+240	1.14	1.90	36.40	31.26	390.70	451.07
3+260	2.49	1.00	36.29	29.00	426.99	480.08
3+280	2.15	1.17	46.42	21.70	473.41	501.78
3+300	2.88	0.83	50.46	20.05	523.87	521.82

DRAFT
Aug 25, 2021

DILLON CONSULTING

DATE August 2021

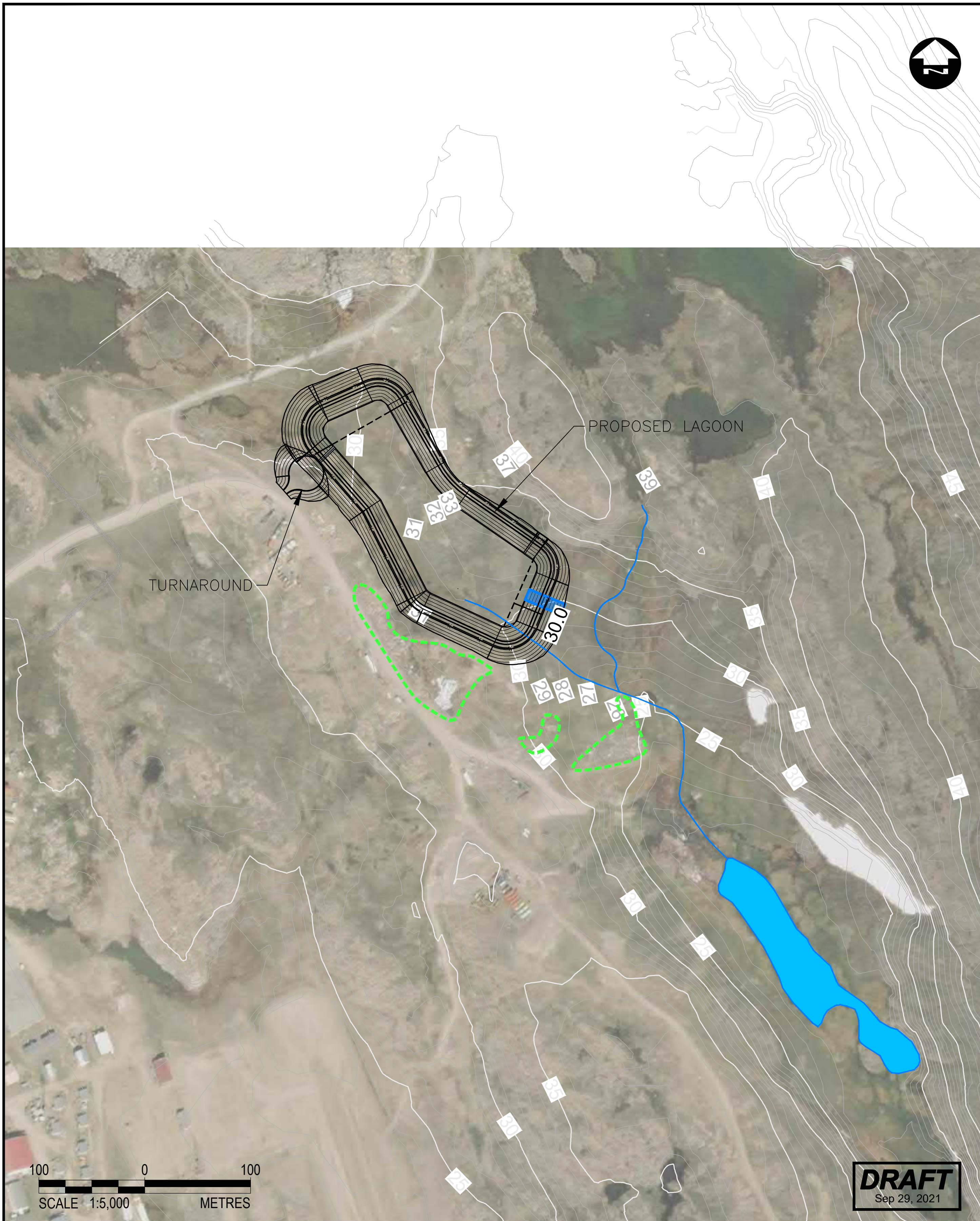
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES DIVERSION DITCHES**

FIGURE NO. **Q-3**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt1.dwg



DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1A**
HAMLET OF NAUJAAT, NUNAVUT

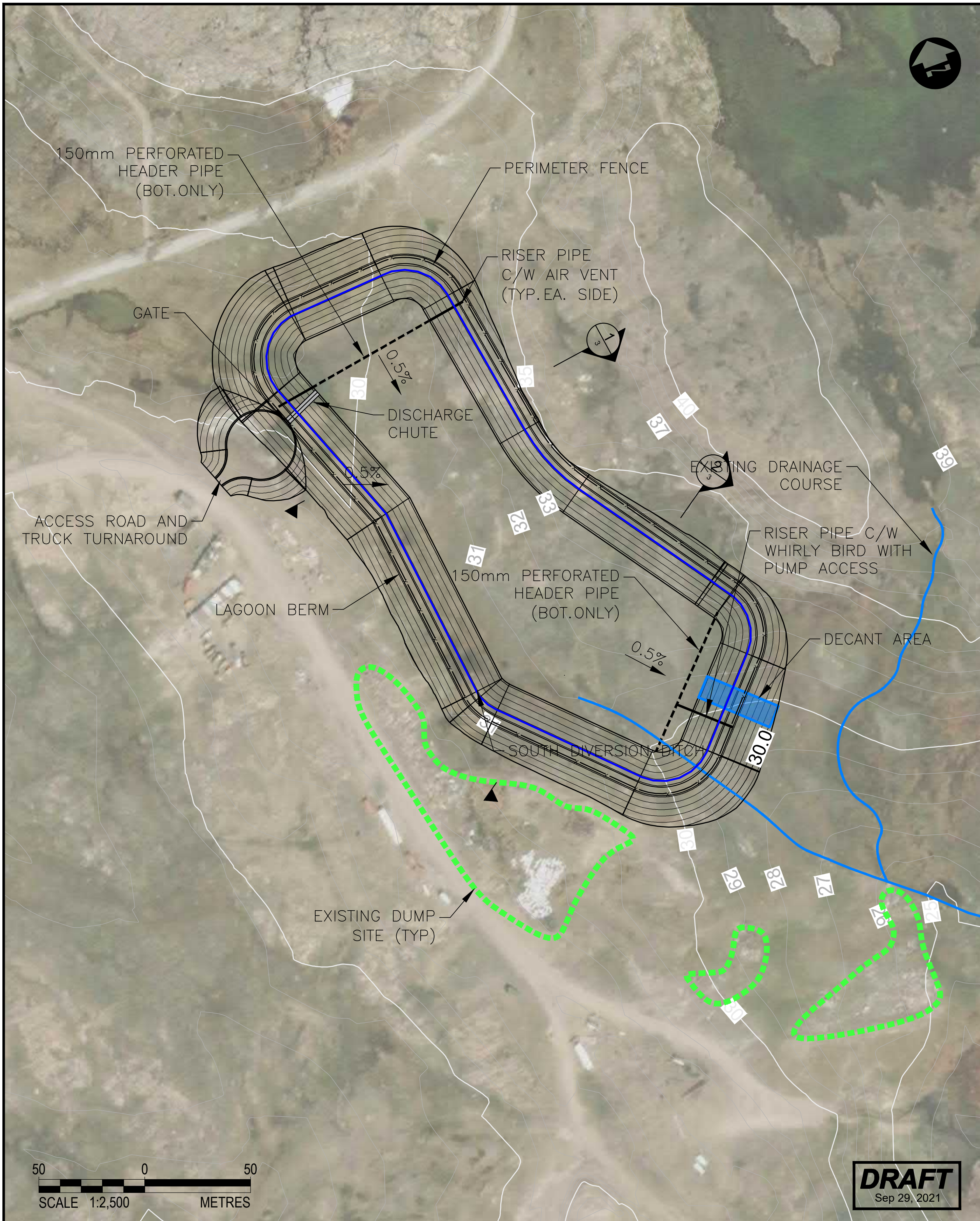
PROJECT NO. **21-2233**

TITLE **LAGOON SITE PLAN**

FIGURE NO. **1**

DATE **September 2021**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt1(r1).dwg



FileName:c:\pw working directory\projects 2021\40skb\dms55676\21233-02-site-opt1(r1).dwg

DILLON CONSULTING

DATE September 2021

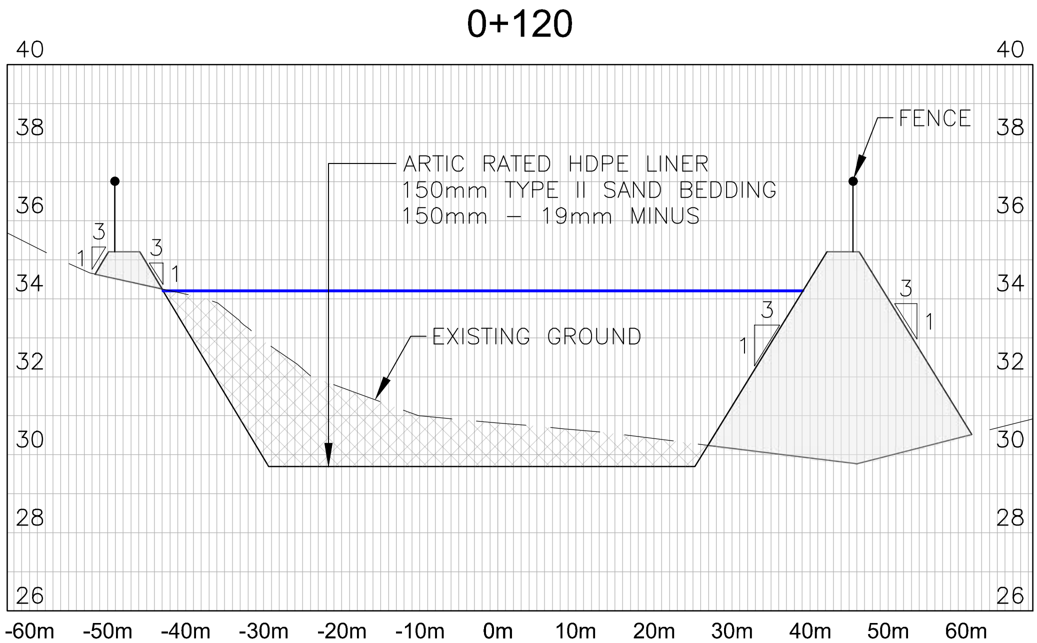
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**

HAMLET OF NAUJAAT, NUNAVUT

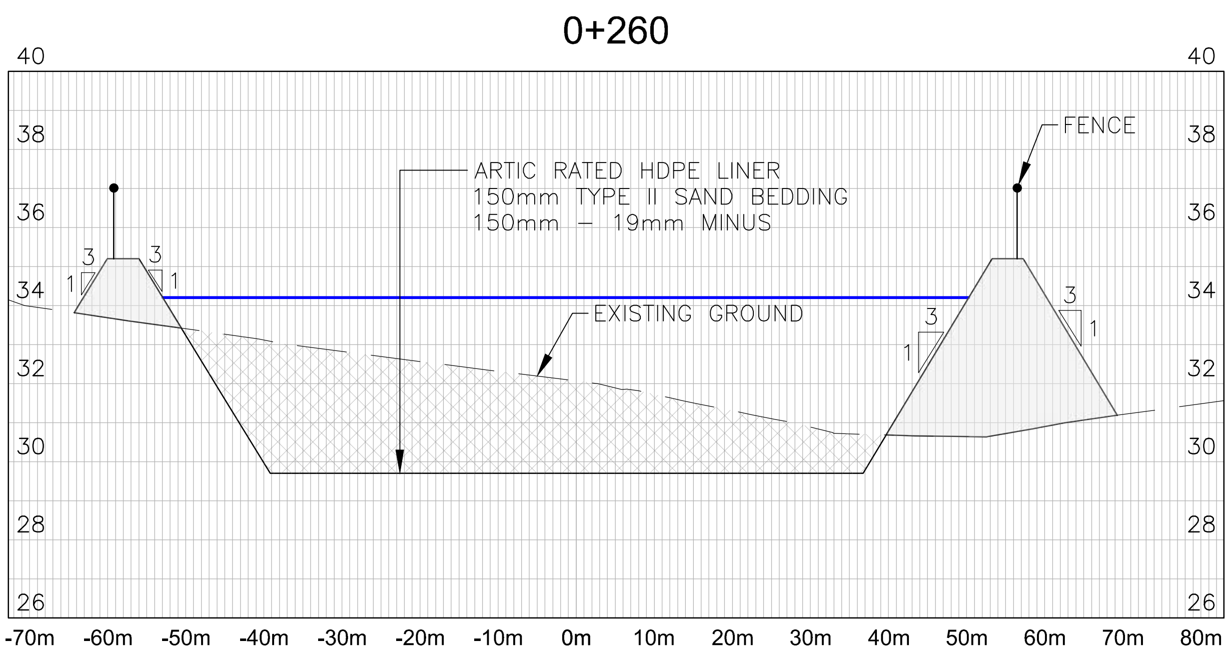
PROJECT NO. **21-2233**

TITLE **LAGOON PLAN**

FIGURE NO. **2**



1 SECTION
3

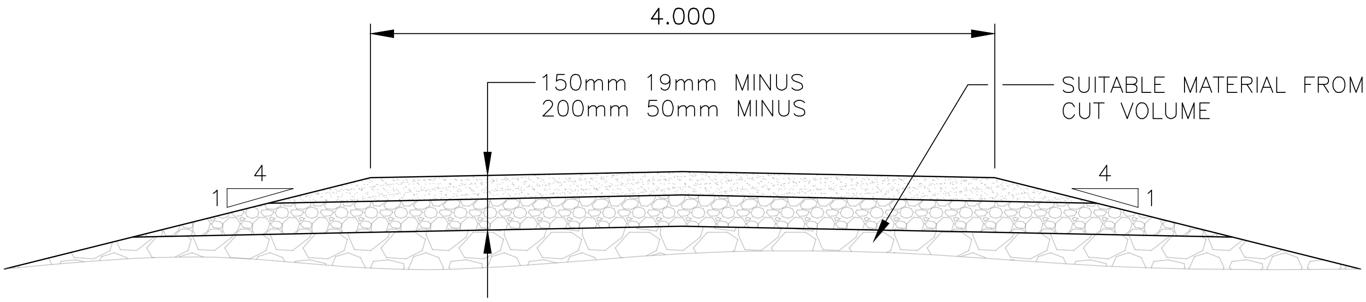


2 SECTION
3

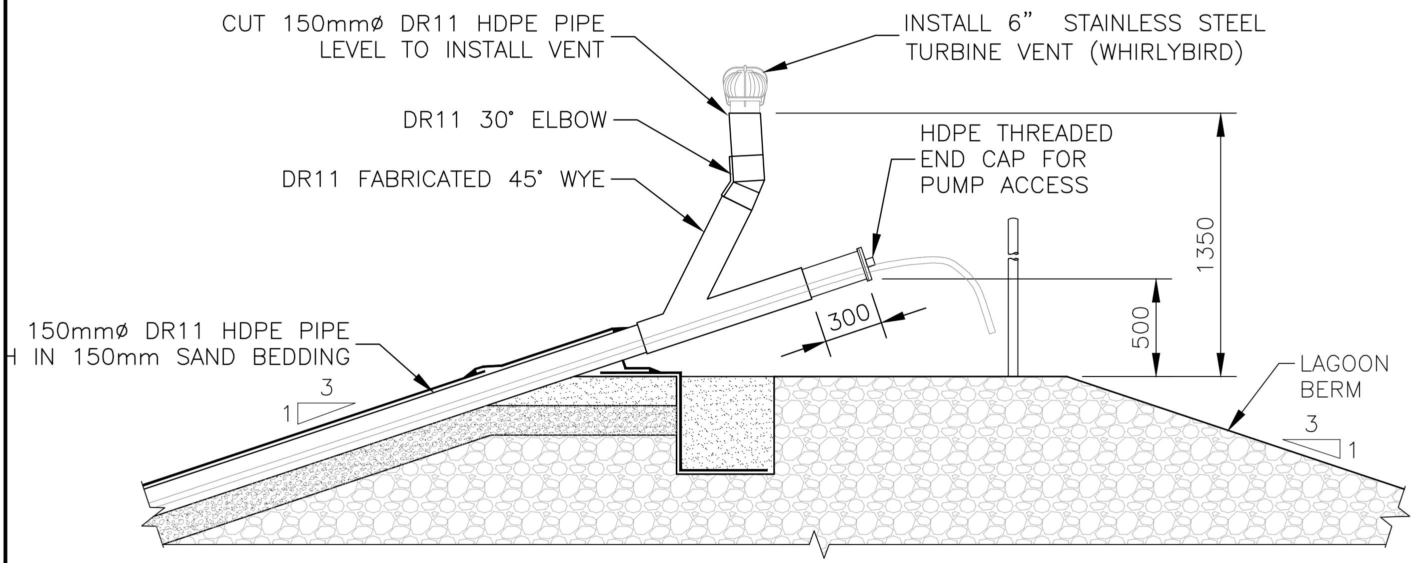
DRAFT
Sep 29, 2021

FileName:c:\pw working directory\projects 2021\40skb\dms55676\21233-02-site-opt1(r1).dwg

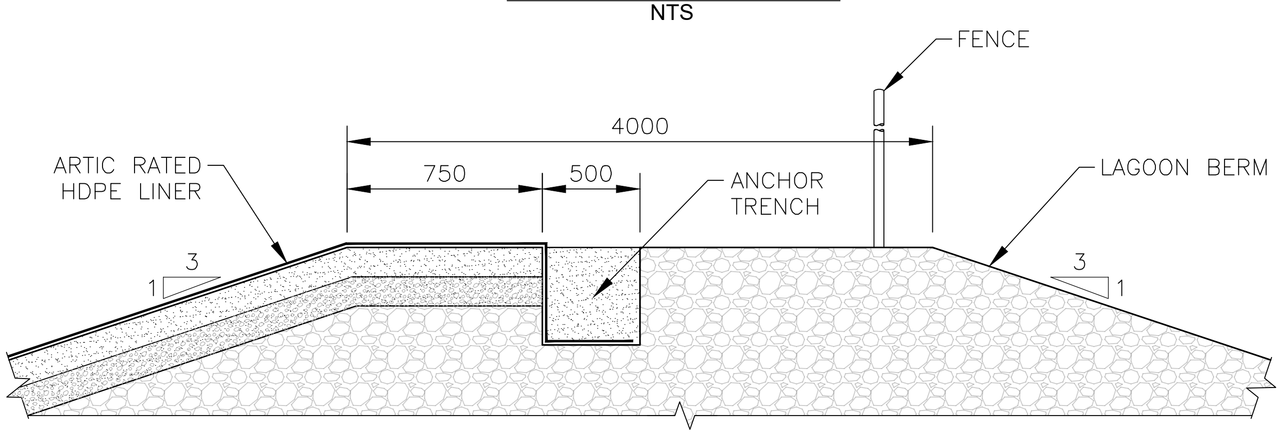
DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
DATE **September 2021**	TITLE **LAGOON SECTIONS**	FIGURE NO. **3**



ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



ANCHOR TRENCH DETAIL
NTS

DRAFT
Sep 29, 2021

DILLON CONSULTING

DATE September 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **DETAILS**

PROJECT NO. **21-2233**

FIGURE NO. **4**

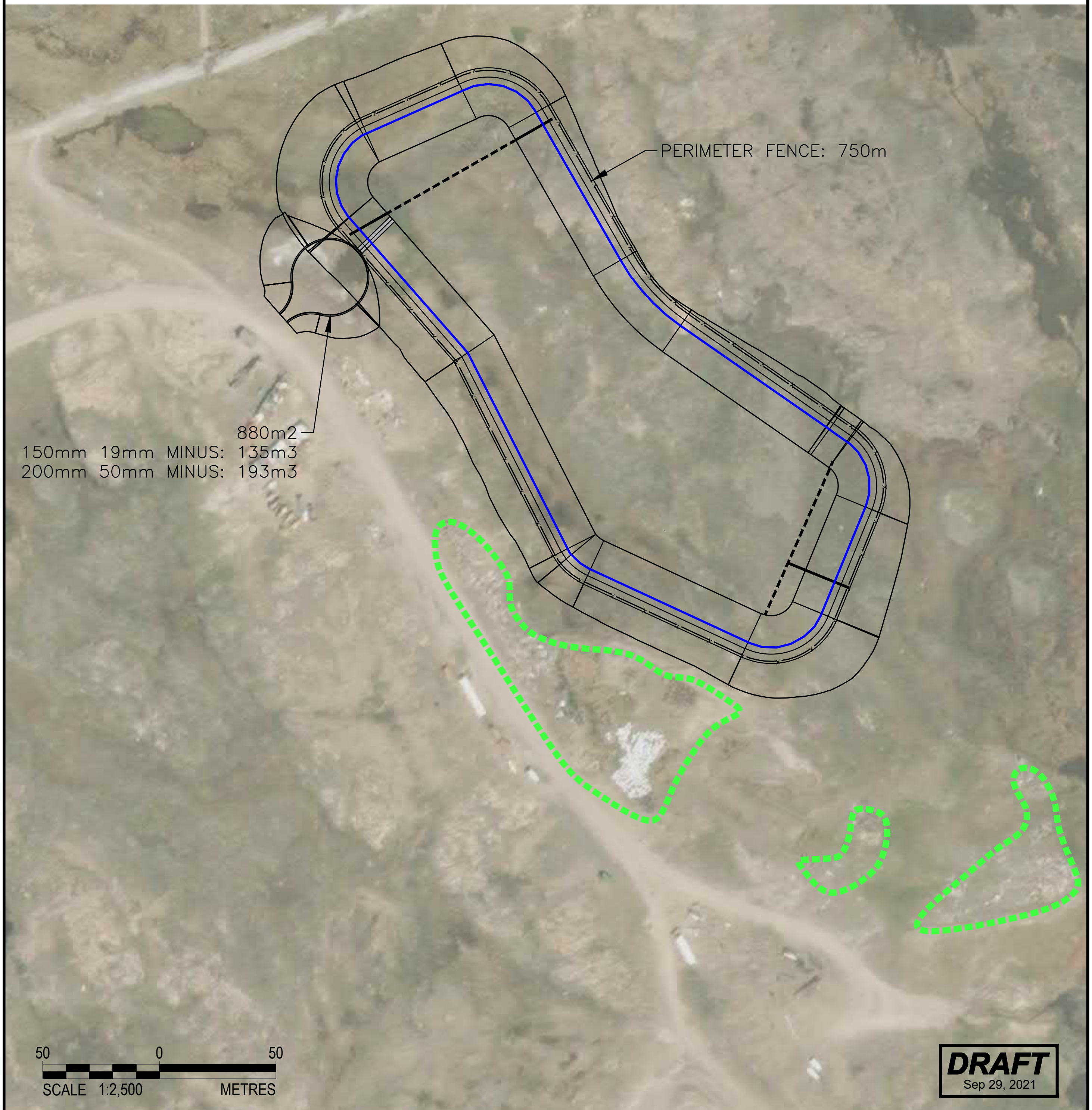
FileName:c:\pw working directory\projects 2021\40skb\dms55676\21233-02-site-opt1(r1).dwg

ARTIC RATED HDPE LINER:............................29,500m2
TYPE II SAND BEDDING:..................................4,425m3
TYPE II 19mm MINUS....................................4,425m3

LAGOON CUT.....................................29,200m3
LAGOON CONSTRUCTION FILL............53,000m3
NET (FILL)..23,800m3

150mm HDPE PIPE (PERFORATED)..............135m
150mm HDPE PIPE (SLOPES)........................65m
150mm HDPE PIPE (ABOVE T/O BERM)..........9m

LAGOON CAPACITY: 90,000m3



DILLON CONSULTING

DATE September 2021

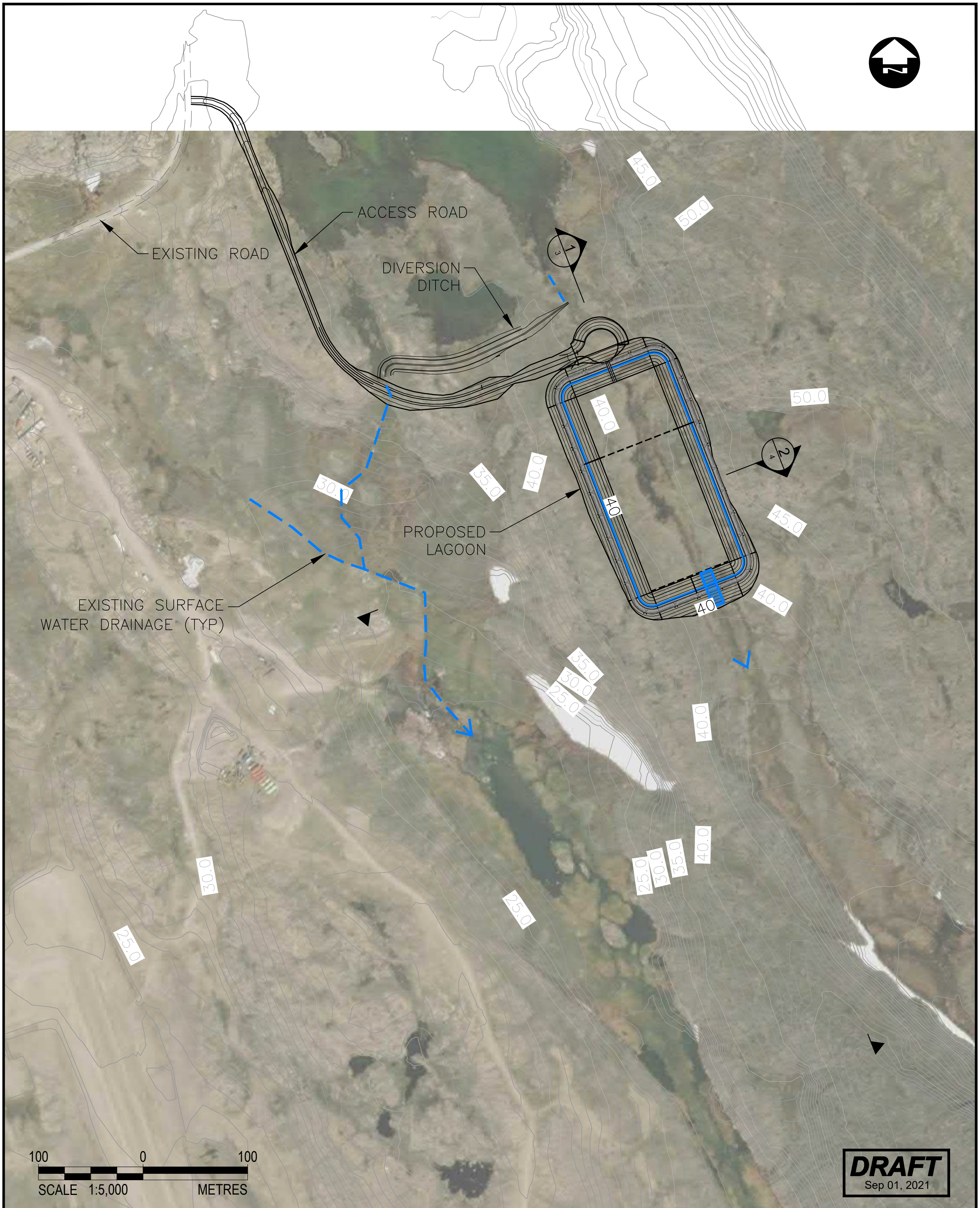
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES**

PROJECT NO. **21-2233**

FIGURE NO. **Q-1**

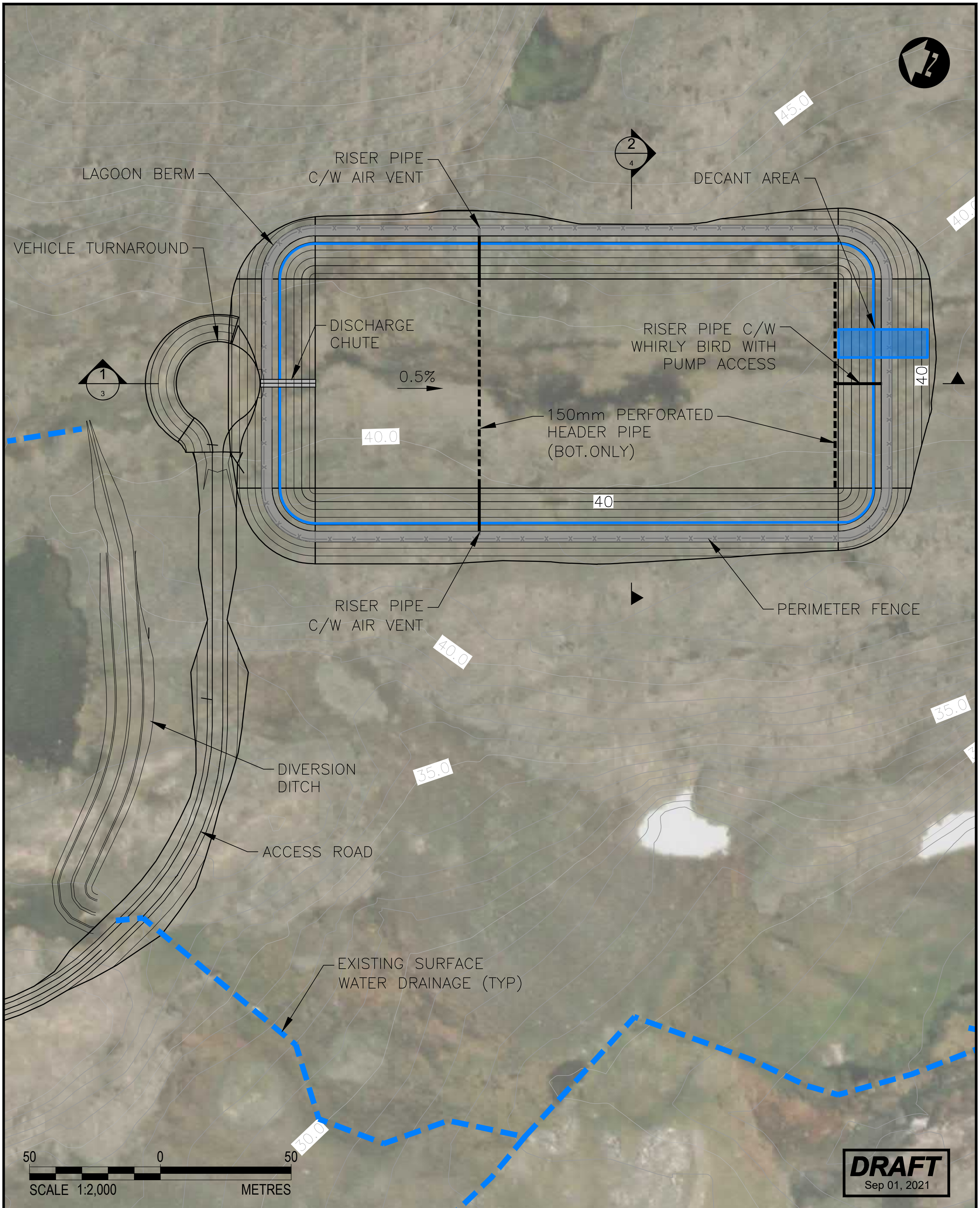
FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt1(r1).dwg



FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt3.dwg

DILLON CONSULTING

DATE August 2021	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
	TITLE **SITE PLAN**	FIGURE NO. **1**



DILLON CONSULTING

DATE August 2021

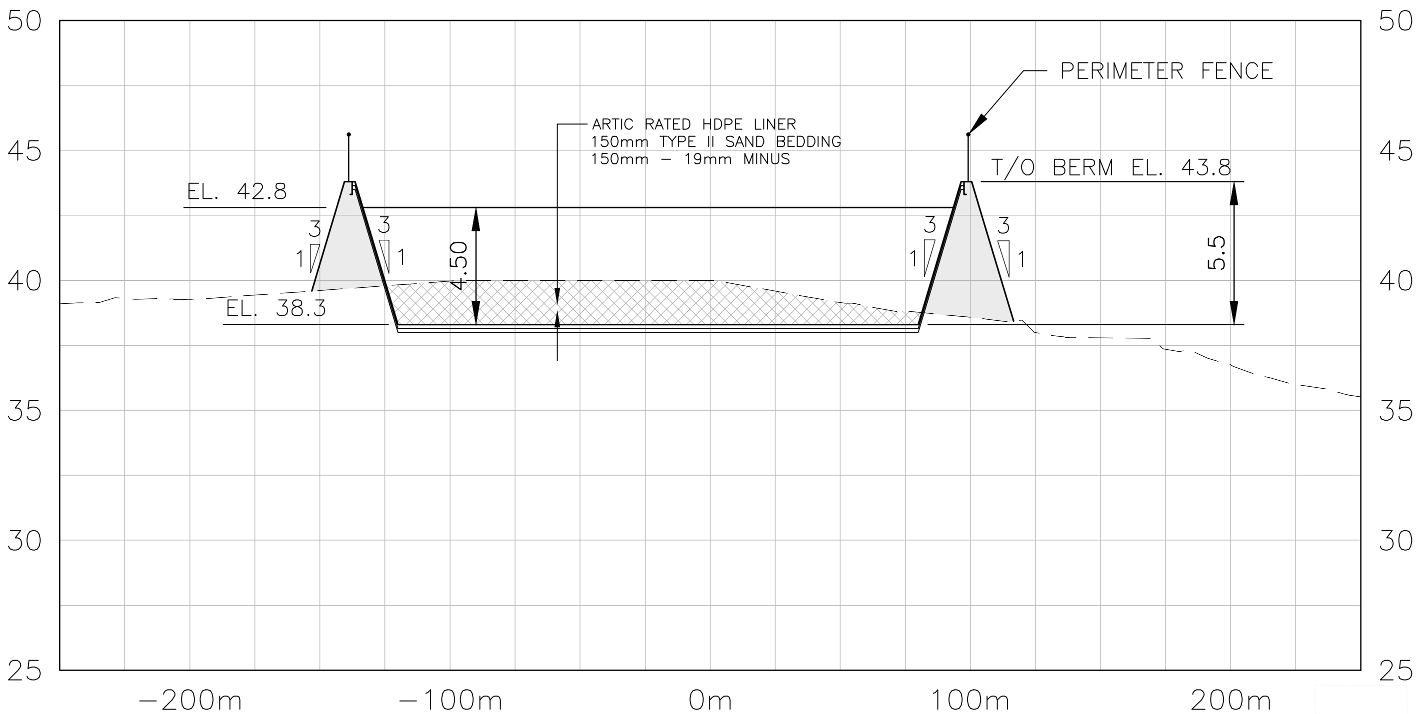
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **LAGOON PLAN**

FIGURE NO. **2**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt3.dwg



1
3
SECTION

CAPACITY: 90,000m3
CUT: 29,400m3
FILL: 26,600m3

DRAFT
Sep 01, 2021

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3**
HAMLET OF NAUJAAT, NUNAVUT

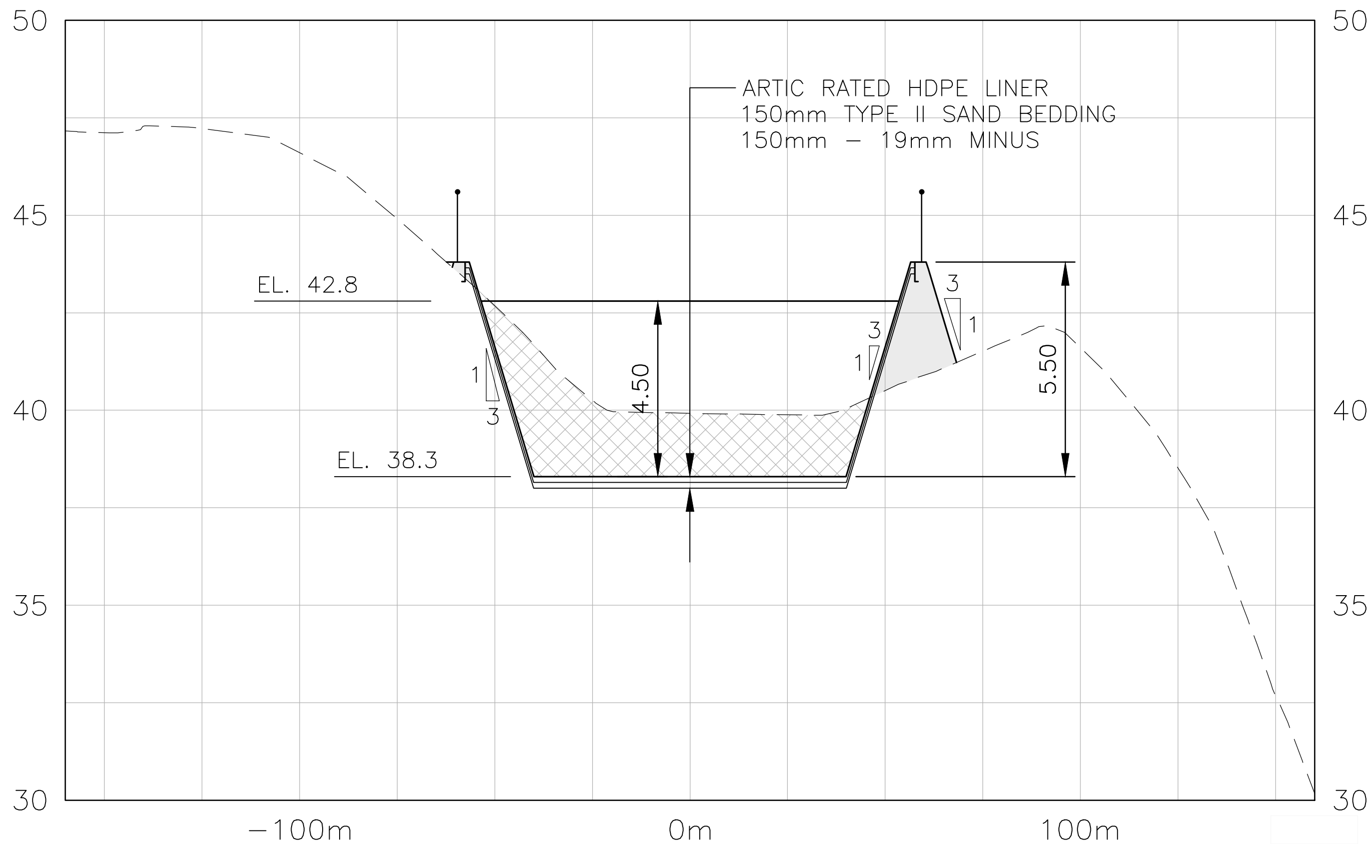
PROJECT NO. **21-2233**

TITLE **SECTION 1**

FIGURE NO. **3**

DATE **August 2021**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt3.dwg



2
4
SECTION

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Sep 01, 2021

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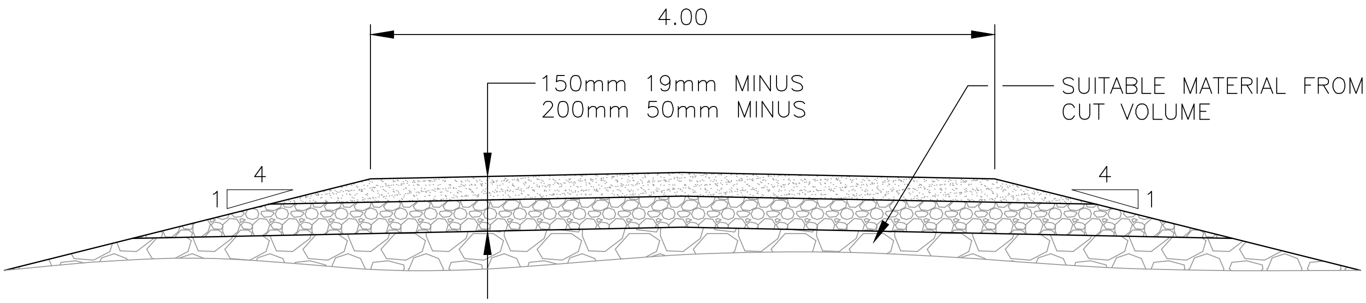
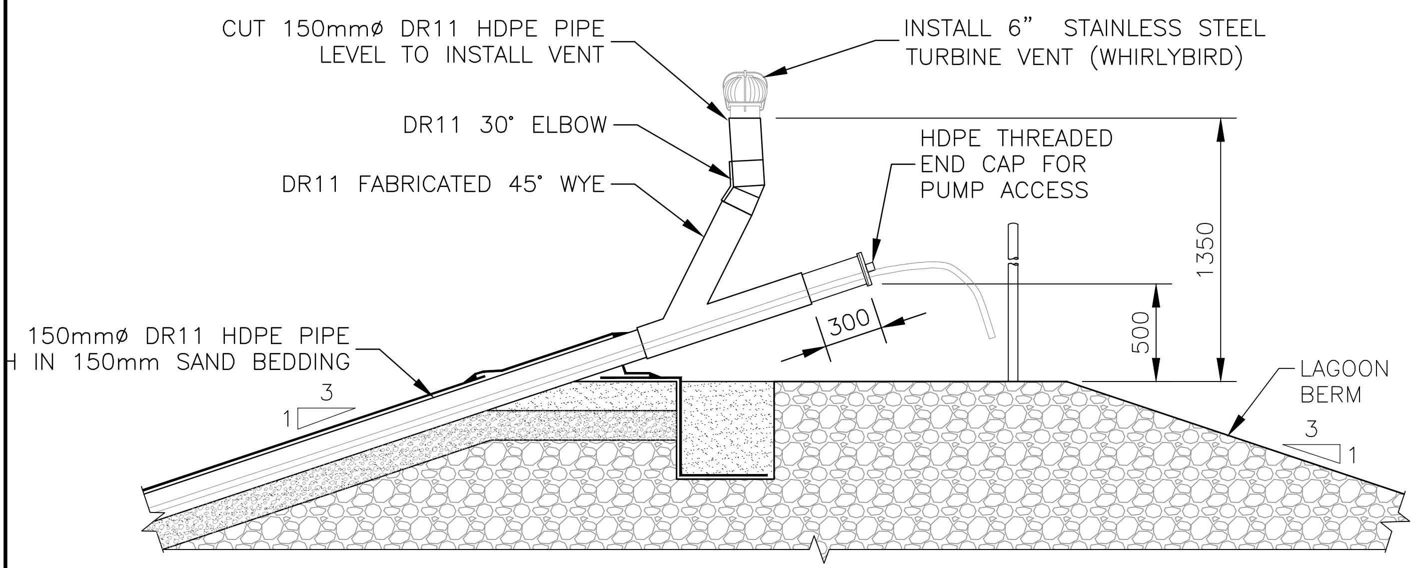
	PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3 HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
DATE August 2021	TITLE SECTION 2	FIGURE NO. 4

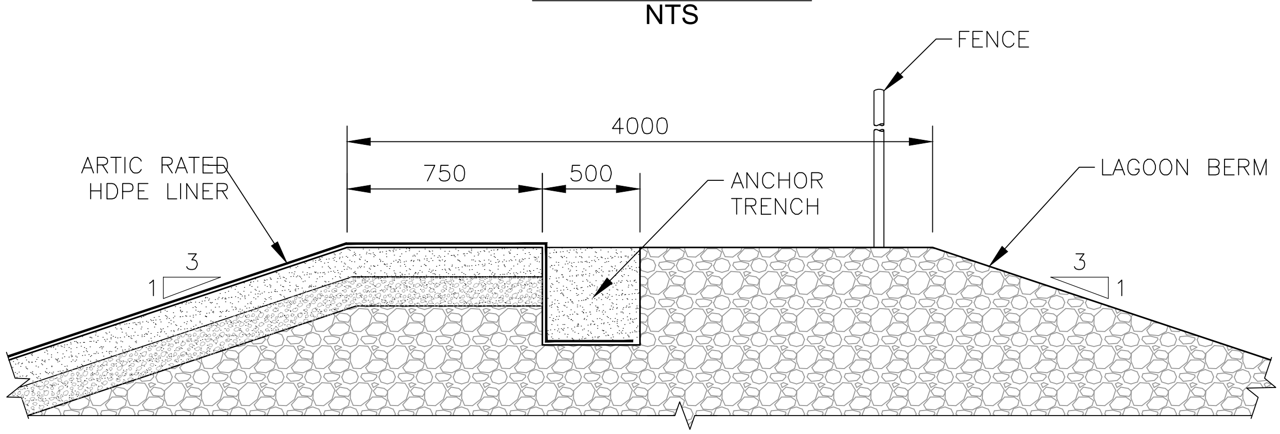
FileName:c:\pw working directory\projects 2021\40skb\dms55676\21223-02-site-opt3.dwg



ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



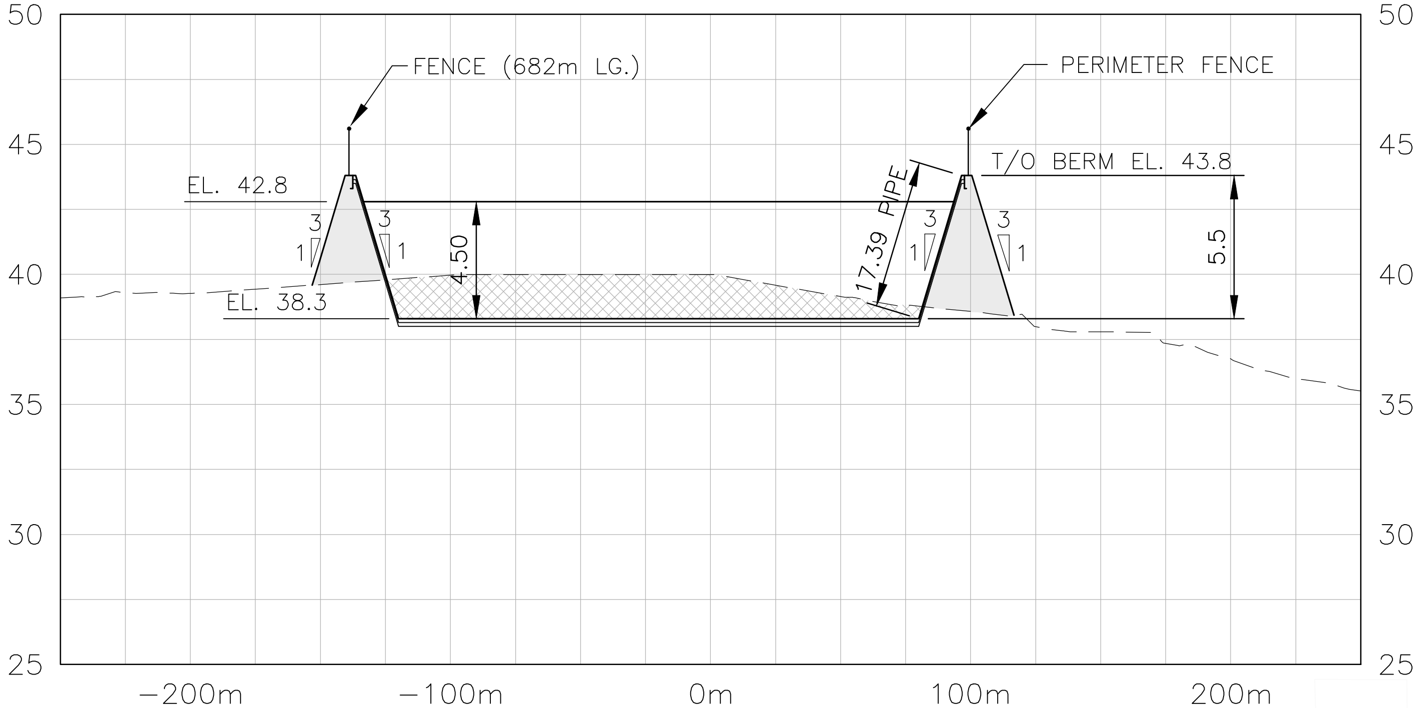
ANCHOR TRENCH DETAIL
NTS

DRAFT
Sep 01, 2021

DILLON CONSULTING

DATE **August 2021**	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
	TITLE **DETAILS**	FIGURE NO. **5**

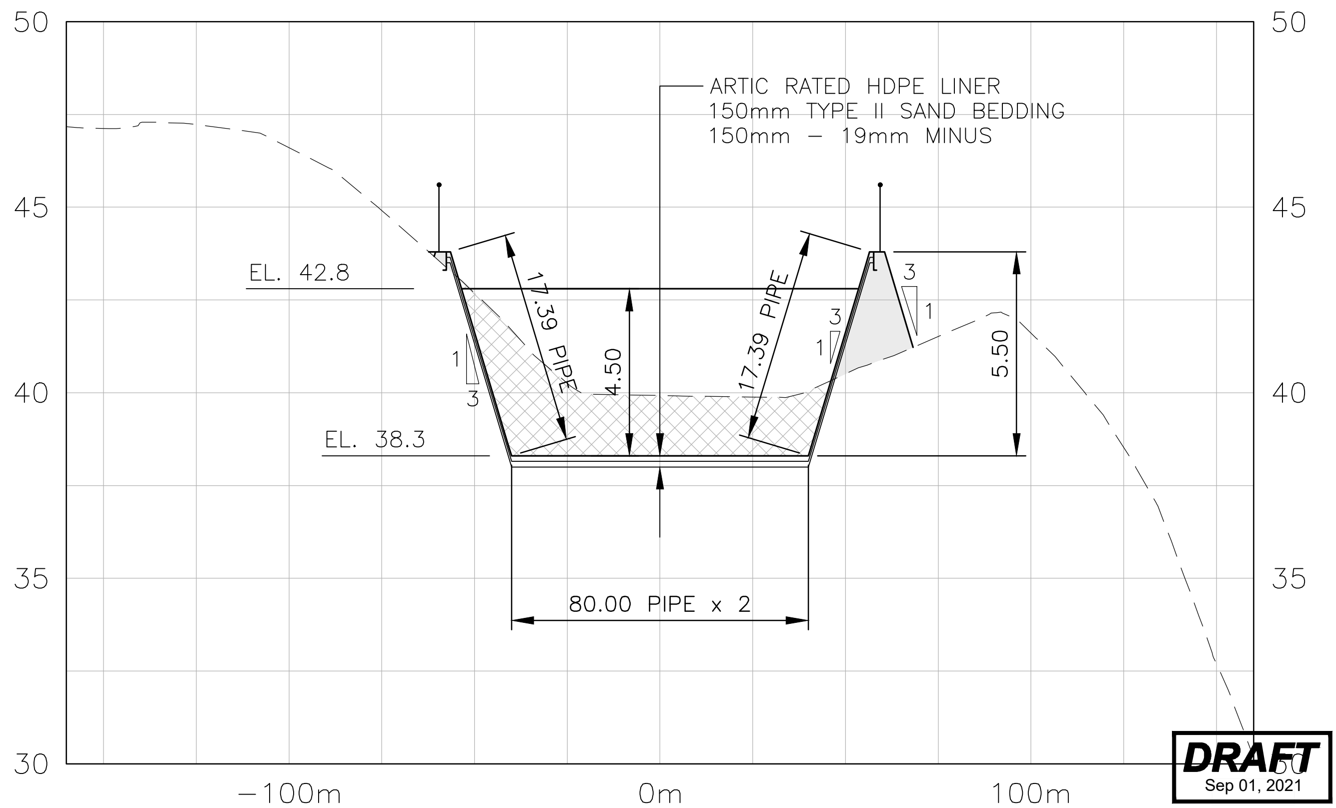
FileName:c:\pw working directory\projects 2021\40skbldms55676\21223-02-site-opt3.dwg



ARTIC RATED HDPE LINER:.................................28,600m2
TYPE II SAND BEDDING: 29,500 x 0.15 ....4,290m3
TYPE II 19mm MINUS...4,290m3

150mm HDPE PIPE (PERFORATED)...........160m
150mm HDPE PIPE (SLOPES)........................65m
150mm HDPE PIPE (ABOVE T/O BERM)..........9m

LAGOON CUT....................................31,400m3
LAGOON CONSTRUCTION FILL...........25,200m3
NET (CUT)..6,200m3



DRAFT
Sep 01, 2021

DILLON CONSULTING

DATE August 2021

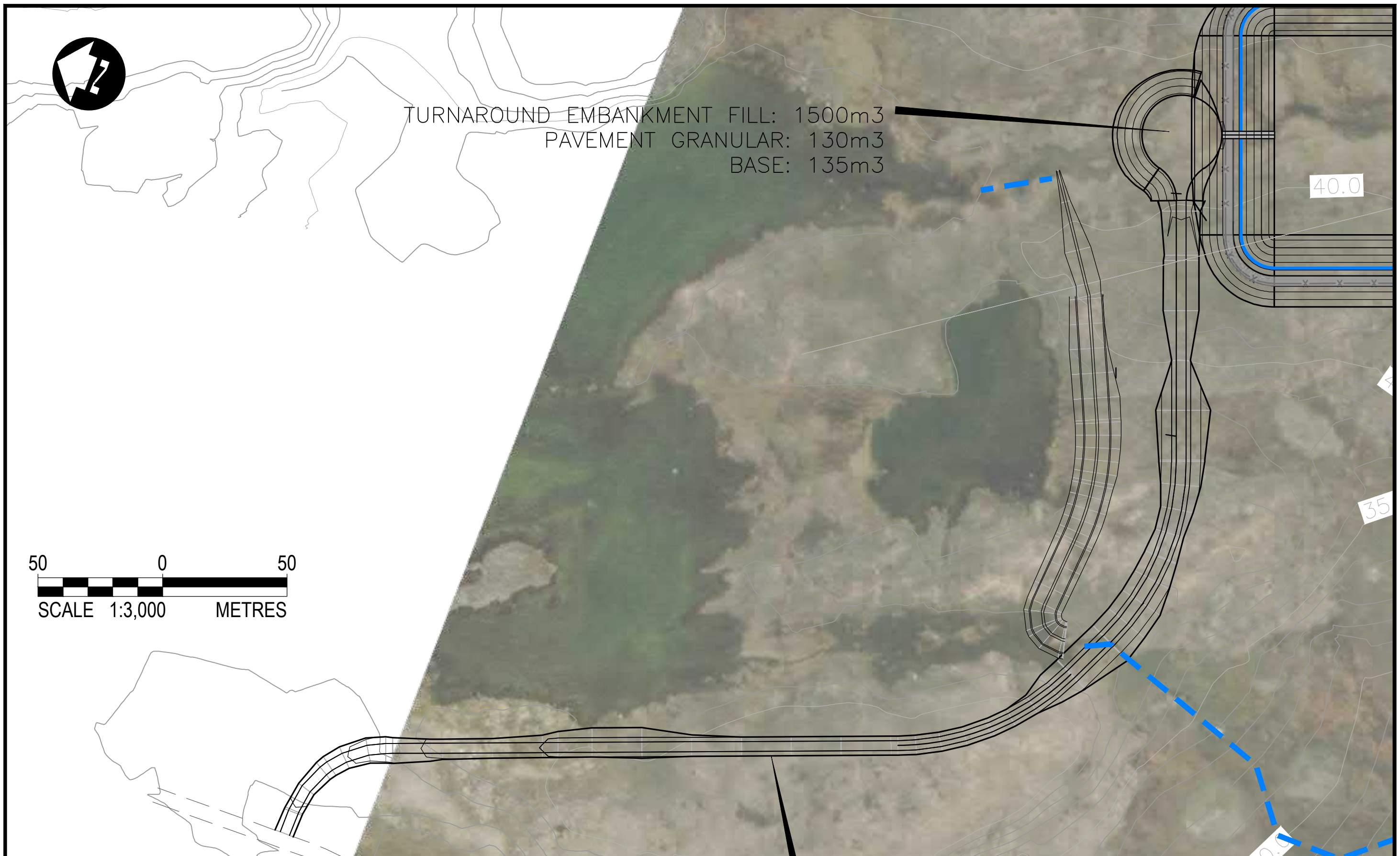
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3**
HAMLET OF NAUJAAT, NUNAVUT

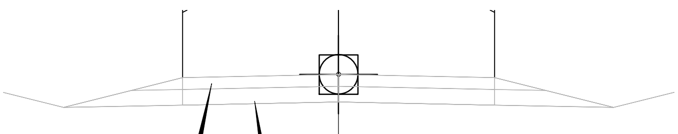
TITLE **QUANTITIES**
LAGOON SECTIONS

PROJECT NO. **21-2233**

FIGURE NO. **Q-1**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt3.dwg





MATERIAL VOLUME

STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	0.70	0.00	0.00
3+020.00	0.70	13.96	13.96
3+040.00	0.70	13.96	27.91
3+060.00	0.70	13.96	41.87
3+070.00	0.70	6.98	48.85
3+080.00	0.70	6.98	55.83
3+090.00	0.70	6.98	62.80
3+100.00	0.70	6.98	69.78
3+110.00	0.70	6.98	76.76
3+120.00	0.70	6.98	83.74
3+130.00	0.70	6.98	90.72
3+140.00	0.70	6.98	97.70
3+150.00	0.70	6.98	104.67
3+160.00	0.70	6.98	111.65
3+170.00	0.70	6.98	118.63
3+180.00	0.70	6.98	125.61
3+190.00	0.70	6.98	132.59
3+200.00	0.70	6.98	139.57
3+210.00	0.70	6.98	146.54
3+220.00	0.70	6.98	153.52
3+230.00	0.70	6.98	160.50
3+240.00	0.70	6.98	167.48
3+250.00	0.70	6.98	174.46
3+260.00	0.70	6.98	181.43
3+270.00	0.70	6.98	188.41
3+280.00	0.70	6.98	195.39
3+290.00	0.70	6.98	202.37
3+300.00	0.70	6.98	209.35
3+310.00	0.70	6.98	216.33
3+320.00	0.70	6.98	223.30
3+330.00	0.70	6.98	230.28
3+340.00	0.70	6.98	237.26
3+350.00	0.70	6.98	244.24
3+360.00	0.70	6.98	251.22
3+380.00	0.70	13.96	265.17
3+400.00	0.70	13.96	279.13
3+420.00	0.70	13.96	293.09
3+440.00	0.70	13.96	307.04
3+445.70	0.70	3.98	311.02

MATERIAL VOLUME

STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	1.23	0.00	0.00
3+020.00	1.23	24.70	24.70
3+040.00	1.23	24.70	49.39
3+060.00	1.23	24.70	74.09
3+070.00	1.23	12.35	86.43
3+080.00	1.23	12.35	98.78
3+090.00	1.23	12.35	111.13
3+100.00	1.23	12.35	123.48
3+110.00	1.23	12.35	135.83
3+120.00	1.23	12.35	148.17
3+130.00	1.23	12.35	160.52
3+140.00	1.23	12.35	172.87
3+150.00	1.23	12.35	185.22
3+160.00	1.23	12.35	197.57
3+170.00	1.23	12.35	209.91
3+180.00	1.23	12.35	222.26
3+190.00	1.23	12.35	234.61
3+200.00	1.23	12.35	246.96
3+210.00	1.23	12.35	259.30
3+220.00	1.23	12.35	271.65
3+230.00	1.23	12.35	284.00
3+240.00	1.23	12.35	296.35
3+250.00	1.23	12.35	308.70
3+260.00	1.23	12.35	321.04
3+270.00	1.23	12.35	333.39
3+280.00	1.23	12.35	345.74
3+290.00	1.23	12.35	358.09
3+300.00	1.23	12.35	370.43
3+310.00	1.23	12.35	382.78
3+320.00	1.23	12.35	395.13
3+330.00	1.23	12.35	407.48
3+340.00	1.23	12.35	419.83
3+350.00	1.23	12.35	432.17
3+360.00	1.23	12.35	444.52
3+380.00	1.23	24.70	469.22
3+400.00	1.23	24.70	493.91
3+420.00	1.23	24.70	518.61
3+440.00	1.23	24.70	543.30
3+445.70	1.23	7.04	550.34

ALIGNMENT – ACCESS ROAD EMBANKMENT FILL

STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+000	0.00	0.37	0.00	0.00	0.00	0.00
3+020	0.89	0.00	8.84	3.78	8.84	3.78
3+040	2.86	0.00	37.40	0.00	46.25	3.78
3+060	3.00	0.00	57.74	0.00	103.99	3.78
3+070	1.79	0.06	23.96	0.29	127.95	4.07
3+080	0.77	0.02	12.83	0.37	140.77	4.45
3+090	0.68	0.00	7.29	0.09	148.07	4.54
3+100	0.71	0.00	7.00	0.01	155.06	4.55
3+110	0.85	0.00	7.81	0.02	162.87	4.56
3+120	1.65	0.00	12.51	0.02	175.38	4.58
3+130	6.34	0.00	39.95	0.01	215.33	4.59
3+140	4.00	0.00	51.66	0.01	266.99	4.60
3+150	8.24	0.01	61.15	0.06	328.14	4.66
3+160	9.56	0.00	88.99	0.06	417.14	4.73
3+170	4.57	0.01	70.64	0.06	487.78	4.79
3+180	0.94	0.00	27.55	0.06	515.33	4.85
3+190	0.83	0.03	8.89	0.13	524.22	4.98
3+200	0.83	0.00	8.34	0.13	532.56	5.11
3+210	0.83	0.00	8.34	0.00	540.90	5.11
3+220	0.83	0.00	8.34	0.00	549.23	5.11
3+230	0.83	0.00	8.34	0.00	557.57	5.11
3+240	0.83	0.00	8.34	0.00	565.91	5.11
3+250	0.83	0.00	8.34	0.00	574.25	5.11
3+260	0.83	0.00	8.34	0.00	582.59	5.11
3+270	0.83	0.00	8.34	0.00	590.92	5.11
3+280	0.83	0.00	8.34	0.00	599.26	5.11
3+290	0.83	0.00	8.34	0.00	607.60	5.11
3+300	0.83	0.00	8.34	0.00	615.94	5.11
3+310	0.83	0.00	8.34	0.00	624.27	5.11
3+320	1.20	0.00	10.11	0.00	634.39	5.11
3+330	9.74	0.00	54.16	0.00	688.55	5.11
3+340	16.33	0.00	129.98	0.00	818.53	5.11
3+350	20.47	0.00	184.01	0.00	1002.54	5.11
3+360	25.21	0.00	228.40	0.00	1230.94	5.11
3+380	14.62	0.00	404.00	0.00	1634.94	5.11
3+400	8.98	0.00	237.13	0.00	1872.07	5.11
3+420	6.95	0.00	158.90	0.00	2030.97	5.11
3+440	18.69	0.00	256.99	0.00	2287.95	5.11
3+445.70	21.72	0.00	115.17	0.00	2403.12	5.11

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Sep 01, 2021

DILLON CONSULTING

DATE August 2021

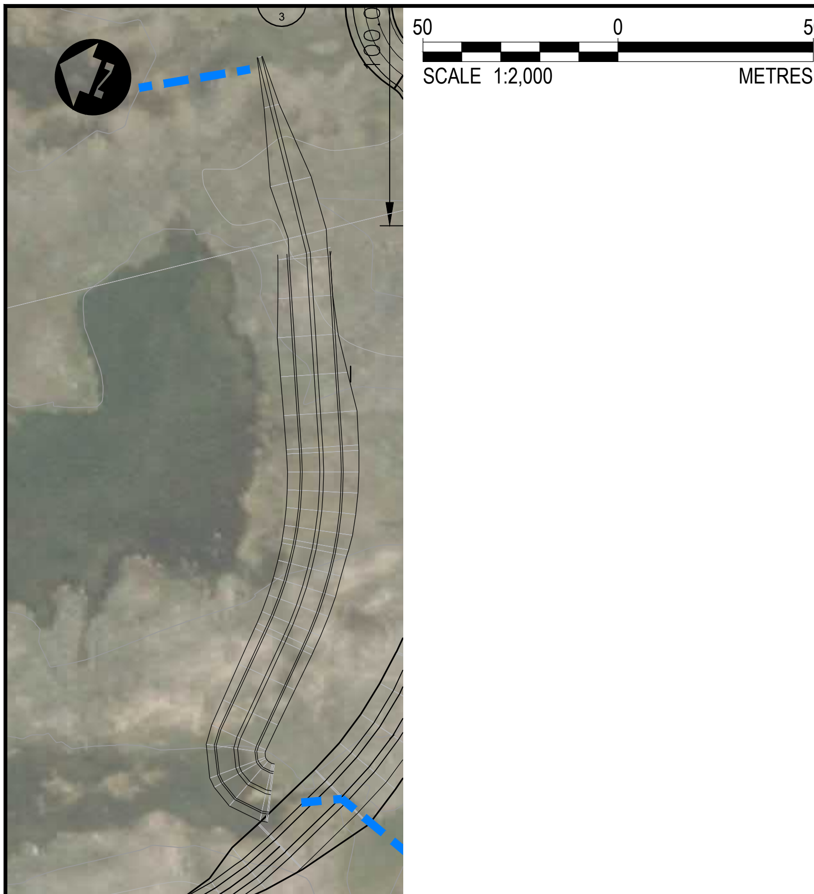
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES**
ACCESS ROAD AND TURNAROUND

PROJECT NO. **21-2233**

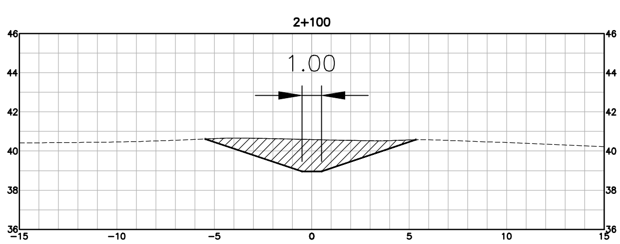
FIGURE NO. **Q-2**

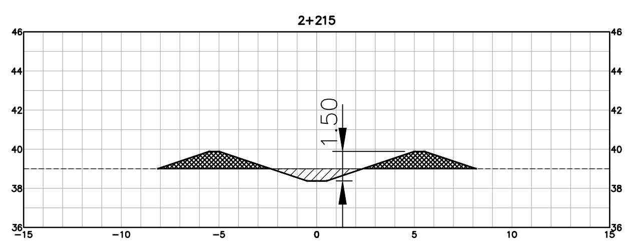
FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt3.dwg

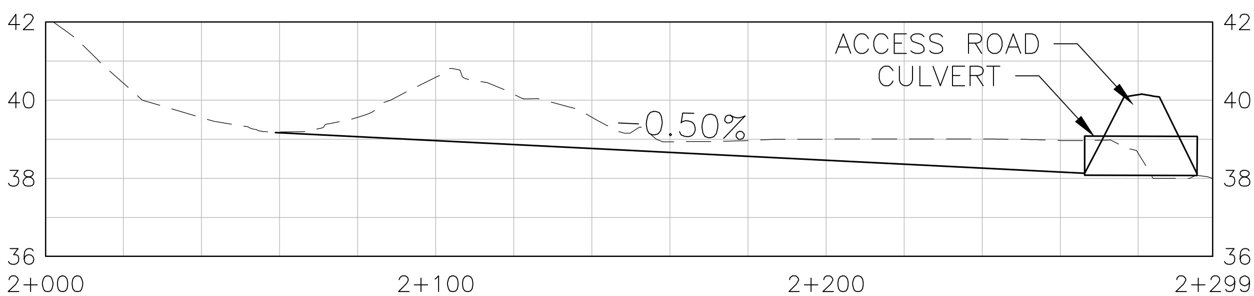


PLAN

ALIGNMENT – DIVERSION DITCH CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
2+000	0.00	0.00	0.00	0.00	0.00	0.00
2+010	0.00	0.00	0.00	0.00	0.00	0.00
2+020	0.00	0.00	0.00	0.00	0.00	0.00
2+030	0.00	0.00	0.00	0.00	0.00	0.00
2+040	0.00	0.00	0.00	0.00	0.00	0.00
2+050	0.00	0.00	0.00	0.00	0.00	0.00
2+060	0.00	0.00	0.00	0.00	0.00	0.00
2+070	0.00	0.23	0.00	1.15	0.00	1.15
2+080	0.00	1.24	0.00	7.35	0.00	8.50
2+090	0.01	4.34	0.06	27.89	0.06	36.39
2+100	0.00	9.60	0.06	69.70	0.12	106.09
2+110	0.26	9.36	1.28	94.82	1.40	200.91
2+118.75	1.11	6.97	5.97	71.42	7.37	272.33
2+120	1.12	6.36	0.27	8.85	7.65	281.18
2+130	2.29	5.13	17.08	57.45	24.72	338.63
2+140	4.39	2.89	33.40	40.08	58.13	378.71
2+150	7.38	1.34	58.84	21.14	116.97	399.85
2+160	10.78	0.49	90.80	9.18	207.77	409.03
2+168.71	10.00	0.64	90.53	4.93	298.30	413.96
2+170	9.89	0.66	12.81	0.84	311.11	414.80
2+175	9.42	0.77	48.65	3.57	359.76	418.38
2+180	8.91	0.90	46.17	4.17	405.93	422.55
2+185	8.37	1.05	43.50	4.87	449.43	427.42
2+190	7.81	1.19	40.70	5.60	490.13	433.02
2+193.57	7.35	1.28	27.17	4.40	517.30	437.42
2+195	7.07	1.31	10.32	1.85	527.62	439.27
2+200	6.41	1.41	33.74	6.81	561.36	446.08
2+205	6.17	1.53	31.44	7.37	592.80	453.45
2+210	5.85	1.65	30.03	7.95	622.83	461.39
2+215	5.55	1.77	28.48	8.54	651.31	469.93
2+218.42	5.34	1.85	18.65	6.19	669.95	476.12
2+220	5.25	1.89	8.35	2.95	678.30	479.07
2+230	4.69	2.15	49.69	20.21	727.99	499.28
2+240	4.19	2.40	44.39	22.77	772.38	522.05
2+247.09	3.86	2.59	28.54	17.67	800.92	539.72
2+250	3.75	2.65	11.07	7.64	811.99	547.36
2+255	3.65	2.71	18.52	13.40	830.51	560.76
2+256.51	3.62	2.73	5.52	4.09	836.03	564.85
2+260	3.54	2.78	12.67	9.59	848.70	574.45
2+265	3.37	2.88	17.67	14.12	866.36	588.57
2+265.93	3.35	2.91	3.22	2.69	869.58	591.25
2+270	0.00	0.00	6.81	5.92	876.39	597.17
2+280	0.00	0.00	0.00	0.00	876.39	597.17
2+290	0.00	0.00	0.00	0.00	876.39	597.17
2+299.09	0.00	0.00	0.00	0.00	876.39	597.17







DIVERSION DITCH PROFILE

DRAFT
Sep 01, 2021

DILLON CONSULTING

DATE August 2021

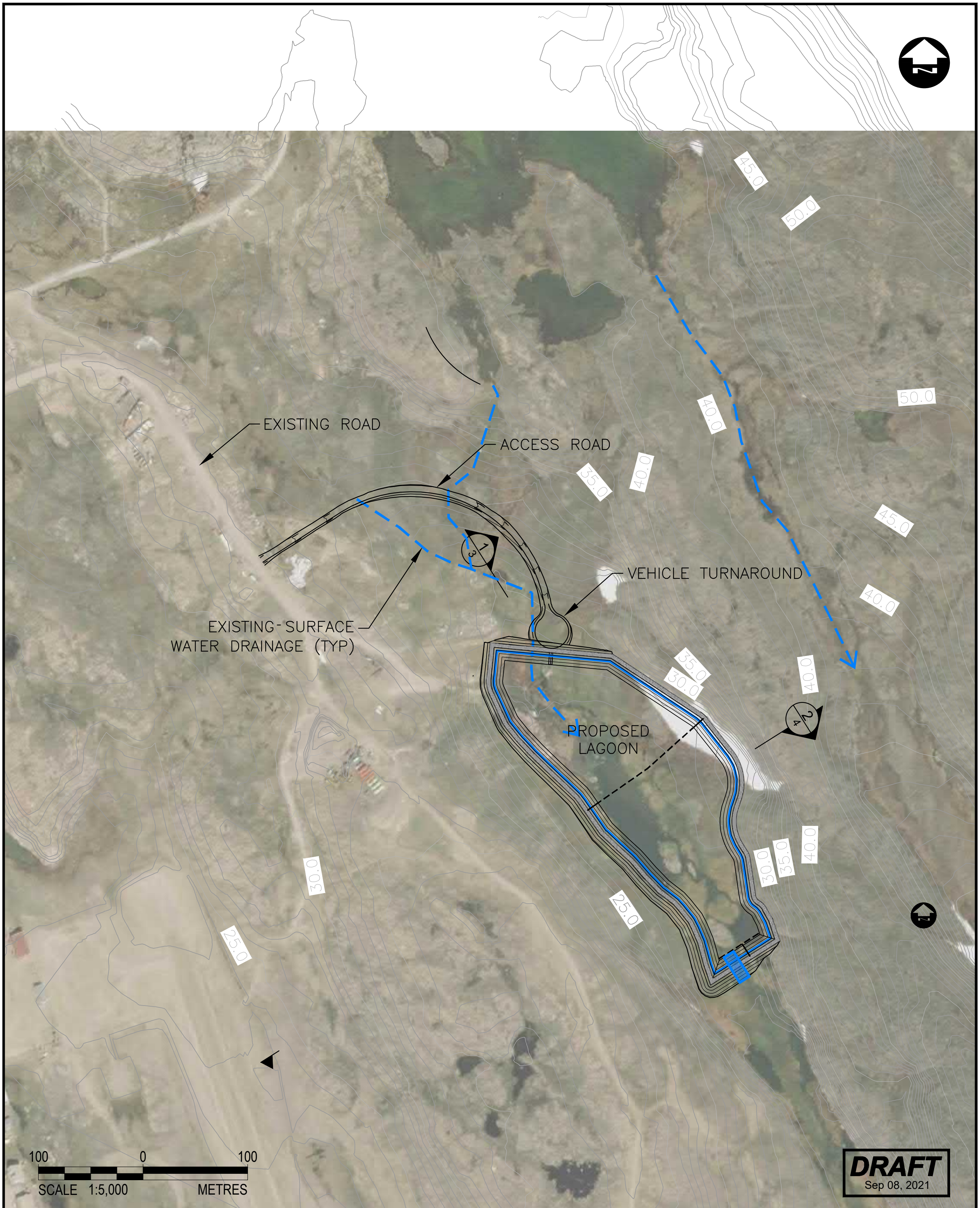
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES**

PROJECT NO. **21-2233**

FIGURE NO. **Q-2**

FileName:c:\pw working directory\projects 2021\40sk\dms55676\212233-02-site-opt3.dwg



FileName:c:\pw working directory\projects 2021\40skb\dms55676\21223-02-site-opt5.dwg

DILLON CONSULTING

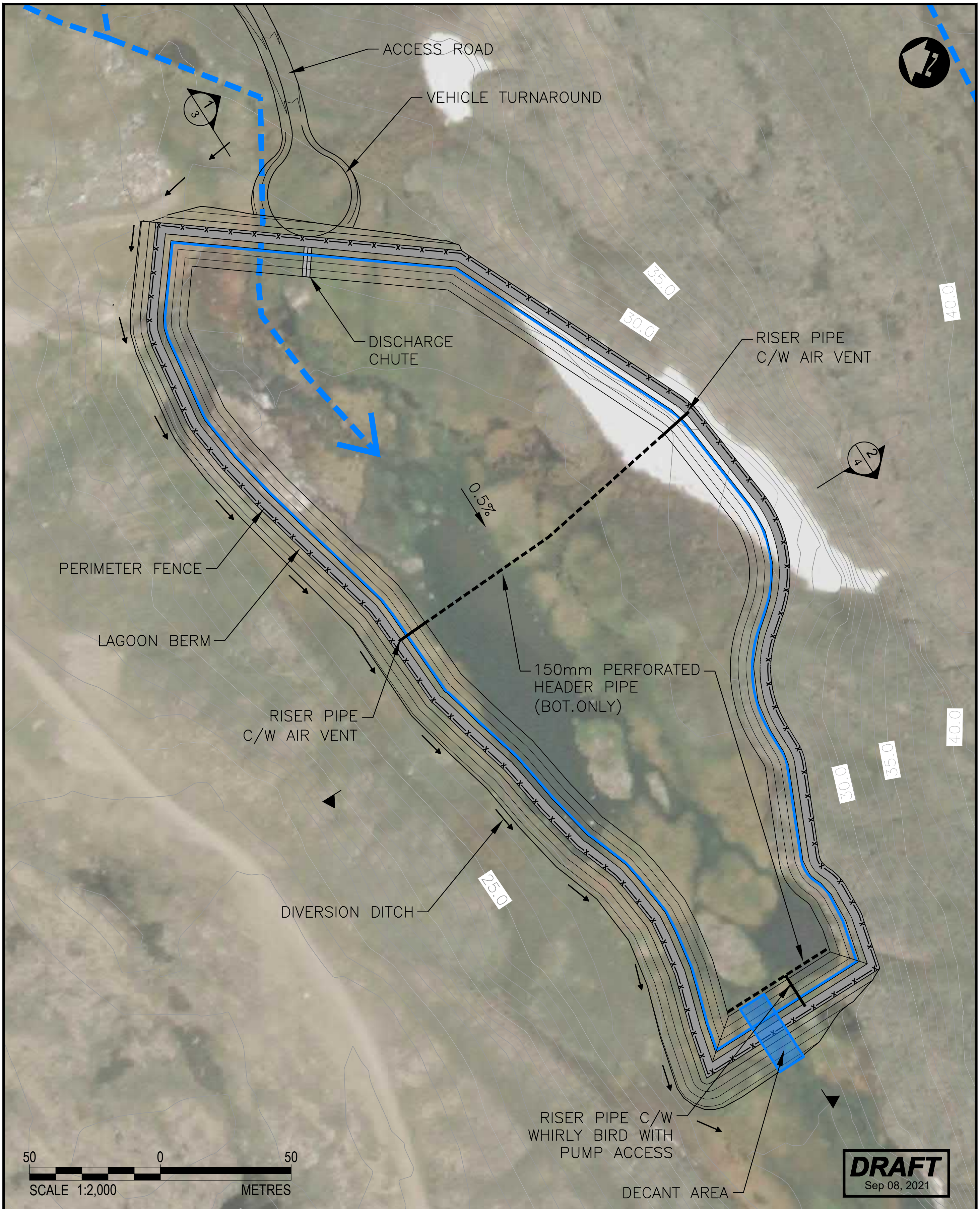
DATE September 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 5**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **SITE PLAN**

PROJECT NO. **21-2233**

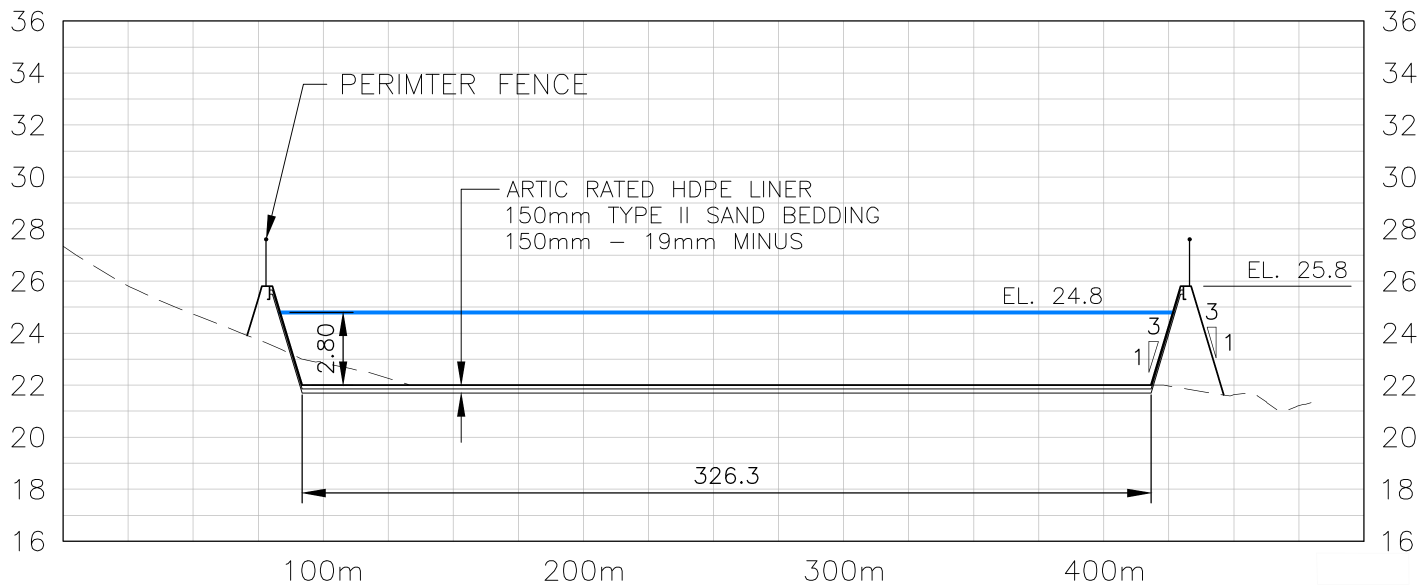
FIGURE NO. **1**



DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 5** HAMLET OF NAUJAAT, NUNAVUT		PROJECT NO. **21-2233**
DATE **September 2021**	TITLE **LAGOON PLAN**	FIGURE NO. **2**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt5.dwg

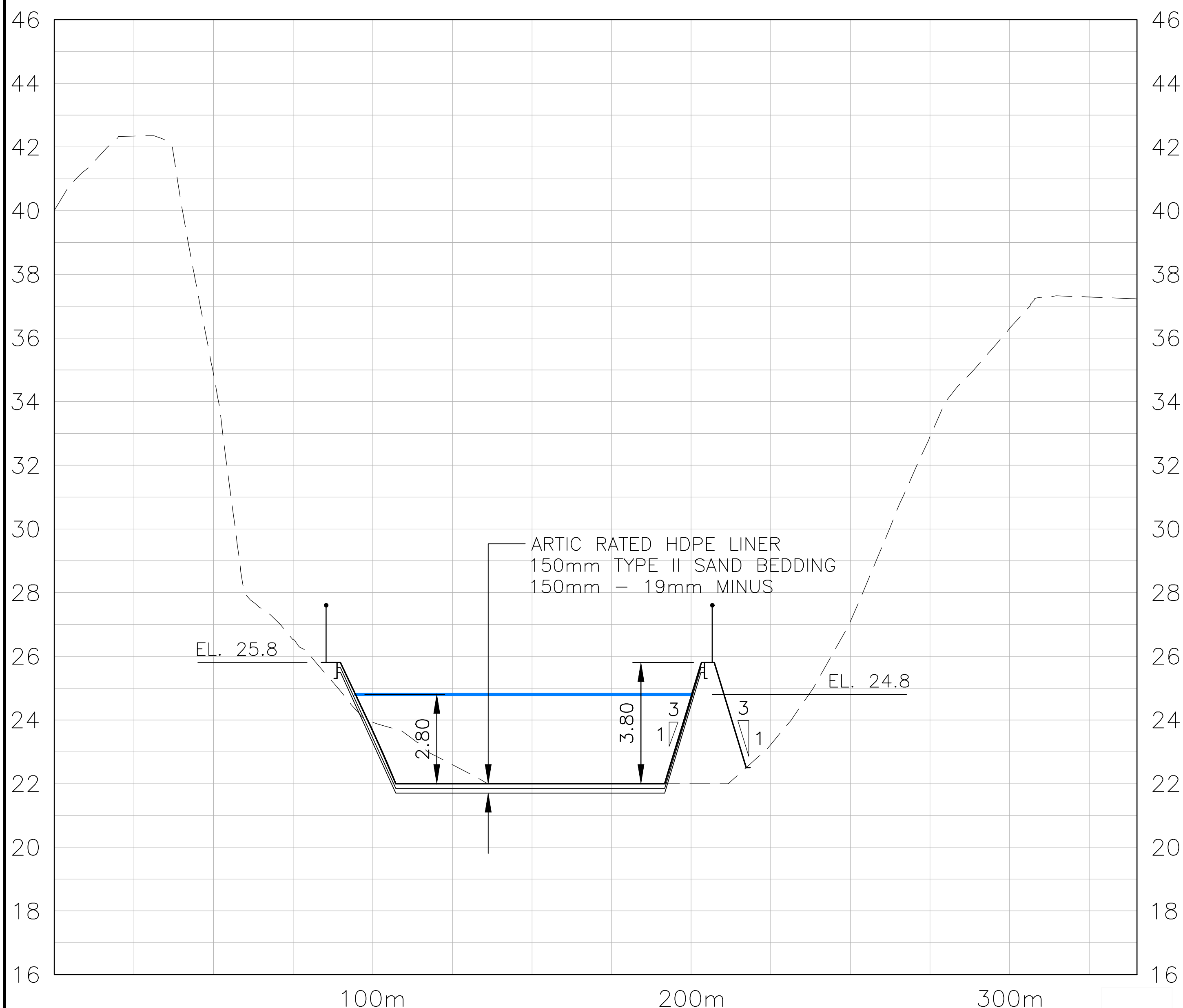


1/3 SECTION

DRAFT
Sep 08, 2021

FileName:c:\pw working directory\projects 2021\40skbldms55676\212233-02-site-opt5.dwg

DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 5** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
DATE **September 2021**	TITLE **SECTION 1**	FIGURE NO. **3**



2
4
SECTION

DRAFT
Sep 08, 2021

FileName:c:\pw working directory\projects 2021\40skb\dms55676\21233-02-site-opt5.dwg

DILLON CONSULTING

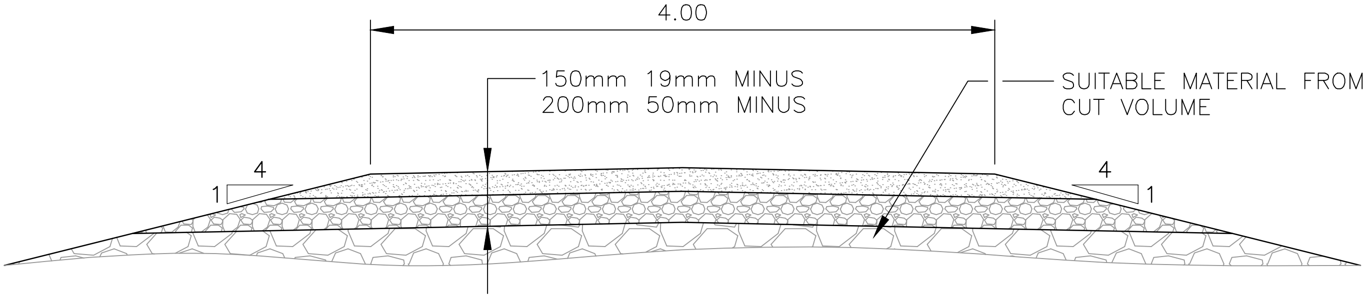
DATE September 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 5**
HAMLET OF NAUJAAT, NUNAVUT

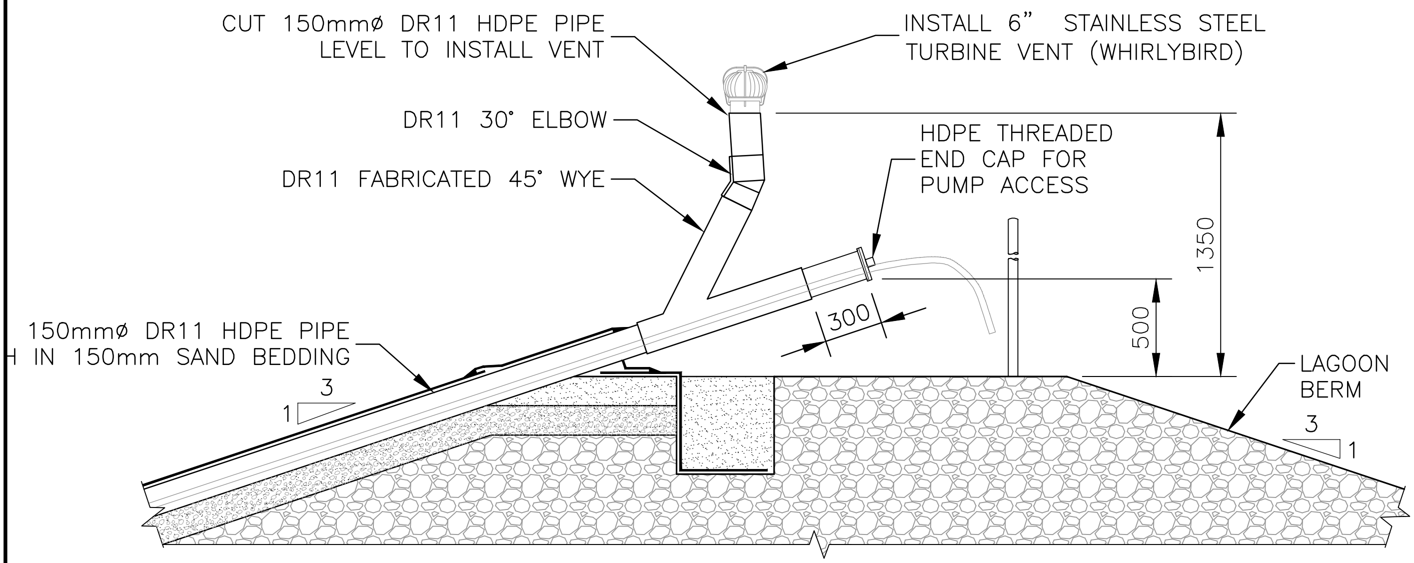
TITLE **SECTION 2**

PROJECT NO. **21-2233**

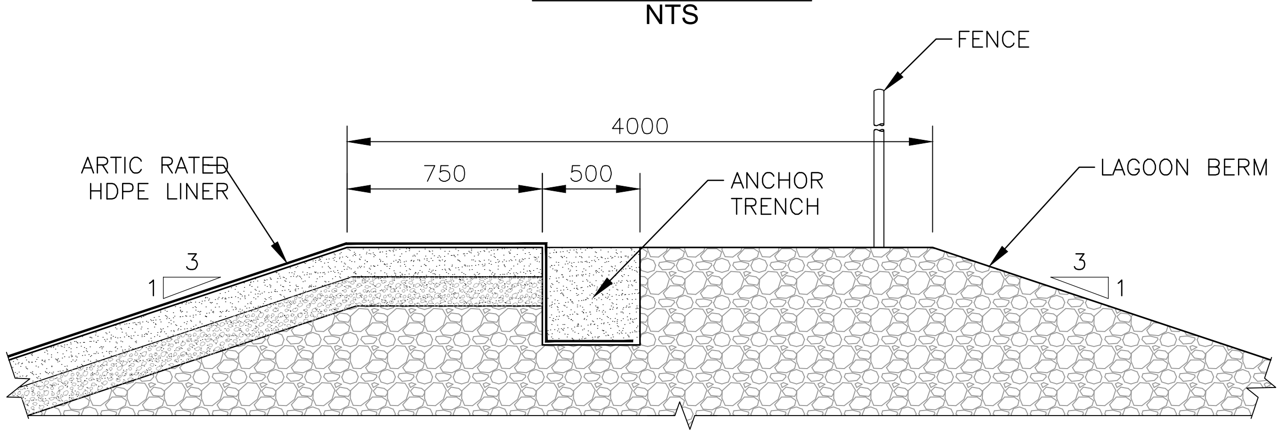
FIGURE NO. **4**



ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



ANCHOR TRENCH DETAIL
NTS

DRAFT
Sep 08, 2021

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 5**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **DETAILS**

FIGURE NO. **5**

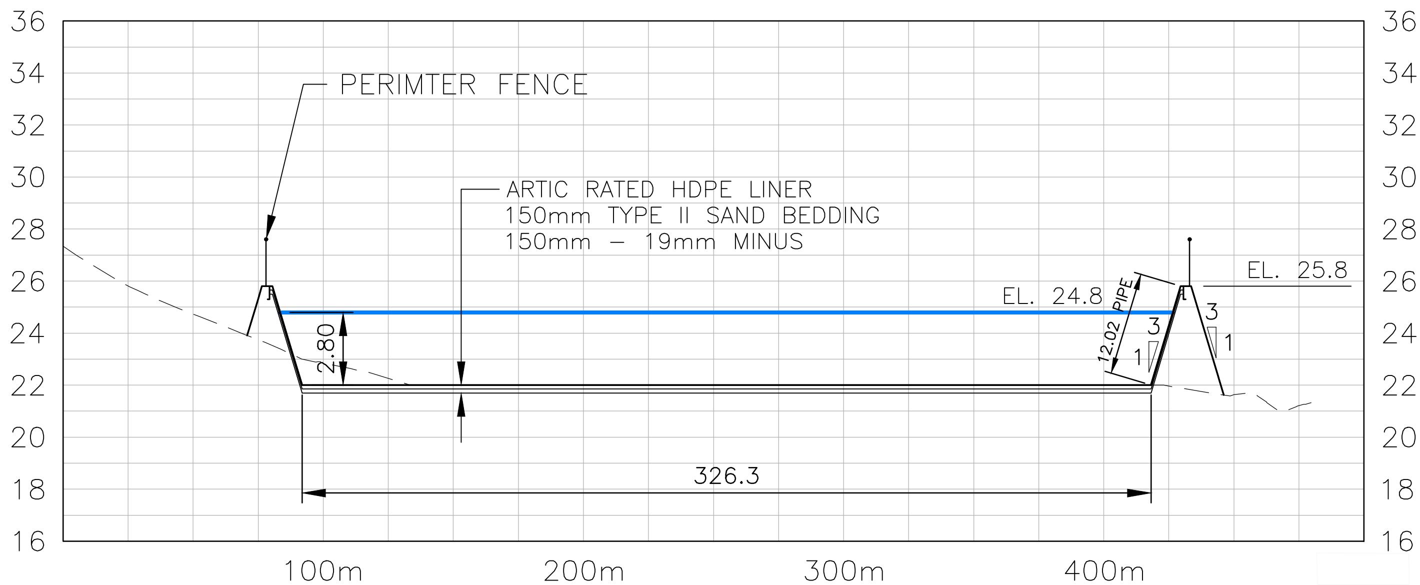
DATE **September 2021**

ARTIC RATED HDPE LINER:..................................42,500m2
TYPE II SAND BEDDING: 29,500 x 0.15 ....6,400m3
TYPE II 19mm MINUS..6,400m3

150mm HDPE PIPE (PERFORATED)(2 LOCATIONS)..................160m
150mm HDPE PIPE (SLOPES)(3 LOCATIONS)............................36m
150mm HDPE PIPE (ABOVE T/O BERM)(3 LOCATIONS).............9m

PERIMETER FENCE...940m

LAGOON CUT....................................7,900m3
LAGOON CONSTRUCTION FILL..........29,000m3
NET (FILL)......................................21,100m3



1 / 3 SECTION

DRAFT
Sep 08, 2021

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt5.dwg

DILLON CONSULTING

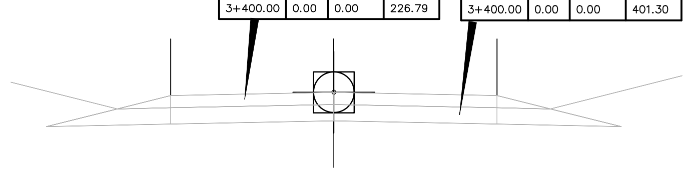
PROJECT	LAGOON SCHEMATIC DESIGN - OPTION 5 HAMLET OF NAUJAAT, NUNAVUT
PROJECT NO.	21-2233
TITLE	QUANTITIES - LAGOON
FIGURE NO.	Q-1
DATE	September 2021

ALIGNMENT – ACCESS ROAD EMBANKMENT FILL						
STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+020	0.40	0.00	0.00	0.00	0.00	0.00
3+040	1.48	0.00	18.85	0.00	18.85	0.00
3+060	0.68	0.00	21.66	0.00	40.51	0.00
3+070	0.12	0.15	4.00	0.77	44.51	0.78
3+080	0.29	0.21	2.02	1.81	46.53	2.58
3+090	0.76	0.02	5.24	1.13	51.77	3.71
3+100	1.53	0.00	11.48	0.10	63.24	3.81
3+110	1.33	0.00	14.23	0.00	77.47	3.81
3+120	2.21	0.00	17.59	0.00	95.06	3.81
3+130	3.17	0.00	26.74	0.00	121.80	3.81
3+140	3.83	0.00	34.74	0.00	156.54	3.81
3+150	4.47	0.00	41.22	0.00	197.76	3.81
3+160	5.11	0.00	47.57	0.00	245.32	3.81
3+170	5.13	0.00	50.79	0.00	296.12	3.81
3+180	4.10	0.00	45.75	0.00	341.87	3.81
3+190	3.43	0.00	37.26	0.00	379.13	3.81
3+200	2.44	0.00	28.95	0.00	408.08	3.81
3+210	1.81	0.08	20.88	0.40	428.96	4.21
3+220	1.43	0.20	15.91	1.42	444.87	5.63
3+230	1.55	0.15	14.65	1.81	459.52	7.44
3+240	3.26	0.00	23.72	0.79	483.24	8.23
3+250	4.43	0.00	38.06	0.00	521.30	8.23
3+260	6.20	0.00	52.68	0.00	573.98	8.23
3+270	5.26	0.00	56.71	0.00	630.69	8.23
3+280	3.46	0.00	43.09	0.00	673.77	8.23
3+290	2.59	0.00	29.85	0.00	703.62	8.23
3+300	2.32	0.00	24.19	0.00	727.80	8.23
3+310	2.31	0.00	22.82	0.00	750.62	8.23
3+320	2.65	0.00	24.51	0.00	775.14	8.23
3+330	3.15	0.00	28.75	0.00	803.88	8.23
3+340	3.62	0.00	33.63	0.00	837.52	8.23
3+350	0.00	0.00	18.12	0.00	855.64	8.23
3+360	0.00	0.00	0.00	0.00	855.64	8.23
3+380	0.00	0.00	0.00	0.00	855.64	8.23
3+400	0.00	0.00	0.00	0.00	855.64	8.23

MATERIAL VOLUME PAVEMENT			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+020.00	0.70	0.00	0.00
3+040.00	0.70	13.96	13.96
3+060.00	0.70	13.96	27.91
3+070.00	0.70	6.98	34.89
3+080.00	0.70	6.98	41.87
3+090.00	0.70	6.98	48.85
3+100.00	0.70	6.98	55.83
3+110.00	0.70	6.98	62.80
3+120.00	0.70	6.98	69.78
3+130.00	0.70	6.98	76.76
3+140.00	0.70	6.98	83.74
3+150.00	0.70	6.98	90.72
3+160.00	0.70	6.98	97.70
3+170.00	0.70	6.98	104.67
3+180.00	0.70	6.98	111.65
3+190.00	0.70	6.98	118.63
3+200.00	0.70	6.98	125.61
3+210.00	0.70	6.98	132.59
3+220.00	0.70	6.98	139.57
3+230.00	0.70	6.98	146.54
3+240.00	0.70	6.98	153.52
3+250.00	0.70	6.98	160.50
3+260.00	0.70	6.98	167.48
3+270.00	0.70	6.98	174.46
3+280.00	0.70	6.98	181.43
3+290.00	0.70	6.98	188.41
3+300.00	0.70	6.98	195.39
3+310.00	0.70	6.98	202.37
3+320.00	0.70	6.98	209.35
3+330.00	0.70	6.98	216.33
3+340.00	0.70	6.98	223.30
3+350.00	0.00	3.49	226.79
3+360.00	0.00	0.00	226.79
3+380.00	0.00	0.00	226.79
3+400.00	0.00	0.00	226.79

MATERIAL VOLUME SUB–BASE			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+020.00	1.23	0.00	0.00
3+040.00	1.23	24.70	24.70
3+060.00	1.23	24.70	49.39
3+070.00	1.23	12.35	61.74
3+080.00	1.23	12.35	74.09
3+090.00	1.23	12.35	86.43
3+100.00	1.23	12.35	98.78
3+110.00	1.23	12.35	111.13
3+120.00	1.23	12.35	123.48
3+130.00	1.23	12.35	135.83
3+140.00	1.23	12.35	148.17
3+150.00	1.23	12.35	160.52
3+160.00	1.23	12.35	172.87
3+170.00	1.23	12.35	185.22
3+180.00	1.23	12.35	197.57
3+190.00	1.23	12.35	209.91
3+200.00	1.23	12.35	222.26
3+210.00	1.23	12.35	234.61
3+220.00	1.23	12.35	246.96
3+230.00	1.23	12.35	259.30
3+240.00	1.23	12.35	271.65
3+250.00	1.23	12.35	284.00
3+260.00	1.23	12.35	296.35
3+270.00	1.23	12.35	308.70
3+280.00	1.23	12.35	321.04
3+290.00	1.23	12.35	333.39
3+300.00	1.23	12.35	345.74
3+310.00	1.23	12.35	358.09
3+320.00	1.23	12.35	370.43
3+330.00	1.23	12.35	382.78
3+340.00	1.23	12.35	395.13
3+350.00	0.00	6.17	401.30
3+360.00	0.00	0.00	401.30
3+380.00	0.00	0.00	401.30
3+400.00	0.00	0.00	401.30

DRAFT
Sep 08, 2021



DILLON CONSULTING

DATE September 2021

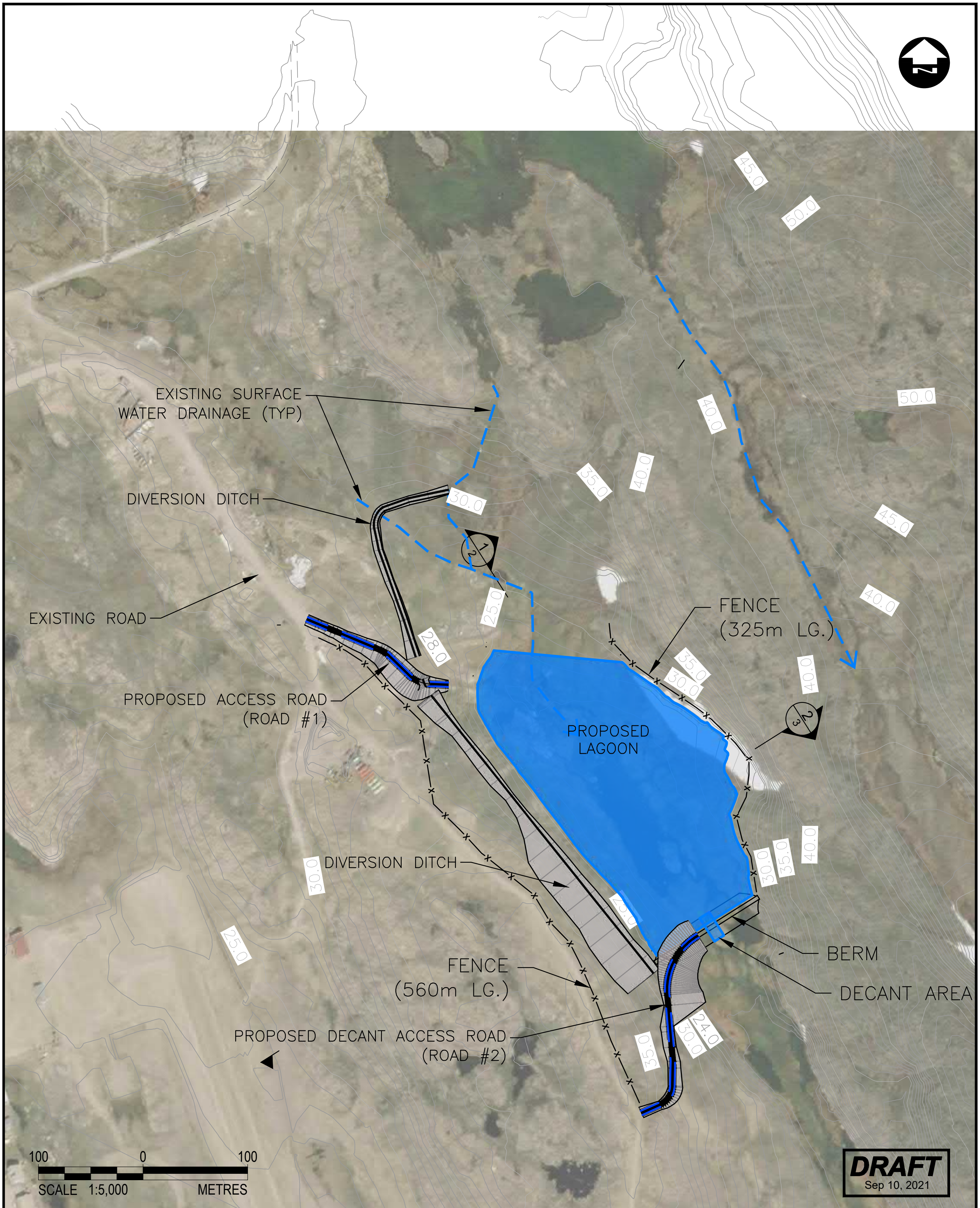
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 1**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES ACCESS ROAD AND TURNAROUND**

FIGURE NO. **Q-2**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt5.dwg



DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8**
HAMLET OF NAUJAAT, NUNAVUT

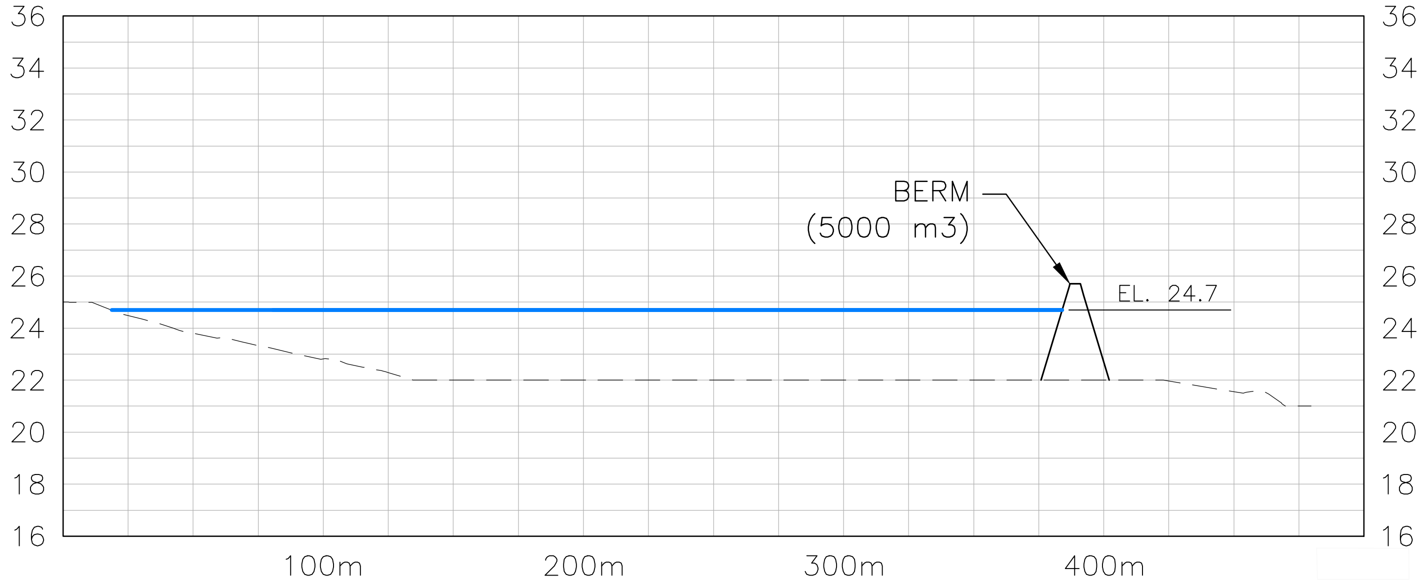
PROJECT NO. **21-2233**

TITLE **SITE PLAN**

FIGURE NO. **1**

DATE **September 2021**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt8.dwg



1
3
SECTION

DRAFT
Sep 10, 2021

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8**
HAMLET OF NAUJAAT, NUNAVUT

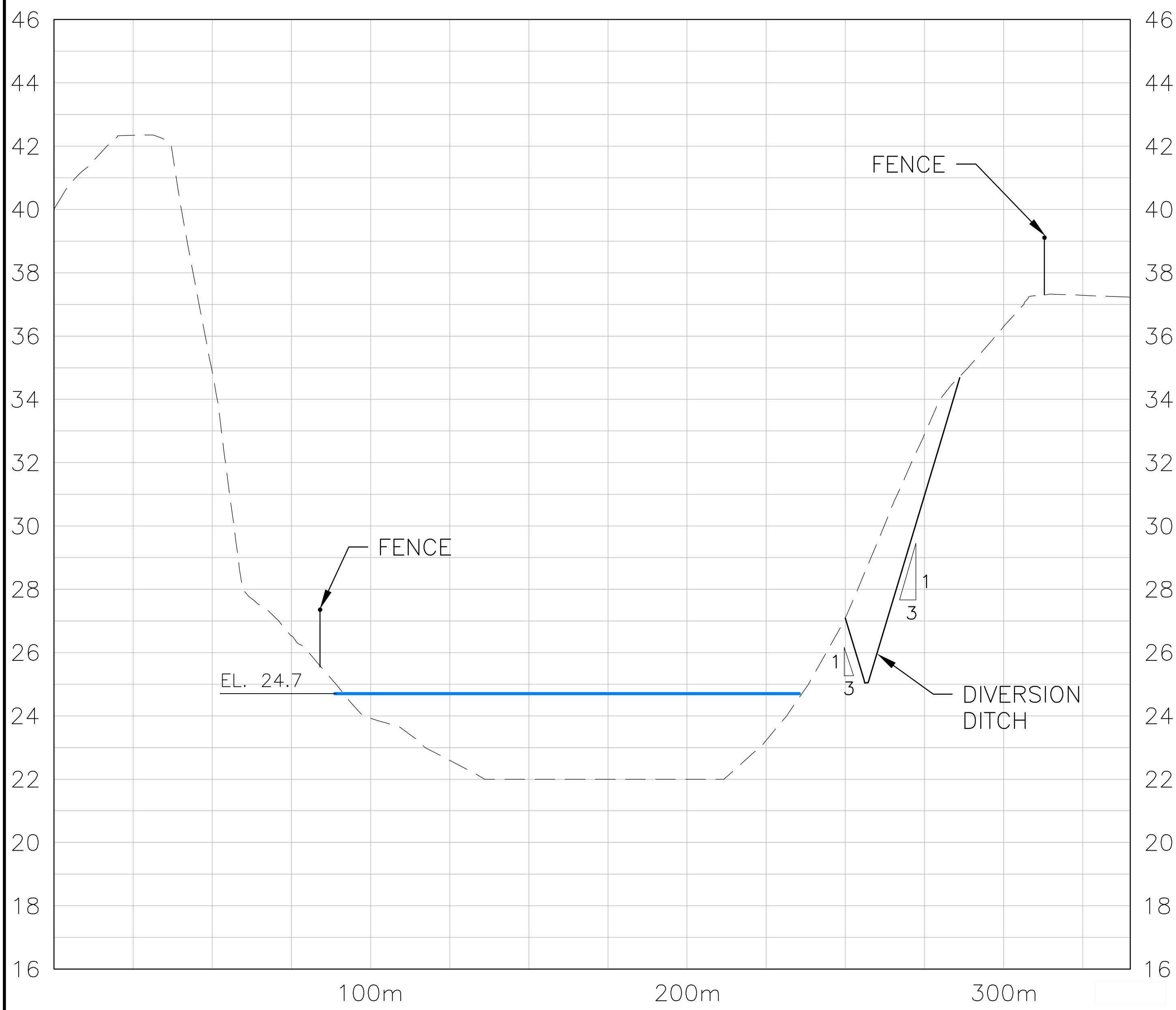
PROJECT NO. **21-2233**

TITLE **SECTION 1**

FIGURE NO. **2**

DATE **September 2021**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt8.dwg



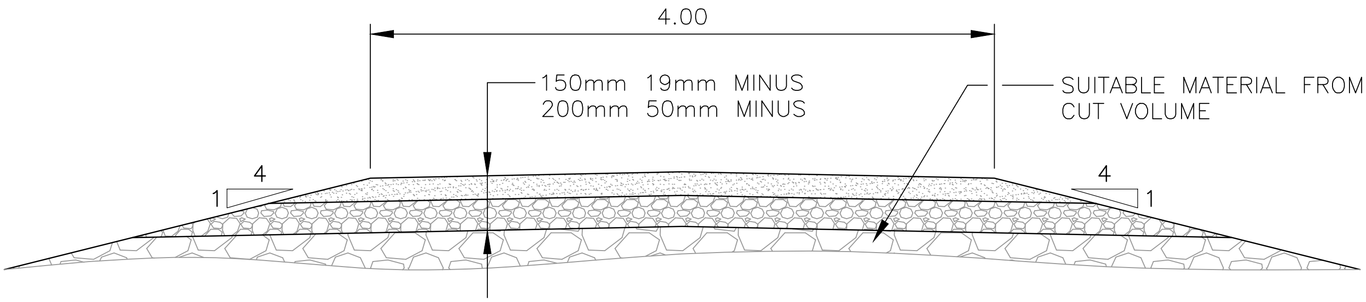
2
4
SECTION

DRAFT
Sep 10, 2021

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8** HAMLET OF NAUJAAT, NUNAVUT		PROJECT NO. **21-2233**
DATE **September 2021**	TITLE **SECTION 2**	FIGURE NO. **3**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\21223-02-site-opt8.dwg



TYPICAL ACCESS ROAD DETAIL
NTS

DRAFT
Sep 10, 2021

DILLON CONSULTING

DATE September 2021	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
	TITLE **DETAILS**	FIGURE NO. **5**

FileName:c:\pw working directory\projects 2021\40skbldms55676\21223-02-site-opt8.dwg

ALIGNMENT – DIVERSION DITCH
TOTAL VOLUME TABLE

STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
2+020	1.26	1.77	0.00	0.00	0.00	0.00
2+030	1.90	1.08	15.81	14.24	15.81	14.24
2+040	1.74	1.15	17.22	11.15	33.03	25.39
2+060	0.97	1.86	27.11	30.01	60.14	55.40
2+080	0.91	1.75	15.20	36.30	75.33	91.70
2+100	0.20	4.63	10.26	64.34	85.59	156.05
2+120	0.09	5.07	2.84	97.37	88.43	253.41
2+140	0.01	5.57	1.01	106.42	89.44	359.84
2+160	0.54	2.59	5.50	81.56	94.95	441.39
2+180	0.52	3.19	10.63	57.72	105.58	499.11
2+200	0.00	7.99	5.27	111.65	110.84	610.76
2+220	0.00	16.14	0.04	241.26	110.88	852.03
2+240	0.02	31.51	0.25	476.43	111.13	1328.46
2+260	0.00	40.10	0.26	742.84	111.39	2071.30
2+280	0.02	20.63	0.23	607.21	111.62	2678.51
2+300	0.00	9.56	0.23	301.89	111.85	2980.40
2+320	0.00	11.97	0.00	215.38	111.85	3195.78
2+340	0.00	15.10	0.00	270.71	111.85	3466.49
2+360	0.00	11.34	0.00	264.32	111.85	3730.81
2+380	0.00	6.14	0.00	174.71	111.85	3905.52
2+400	0.00	8.65	0.00	147.88	111.85	4053.39
2+420	0.00	20.70	0.00	293.55	111.85	4346.95
2+440	0.00	47.40	0.00	681.05	111.85	5028.00
2+460	0.00	71.29	0.00	1186.93	111.85	6214.92
2+480	0.00	70.93	0.00	1422.25	111.85	7637.17
2+500	0.00	76.31	0.00	1472.45	111.85	9109.62
2+520	0.00	70.67	0.00	1469.78	111.85	10579.41
2+560	0.45	67.54	8.96	2764.09	120.81	13343.49
2+580	0.00	99.84	4.48	1673.73	125.29	15017.22
2+600	0.00	0.00	0.00	998.35	125.29	16015.58
2+724.06	0.00	0.00	0.00	0.00	125.29	16015.58

DRAFT
Sep 10, 2021

DILLON CONSULTING

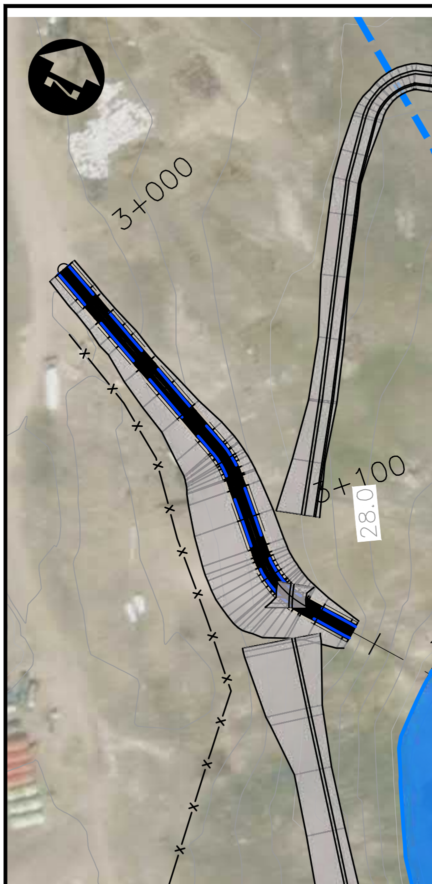
DATE September 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES - DIVERSION DITCH**

PROJECT NO. **21-2233**

FIGURE NO. **Q-1**



ALIGNMENT — ACCESS ROAD TOTAL VOLUME TABLE

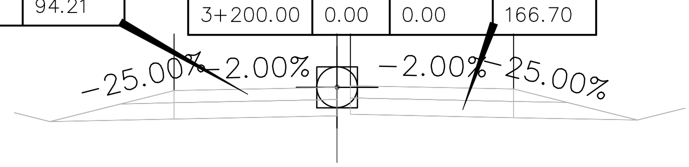
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+020	0.00	3.52	0.00	0.00	0.00	0.00
3+040	0.00	5.17	0.00	86.84	0.00	86.84
3+060	0.00	9.87	0.00	150.38	0.00	237.22
3+070	0.00	16.32	0.00	130.98	0.00	368.20
3+080	0.00	22.55	0.00	184.70	0.00	552.90
3+090	0.00	29.53	0.00	239.77	0.00	792.67
3+100	0.00	35.20	0.00	323.62	0.00	1116.29
3+110	0.00	38.85	0.00	370.22	0.00	1486.51
3+120	0.00	37.34	0.00	412.96	0.00	1899.47
3+130	0.00	28.44	0.00	360.94	0.00	2260.41
3+140	0.00	12.71	0.00	213.10	0.00	2473.51
3+150	0.00	5.98	0.00	93.48	0.00	2566.99
3+160	0.00	0.00	0.00	29.92	0.00	2596.91
3+170	0.00	0.00	0.00	0.00	0.00	2596.91
3+180	0.00	0.00	0.00	0.00	0.00	2596.91
3+190	0.00	0.00	0.00	0.00	0.00	2596.91
3+200	0.00	0.00	0.00	0.00	0.00	2596.91

MATERIAL VOLUME

STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+020.00	0.70	0.00	0.00
3+040.00	0.70	13.96	13.96
3+060.00	0.70	13.96	27.91
3+070.00	0.70	6.98	34.89
3+080.00	0.70	6.98	41.87
3+090.00	0.70	6.98	48.85
3+100.00	0.70	6.98	55.83
3+110.00	0.70	6.98	62.80
3+120.00	0.70	6.98	69.78
3+130.00	0.70	6.98	76.76
3+140.00	0.70	6.98	83.74
3+150.00	0.70	6.98	90.72
3+160.00	0.00	3.49	94.21
3+170.00	0.00	0.00	94.21
3+180.00	0.00	0.00	94.21
3+190.00	0.00	0.00	94.21
3+200.00	0.00	0.00	94.21

MATERIAL VOLUME

STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+020.00	1.23	0.00	0.00
3+040.00	1.23	24.70	24.70
3+060.00	1.23	24.70	49.39
3+070.00	1.23	12.35	61.74
3+080.00	1.23	12.35	74.09
3+090.00	1.23	12.35	86.43
3+100.00	1.23	12.35	98.78
3+110.00	1.23	12.35	111.13
3+120.00	1.23	12.35	123.48
3+130.00	1.23	12.35	135.83
3+140.00	1.23	12.35	148.17
3+150.00	1.23	12.35	160.52
3+160.00	0.00	6.17	166.70
3+170.00	0.00	0.00	166.70
3+180.00	0.00	0.00	166.70
3+190.00	0.00	0.00	166.70
3+200.00	0.00	0.00	166.70



DRAFT
Sep 10, 2021

DILLON CONSULTING

DATE September 2021

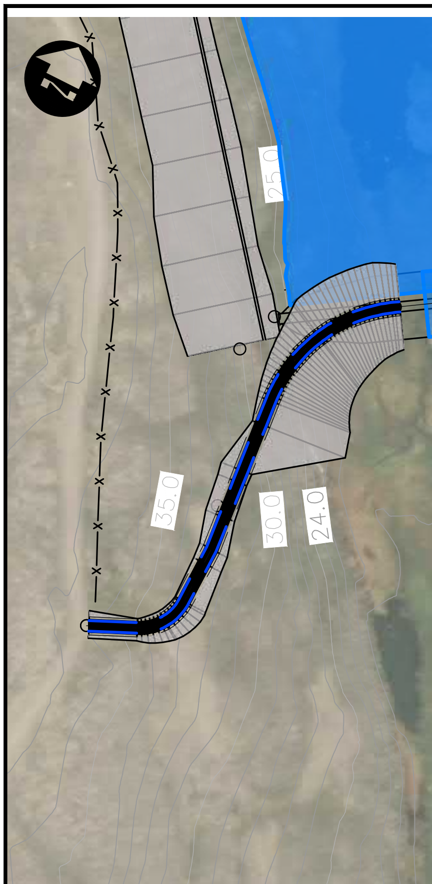
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES ACCESS ROAD #1**

PROJECT NO. **21-2233**

FIGURE NO. **Q-2**

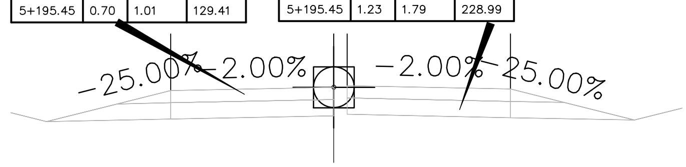
FileName:c:\pw working directory\projects 2021\40skb\dms55676\212233-02-site-opt8.dwg



ALIGNMENT – SOUTH BERM ACCESS ROAD OPTION 2 TOTAL VOLUME TABLE						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
5+000	0.00	0.00	0.00	0.00	0.00	0.00
5+020	1.21	0.02	12.12	0.23	12.12	0.23
5+020.30	1.32	0.01	0.39	0.00	12.50	0.23
5+022	2.15	0.00	3.14	0.01	15.64	0.24
5+024	3.32	0.00	5.76	0.00	21.40	0.24
5+026	4.66	0.00	8.41	0.00	29.80	0.24
5+028	5.74	0.00	11.02	0.00	40.82	0.24
5+030	6.58	0.00	13.17	0.00	53.99	0.24
5+031.56	7.15	0.00	11.57	0.00	65.56	0.24
5+032	7.30	0.00	3.45	0.00	69.01	0.24
5+034	7.82	0.00	16.53	0.00	85.54	0.24
5+036	8.05	0.00	17.55	0.00	103.09	0.24
5+038	7.96	0.00	17.89	0.00	120.97	0.24
5+040	7.54	0.00	17.48	0.00	138.45	0.24
5+042	6.71	0.00	16.15	0.00	154.61	0.24
5+042.81	6.28	0.00	6.01	0.00	160.61	0.24
5+060	2.97	0.19	79.51	1.60	240.12	1.85
5+066.34	2.13	0.45	16.16	2.03	256.28	3.88
5+080	0.08	2.90	15.46	22.35	271.75	26.23
5+100	0.00	5.33	0.82	82.27	272.57	108.50
5+120	40.84	0.00	408.36	53.26	680.93	161.77
5+130.01	64.47	0.00	527.20	0.00	1208.12	161.77
5+140	80.37	0.00	130.90	0.00	1795.61	161.77
5+150	97.03	0.00	168.35	0.00	2564.75	161.77
5+160	109.37	0.00	202.34	0.00	3512.40	161.77
5+170	107.53	0.00	208.14	0.00	4562.65	161.77
5+180	99.59	0.00	196.94	0.00	5572.60	161.77
5+190	85.40	0.00	174.75	0.00	6499.33	161.77
5+195.45	73.55	0.00	109.14	0.00	6932.40	161.77

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
5+000.00	0.00	0.00	0.00
5+020.00	0.70	6.98	6.98
5+020.30	0.70	0.21	7.19
5+022.00	0.70	1.18	8.37
5+024.00	0.70	1.40	9.77
5+026.00	0.70	1.40	11.17
5+028.00	0.70	1.40	12.56
5+030.00	0.70	1.40	13.96
5+031.56	0.70	1.09	15.05
5+032.00	0.70	0.31	15.35
5+034.00	0.70	1.40	16.75
5+036.00	0.70	1.40	18.14
5+038.00	0.70	1.40	19.54
5+040.00	0.70	1.40	20.93
5+042.00	0.70	1.40	22.33
5+042.81	0.70	0.57	22.90
5+060.00	0.70	11.99	34.89
5+066.34	0.70	4.42	39.31
5+080.00	0.70	9.54	48.85
5+100.00	0.70	13.96	62.80
5+120.00	0.70	13.96	76.76
5+130.01	0.70	6.99	83.75
5+140.00	0.70	1.40	90.72
5+150.00	0.70	1.40	97.70
5+160.00	0.70	1.40	104.67
5+170.00	0.70	1.40	111.65
5+180.00	0.70	1.40	118.63
5+190.00	0.70	1.40	125.61
5+195.45	0.70	1.01	129.41

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
5+000.00	0.00	0.00	0.00
5+020.00	1.23	12.35	12.35
5+020.30	1.23	0.38	12.72
5+022.00	1.23	2.09	14.82
5+024.00	1.23	2.47	17.29
5+026.00	1.23	2.47	19.76
5+028.00	1.23	2.47	22.23
5+030.00	1.23	2.47	24.70
5+031.56	1.23	1.93	26.62
5+032.00	1.23	0.54	27.17
5+034.00	1.23	2.47	29.63
5+036.00	1.23	2.47	32.10
5+038.00	1.23	2.47	34.57
5+040.00	1.23	2.47	37.04
5+042.00	1.23	2.47	39.51
5+042.81	1.23	1.01	40.52
5+060.00	1.23	21.22	61.74
5+066.34	1.23	7.82	69.56
5+080.00	1.23	16.87	86.43
5+100.00	1.23	24.70	111.13
5+120.00	1.23	24.70	135.83
5+130.01	1.23	12.36	148.19
5+140.00	1.23	2.47	160.52
5+150.00	1.23	2.47	172.87
5+160.00	1.23	2.47	185.22
5+170.00	1.23	2.47	197.57
5+180.00	1.23	2.47	209.91
5+190.00	1.23	2.47	222.26
5+195.45	1.23	1.79	228.99



DRAFT
Sep 10, 2021

DILLON CONSULTING

DATE September 2021

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 8**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

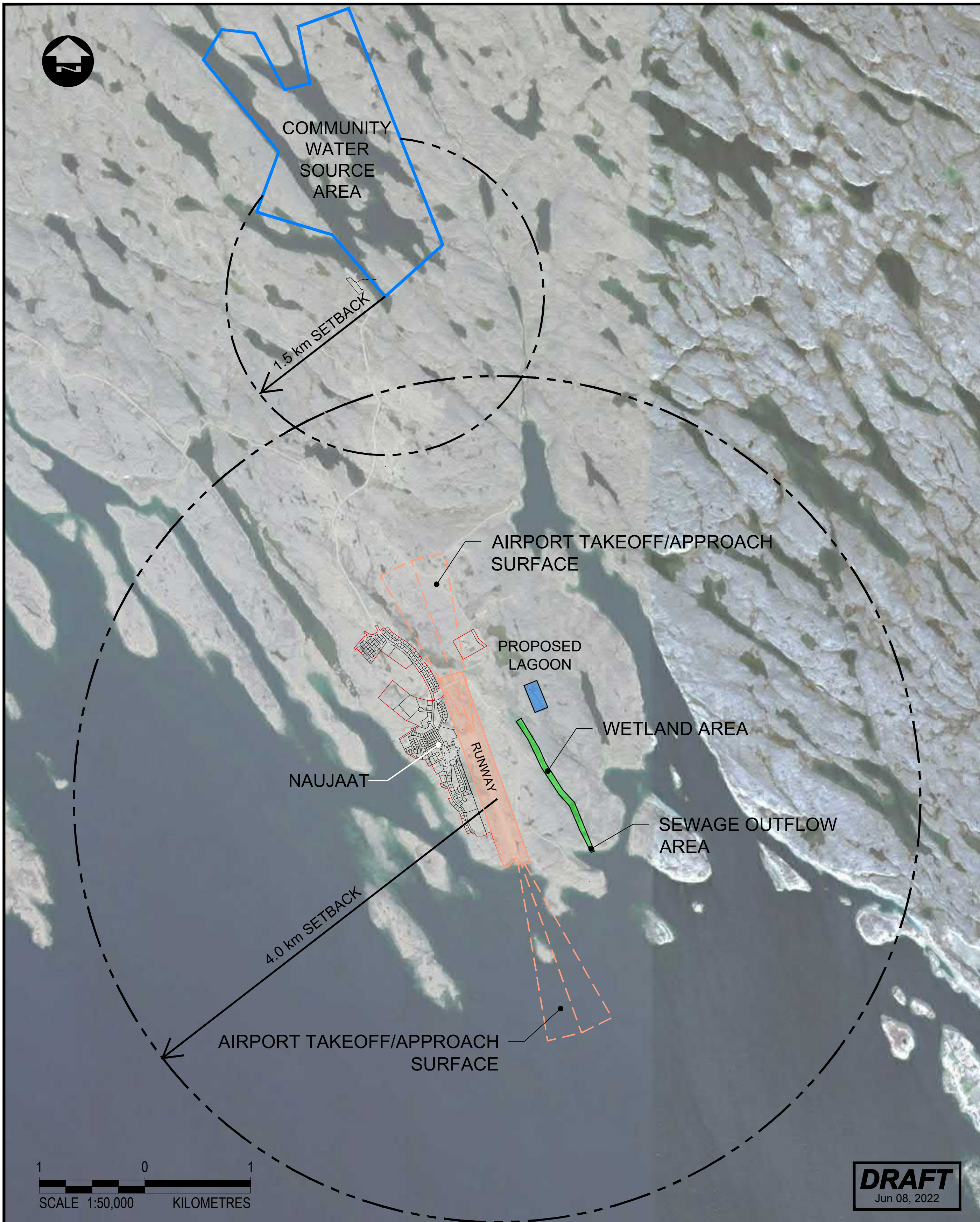
TITLE **QUANTITIES ACCESS ROAD #2**

FIGURE NO. **Q-3**

FileName:c:\pw working directory\projects 2021\40skb\dms55676\21223-02-site-opt8.dwg

Appendix C

Sub-Option 3B Lagoon Constraint Mapping *and Figures*



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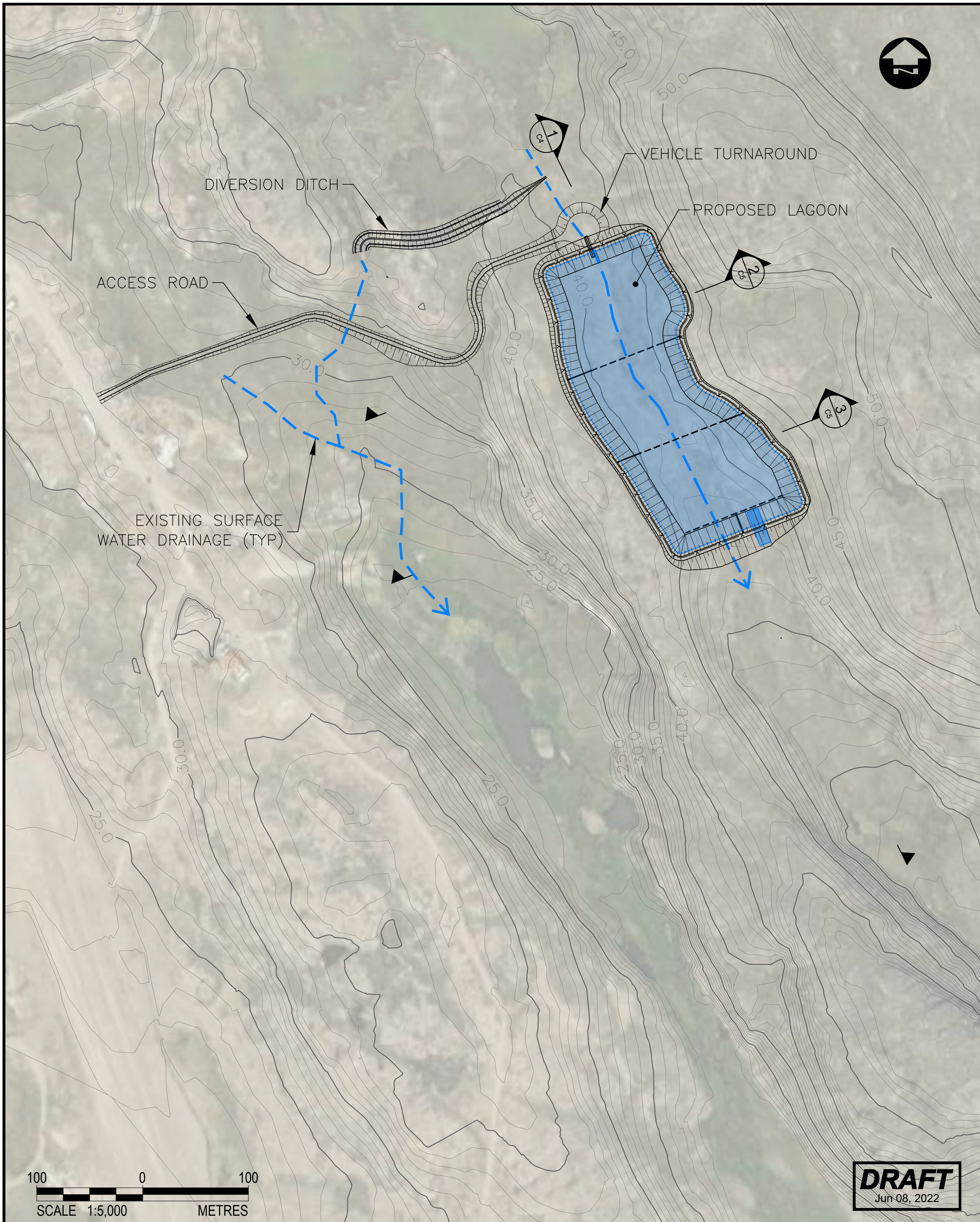
DILLON CONSULTING	PROJECT LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
DATE June 2022	TITLE SETBACKS	FIGURE NO. C1



DILLON CONSULTING

DATE June 2022

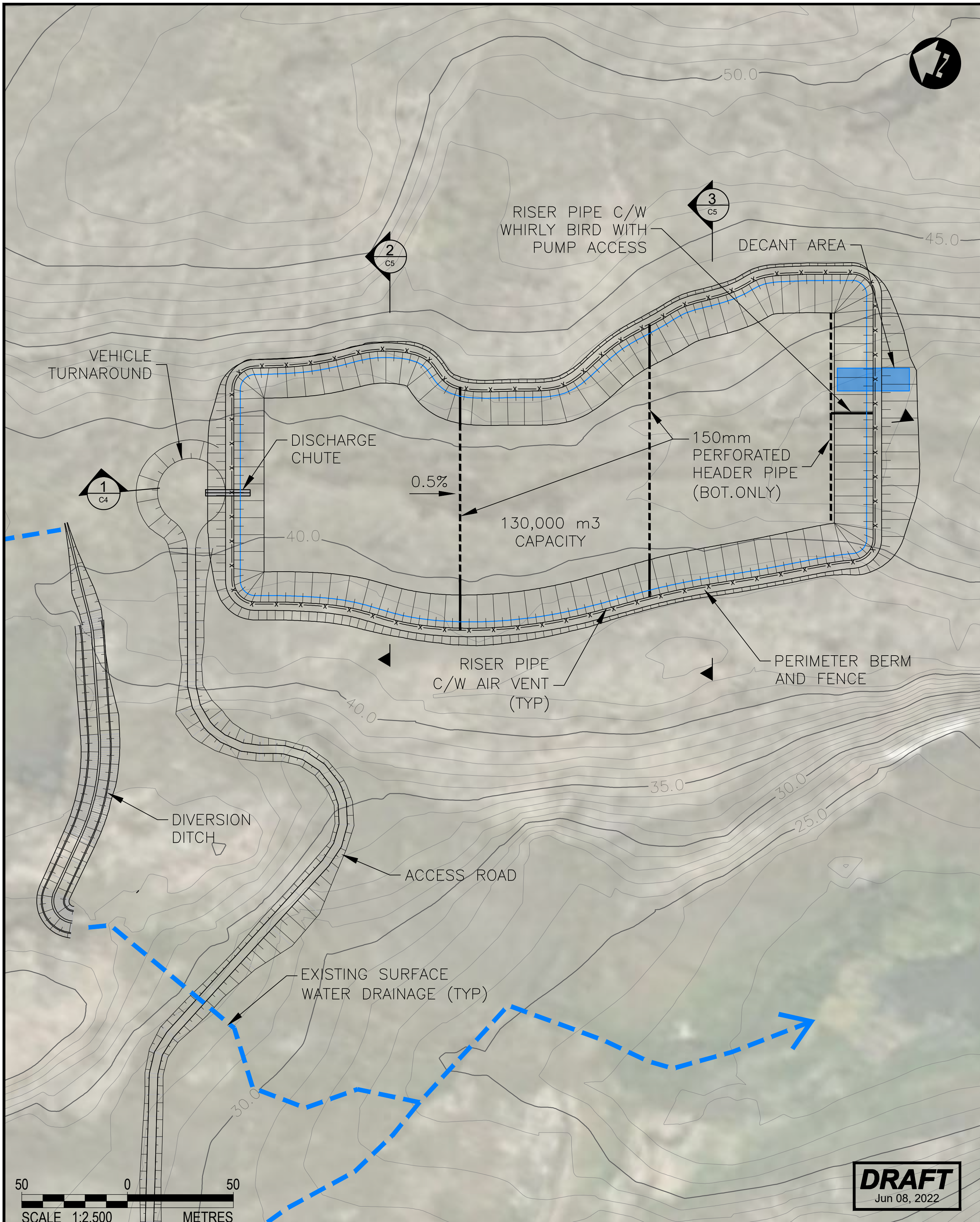
PROJECT
LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

TITLE
SITE PLAN

PROJECT NO.
21-2233

FIGURE NO.
C2

FileName:c:\pw working directory\projects 2021\41tpw\dms94318\21233-02-site-opt3-12-month0.5 percent bottom.dwg



DILLON CONSULTING

DATE June 2022

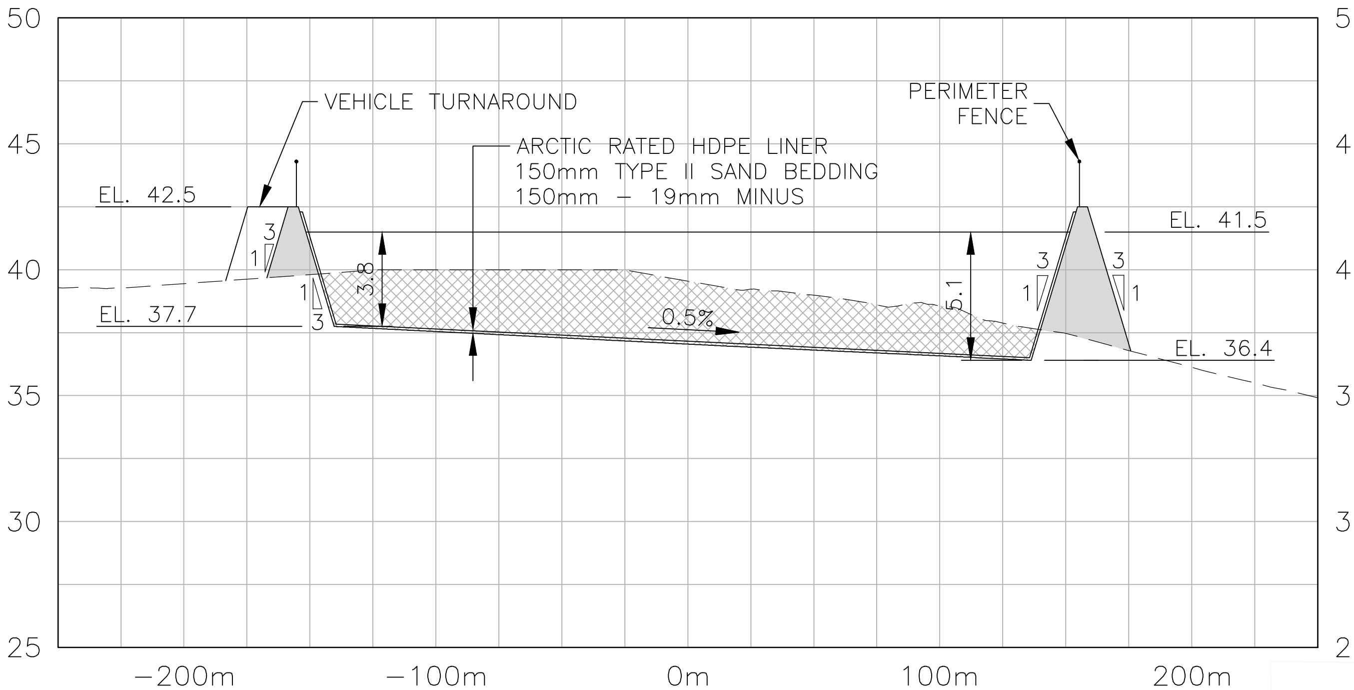
PROJECT
LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

TITLE
LAGOON PLAN

PROJECT NO. 21-2233

FIGURE NO. C3

FileName:c:\pw working directory\projects 2021\41tpw\dms94318\212233-02-site-opt3-12-month0.5 percent bottom.dwg



1 C4 SECTION
HOR. 1:3000 VER. 1:300

DRAFT
Jun 08, 2022

DILLON CONSULTING

PROJECT
LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. 21-2233

TITLE
SECTION 1

FIGURE NO. C4

DATE June 2022

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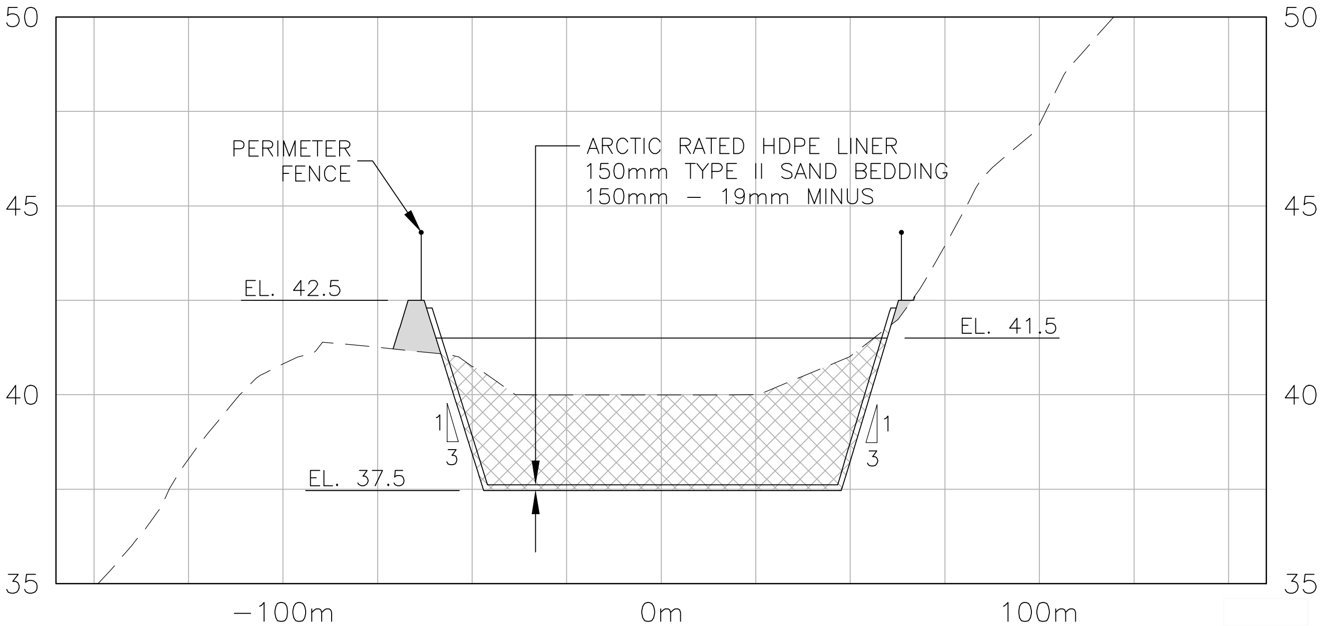
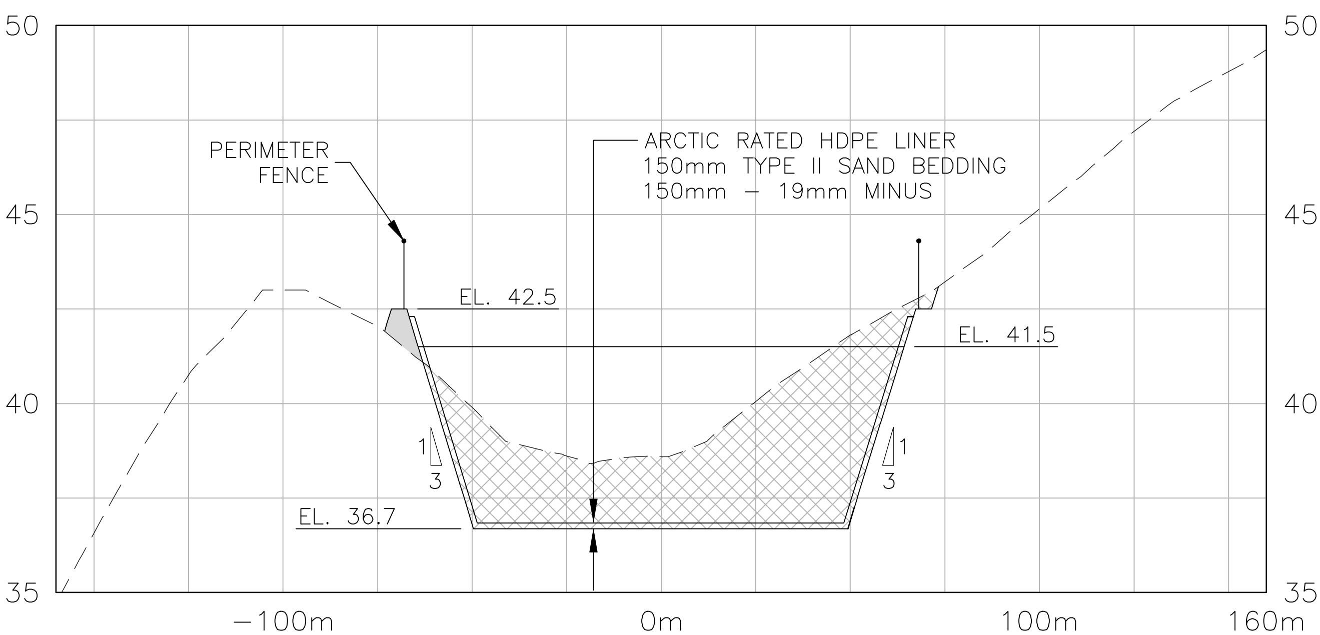


2
C5
SECTION
HOR. 1:2000 VER. 1:200

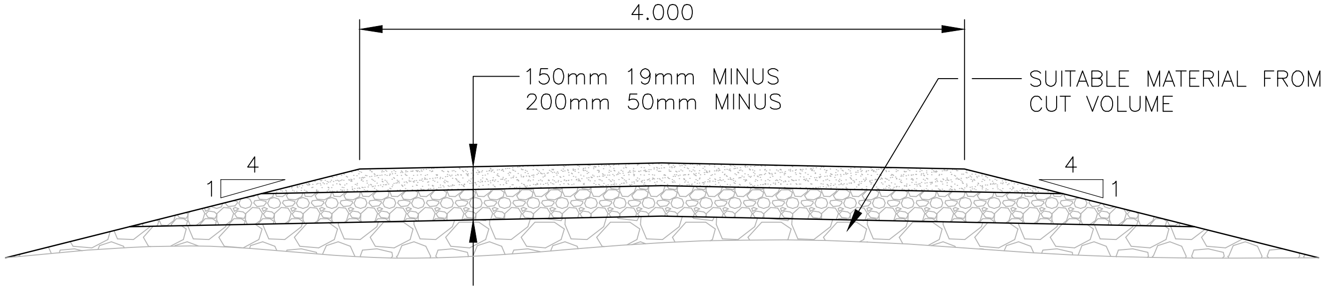


3
C5
SECTION
HOR. 1:2000 VER. 1:200

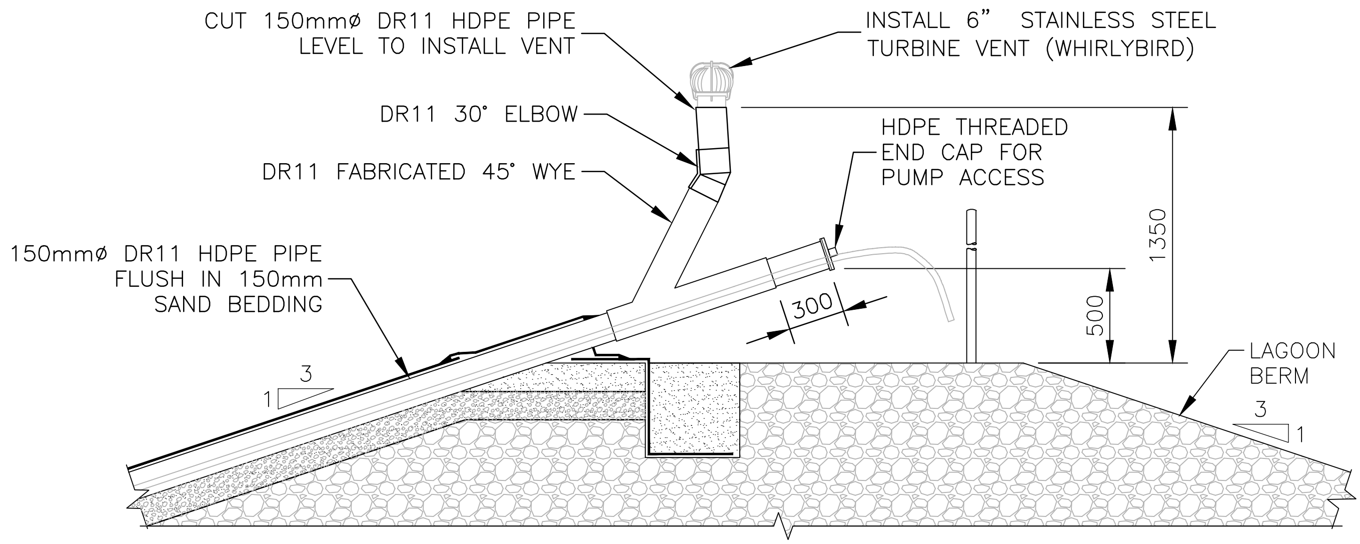
DRAFT
Jun 08, 2022

FileName:c:\pw working directory\projects 2021\41tpw\dms94318\212233-02-site-opt3-12-month0.5 percent bottom.dwg

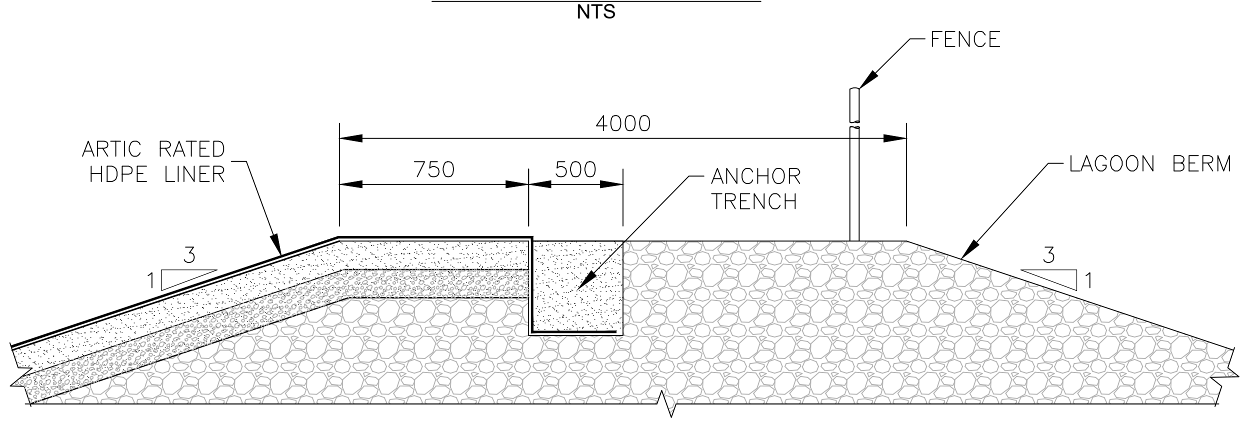
DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **June 2022**	TITLE **SECTIONS 2 AND 3**	FIGURE NO. **C5**



ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



ANCHOR TRENCH DETAIL
NTS

DRAFT
Jun 08, 2022

DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **June 2022**	TITLE **DETAILS**	FIGURE NO. **C6**

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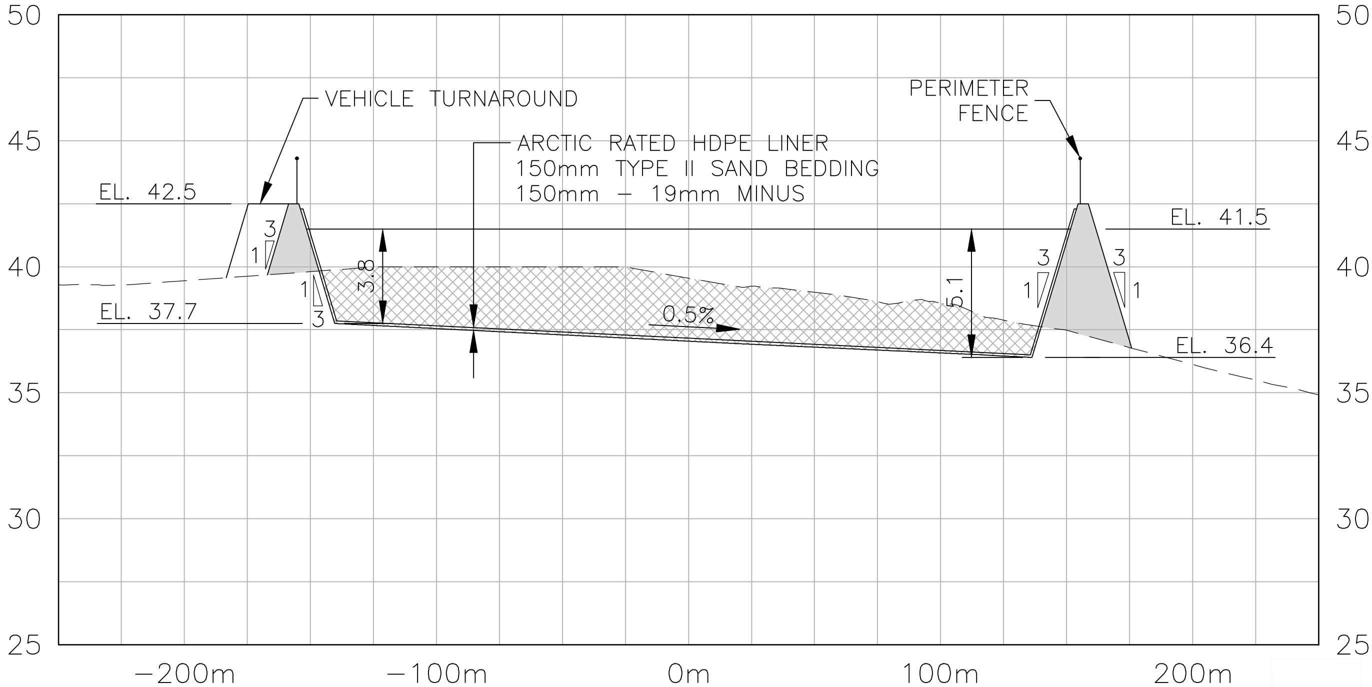


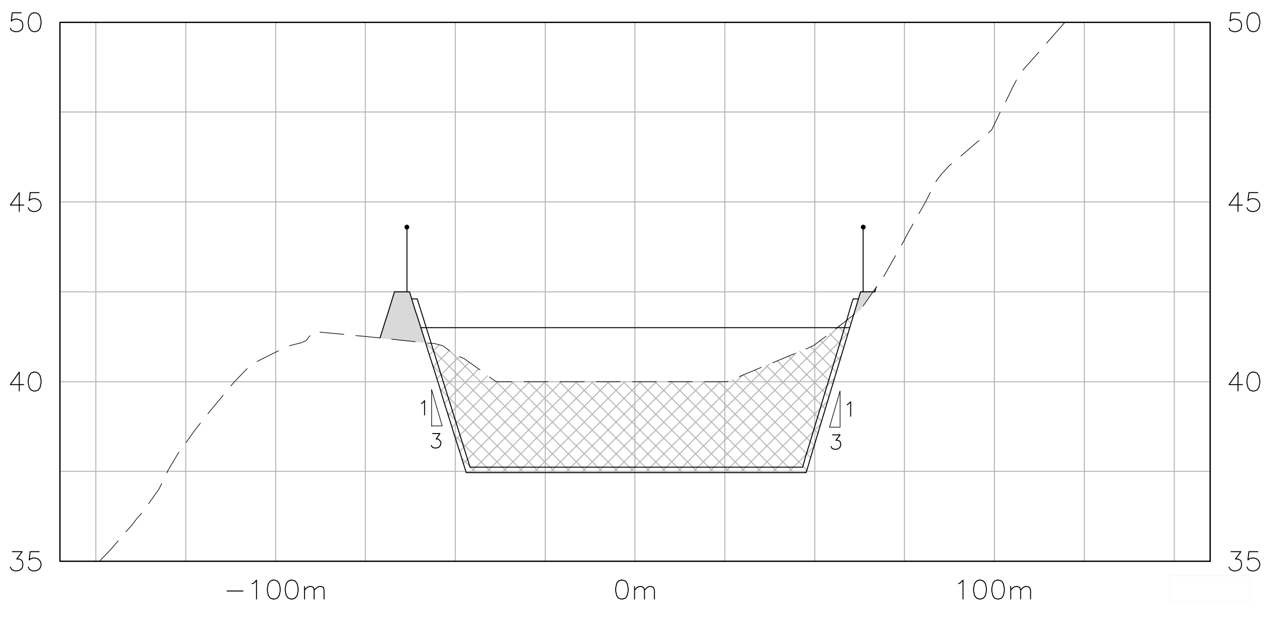
1 SECTION
C4 HOR. 1:3000 VER. 1:300

ARCTIC RATED HDPE LINER:..................................39,500m2
TYPE II SAND BEDDING: 39,500 x 0.15 ....6,000m3
TYPE II 19mm MINUS.......39,,500 x 0.15............6,000m3

LAGOON CUT....................................79,200m3
LAGOON CONSTRUCTION FILL............15,300m3
NET (CUT)..63,900m3

150mm HDPE PIPE (PERFORATED)..............265m
150mm HDPE PIPE (SLOPES)........................70m
150mm HDPE PIPE (ABOVE T/O BERM)........12m

PERIMETER FENCE:....865m



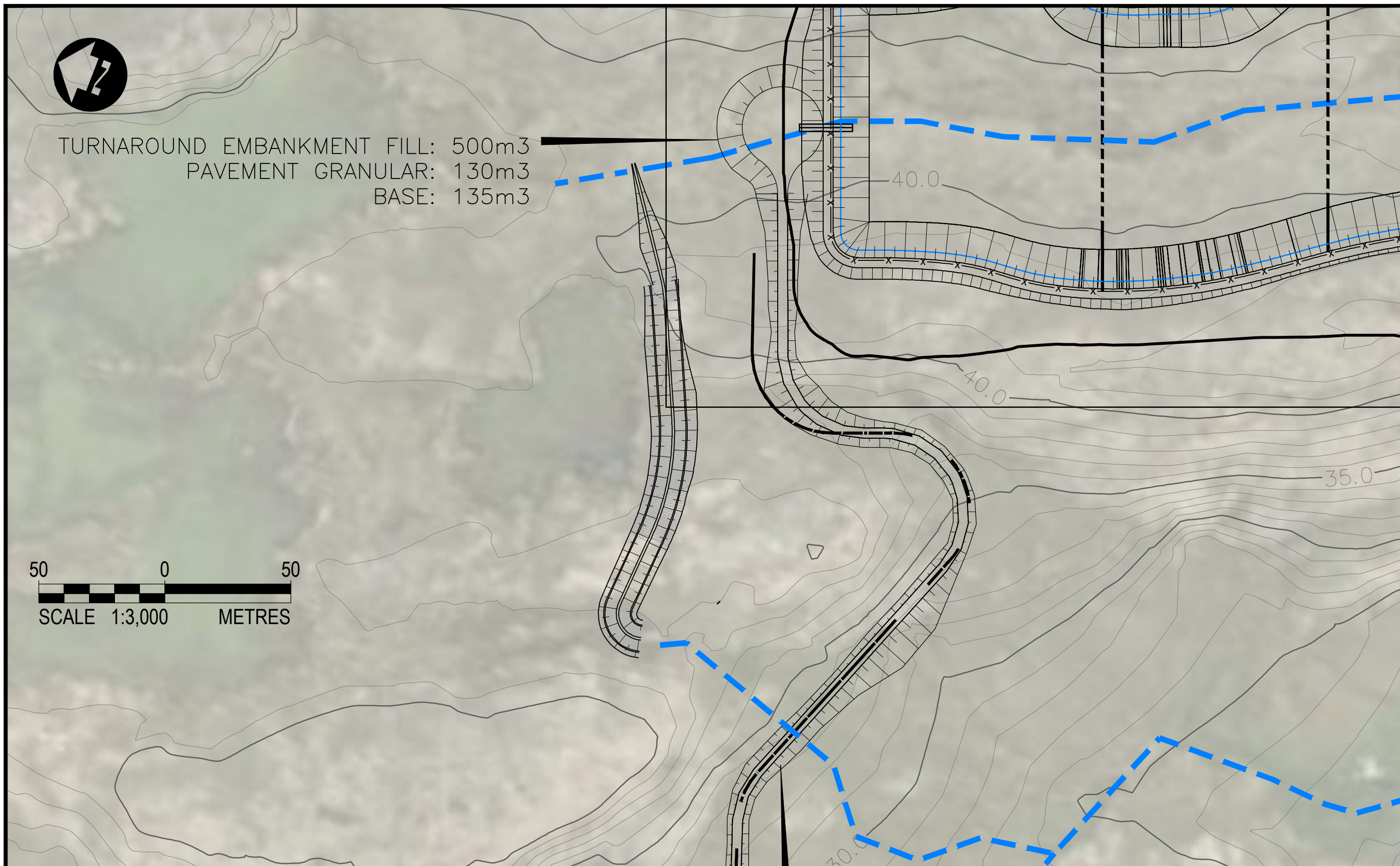
2 SECTION
C5 HOR. 1:2000 VER. 1:200

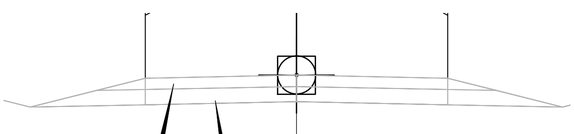
DRAFT
Jun 08, 2022

DILLON CONSULTING

DATE June 2022	PROJECT LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
	TITLE QUANTITIES LAGOON SECTIONS	FIGURE NO. C7

FileName:c:\pw working directory\projects 2021\41tpw\dms94318\21233-02-site-opt3-12-month0.5 percent bottom.dwg





MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	0.70	0.00	0.00
3+020.00	0.70	13.96	13.96
3+040.00	0.70	13.96	27.91
3+060.00	0.70	13.96	41.87
3+070.00	0.70	6.98	48.85
3+080.00	0.70	6.98	55.83
3+090.00	0.70	6.98	62.80
3+100.00	0.70	6.98	69.78
3+110.00	0.70	6.98	76.76
3+120.00	0.70	6.98	83.74
3+130.00	0.70	6.98	90.72
3+140.00	0.70	6.98	97.70
3+150.00	0.70	6.98	104.67
3+160.00	0.70	6.98	111.65
3+170.00	0.70	6.98	118.63
3+180.00	0.70	6.98	125.61
3+190.00	0.70	6.98	132.59
3+200.00	0.70	6.98	139.57
3+210.00	0.70	6.98	146.54
3+220.00	0.70	6.98	153.52
3+230.00	0.70	6.98	160.50
3+240.00	0.70	6.98	167.48
3+250.00	0.70	6.98	174.46
3+260.00	0.70	6.98	181.43
3+270.00	0.70	6.98	188.41
3+280.00	0.70	6.98	195.39
3+290.00	0.70	6.98	202.37
3+300.00	0.70	6.98	209.35
3+310.00	0.70	6.98	216.33
3+320.00	0.70	6.98	223.30
3+330.00	0.70	6.98	230.28
3+340.00	0.70	6.98	237.26
3+350.00	0.70	6.98	244.24
3+360.00	0.70	6.98	251.22
3+380.00	0.70	13.96	265.17
3+400.00	0.70	13.96	279.13
3+420.00	0.70	13.96	293.09
3+440.00	0.70	13.96	307.04
3+445.70	0.70	3.98	311.02

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	1.23	0.00	0.00
3+020.00	1.23	24.70	24.70
3+040.00	1.23	24.70	49.39
3+060.00	1.23	24.70	74.09
3+070.00	1.23	12.35	86.43
3+080.00	1.23	12.35	98.78
3+090.00	1.23	12.35	111.13
3+100.00	1.23	12.35	123.48
3+110.00	1.23	12.35	135.83
3+120.00	1.23	12.35	148.17
3+130.00	1.23	12.35	160.52
3+140.00	1.23	12.35	172.87
3+150.00	1.23	12.35	185.22
3+160.00	1.23	12.35	197.57
3+170.00	1.23	12.35	209.91
3+180.00	1.23	12.35	222.26
3+190.00	1.23	12.35	234.61
3+200.00	1.23	12.35	246.96
3+210.00	1.23	12.35	259.30
3+220.00	1.23	12.35	271.65
3+230.00	1.23	12.35	284.00
3+240.00	1.23	12.35	296.35
3+250.00	1.23	12.35	308.70
3+260.00	1.23	12.35	321.04
3+270.00	1.23	12.35	333.39
3+280.00	1.23	12.35	345.74
3+290.00	1.23	12.35	358.09
3+300.00	1.23	12.35	370.43
3+310.00	1.23	12.35	382.78
3+320.00	1.23	12.35	395.13
3+330.00	1.23	12.35	407.48
3+340.00	1.23	12.35	419.83
3+350.00	1.23	12.35	432.17
3+360.00	1.23	12.35	444.52
3+380.00	1.23	24.70	469.22
3+400.00	1.23	24.70	493.91
3+420.00	1.23	24.70	518.61
3+440.00	1.23	24.70	543.30
3+445.70	1.23	7.04	550.34

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+020	0.00	0.21	0.00	0.00	0.00	0.00
3+040	0.21	0.02	2.08	2.28	2.08	2.28
3+060	0.35	0.01	5.60	0.33	7.68	2.61
3+070	0.54	0.00	4.43	0.09	12.12	2.70
3+080	1.54	0.00	10.39	0.02	22.50	2.71
3+090	2.50	0.00	20.18	0.00	42.68	2.71
3+100	0.81	0.00	16.54	0.00	59.22	2.72
3+110	1.60	0.00	12.04	0.00	71.26	2.72
3+120	1.85	0.00	17.26	0.02	88.52	2.74
3+130	1.62	0.11	17.35	0.54	105.87	3.28
3+140	1.72	0.13	16.69	1.16	122.56	4.44
3+150	1.06	0.38	13.89	2.56	136.46	7.01
3+160	0.67	0.67	8.63	5.26	145.09	12.27
3+170	0.61	0.56	6.42	6.12	151.51	18.39
3+180	0.98	0.28	7.96	4.20	159.47	22.59
3+190	1.15	0.13	10.62	2.07	170.08	24.66
3+200	1.03	0.05	10.90	0.93	180.98	25.58
3+210	0.76	0.16	8.89	1.07	189.88	26.66
3+220	0.97	0.28	8.14	2.40	198.02	29.06
3+230	0.83	1.07	8.32	7.41	206.34	36.47
3+240	1.43	0.66	11.21	8.72	217.55	45.20
3+250	1.90	0.61	16.68	6.39	234.24	51.58
3+260	2.10	0.28	20.00	4.49	254.24	56.08
3+270	2.70	0.22	23.97	2.53	278.21	58.60
3+280	6.35	0.00	45.24	1.11	323.45	59.71
3+290	13.69	0.00	100.22	0.00	423.67	59.71
3+300	18.86	0.00	162.78	0.00	586.45	59.71
3+310	24.55	0.00	217.08	0.00	803.53	59.71
3+320	16.96	0.00	207.58	0.00	1011.11	59.72
3+330	7.98	0.24	124.70	1.21	1135.82	60.93
3+340	5.54	0.00	67.60	1.21	1203.41	62.14
3+350	0.95	0.06	33.36	0.29	1236.77	62.43
3+360	2.07	0.00	15.67	0.29	1252.44	62.71
3+380	1.84	0.00	39.62	0.00	1292.05	62.71
3+400	1.60	0.00	34.04	0.00	1326.09	62.71
3+420	4.06	0.00	56.53	0.00	1382.62	62.71
3+430	5.41	0.00	47.34	0.00	1429.96	62.71
3+440	6.94	0.00	59.48	0.00	1489.45	62.71

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+445.70	10.10	0.00	46.17	0.00	1535.62	62.72
3+450	13.06	0.00	47.66	0.00	1583.28	62.72
3+455	17.51	0.00	73.93	0.00	1657.20	62.72
3+456.49	18.81	0.00	26.39	0.00	1683.59	62.72
3+460	22.28	0.00	70.57	0.00	1754.16	62.72
3+465	23.92	0.00	113.84	0.00	1868.00	62.72
3+470	21.01	0.00	112.56	0.00	1980.56	62.72
3+475	13.01	0.01	86.30	0.02	2066.86	62.74
3+480	6.46	0.00	49.03	0.02	2115.89	62.76
3+481.59	5.60	0.00	9.65	0.00	2125.54	62.76
3+490	2.39	0.00	33.55	0.00	2159.09	62.76
3+500	5.35	0.00	38.67	0.00	2197.76	62.76
3+510	11.45	0.00	84.01	0.00	2281.77	62.77
3+520	19.30	0.00	153.79	0.00	2435.55	62.77
3+530	38.41	0.03	288.56	0.14	2724.12	62.91
3+540	66.31	0.00	523.60	0.14	3247.72	63.05
3+546.96	0.00	0.00	230.61	0.00	3478.33	63.05
3+550	0.00	0.00	0.00	0.00	3478.33	63.05
3+560	0.00	0.00	0.00	0.00	3478.33	63.05
3+570	0.00	0.00	0.00	0.00	3478.33	63.05
3+570.74	0.00	0.00	0.00	0.00	3478.33	63.05
3+580	0.00	0.00	0.00	0.00	3478.33	63.05
3+590	0.00	0.00	0.00	0.00	3478.33	63.05
3+600	0.00	0.00	0.00	0.00	3478.33	63.05
3+605.12	0.00	0.00	0.00	0.00	3478.33	63.05

DRAFT
Jun 08, 2022

DILLON CONSULTING

DATE June 2022

PROJECT
LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

TITLE
QUANTITIES
ACCESS ROAD AND TURNAROUND

PROJECT NO.
21-2233

FIGURE NO.
C8

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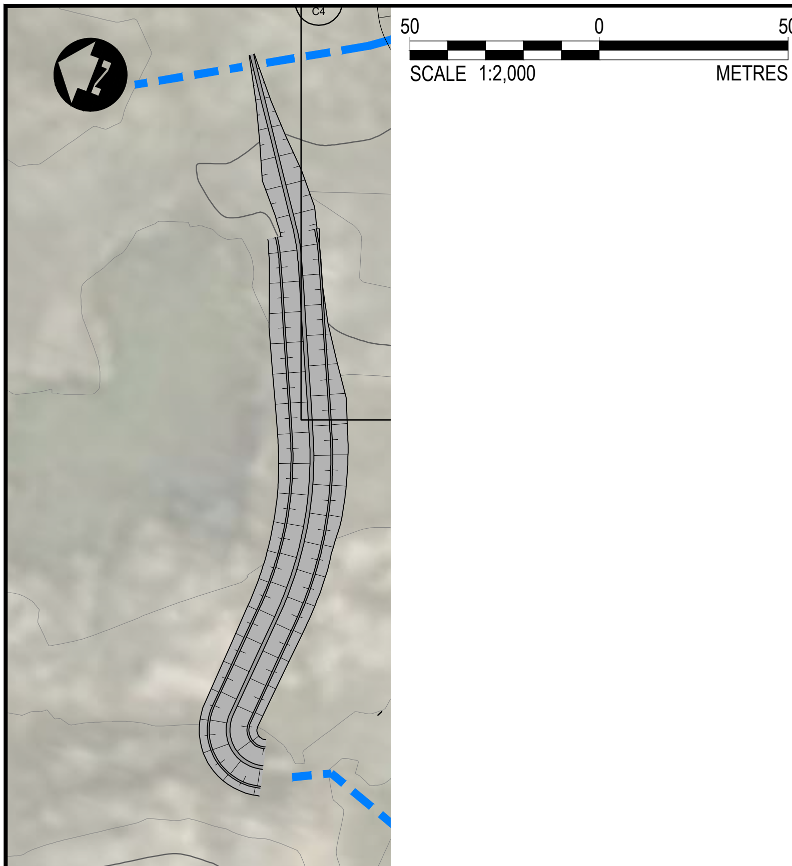
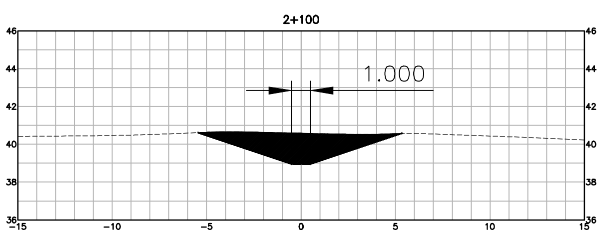
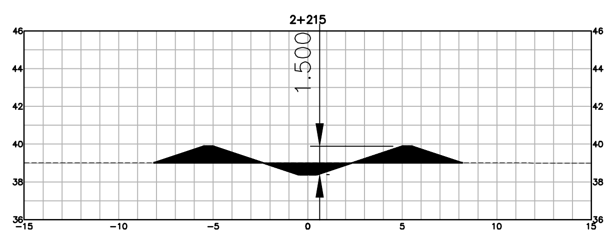
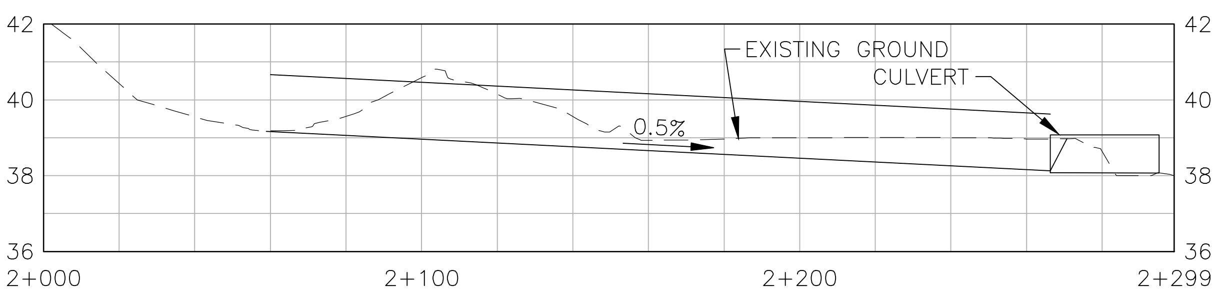


PLAN

ALIGNMENT – DIVERSION DITCH CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
2+000	0.00	0.00	0.00	0.00	0.00	0.00
2+010	0.00	0.00	0.00	0.00	0.00	0.00
2+020	0.00	0.00	0.00	0.00	0.00	0.00
2+030	0.00	0.00	0.00	0.00	0.00	0.00
2+040	0.00	0.00	0.00	0.00	0.00	0.00
2+050	0.00	0.00	0.00	0.00	0.00	0.00
2+060	0.00	0.00	0.00	0.00	0.00	0.00
2+070	0.00	0.23	0.00	1.15	0.00	1.15
2+080	0.00	1.24	0.00	7.35	0.00	8.50
2+090	0.01	4.34	0.06	27.89	0.06	36.39
2+100	0.00	9.60	0.06	69.70	0.12	106.09
2+110	0.26	9.36	1.28	94.82	1.40	200.91
2+118.75	1.11	6.97	5.97	71.42	7.37	272.33
2+120	1.12	6.36	0.27	8.85	7.65	281.18
2+130	2.29	5.13	17.08	57.45	24.72	338.63
2+140	4.39	2.89	33.40	40.08	58.13	378.71
2+150	7.38	1.34	58.84	21.14	116.97	399.85
2+160	10.78	0.49	90.80	9.18	207.77	409.03
2+168.71	10.00	0.64	90.53	4.93	298.30	413.96
2+170	9.89	0.66	12.81	0.84	311.11	414.80
2+175	9.42	0.77	48.65	3.57	359.76	418.38
2+180	8.91	0.90	46.17	4.17	405.93	422.55
2+185	8.37	1.05	43.50	4.87	449.43	427.42
2+190	7.81	1.19	40.70	5.60	490.13	433.02
2+193.57	7.35	1.28	27.17	4.40	517.30	437.42
2+195	7.07	1.31	10.32	1.85	527.62	439.27
2+200	6.41	1.41	33.74	6.81	561.36	446.08
2+205	6.17	1.53	31.44	7.37	592.80	453.45
2+210	5.85	1.65	30.03	7.95	622.83	461.39
2+215	5.55	1.77	28.48	8.54	651.31	469.93
2+218.42	5.34	1.85	18.65	6.19	669.95	476.12
2+220	5.25	1.89	8.35	2.95	678.30	479.07
2+230	4.69	2.15	49.69	20.21	727.99	499.28
2+240	4.19	2.40	44.39	22.77	772.38	522.05
2+247.09	3.86	2.59	28.54	17.67	800.92	539.72
2+250	3.75	2.65	11.07	7.64	811.99	547.36
2+255	3.65	2.71	18.52	13.40	830.51	560.76
2+256.51	3.62	2.73	5.52	4.09	836.03	564.85
2+260	3.54	2.78	12.67	9.59	848.70	574.45
2+265	3.37	2.88	17.67	14.12	866.36	588.57
2+265.93	3.35	2.91	3.22	2.69	869.58	591.25
2+270	0.00	0.00	6.81	5.92	876.39	597.17
2+280	0.00	0.00	0.00	0.00	876.39	597.17
2+290	0.00	0.00	0.00	0.00	876.39	597.17
2+299.09	0.00	0.00	0.00	0.00	876.39	597.17







DIVERSION DITCH PROFILE

DRAFT
Jun 08, 2022

DILLON CONSULTING

DATE June 2022

PROJECT
LAGOON SCHEMATIC DESIGN - SUB-OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

TITLE
QUANTITIES
DIVERSION DITCH

PROJECT NO.
21-2233

FIGURE NO.
C9

Appendix D

Naujaat WWTF – Option 3: 10 Month vs.
12 Month Capacity – R1 Memo

Memo

To: Ashwani Sharma, Project Manager

From: Keith Barnes, Project Manager

cc: Roberto Woisky, Wayne Thistle, David Brown, Sarah Collins

Date: April 13, 2022

Subject: Naujaat WWTF – Option 3: 10 Month vs. 12 Month Capacity – R1

Our File: File #21-2233

Introduction

Dillon Consulting (Dillon) submitted the Naujaat WWTF Draft Pre-Design Report on December 17, 2021 to the Government of Nunavut (GN). Upon review of the report, and the subsequent review meeting on February 14, 2022, the GN asked whether Dillon could further investigate land constraints at the site of Option 3 for sub-options that would provide a larger lagoon footprint and/or capacity, including the comparison of:

- Sub-Option 3A: 10 month capacity lagoon cell with a depth of 3 m; and,
- Sub-Option 3B: 12 month capacity lagoon cell with a depth of 4.5 m.

Dillon met with the GN on March 28, 2022 to discuss these options. The direction from the GN was to update the 10 month option, with a 4.5 m depth and provide a cost estimate for comparison to the other sub-options discussed. Dillon prepared schematic design drawings and cost estimates for the new sub-option.

- Sub-Option 3C: 10 month capacity lagoon cell with a depth of 4.5 m.

As part of the comparison, Dillon completed schematic design drawings, comparison of advantages/disadvantages and updated cost estimates of each sub-option.

Comparison of Sub-Options

The treatment facility will be designed with a new upstream primary lagoon cell for all sub-options, which will provide storage and some treatment until seasonal discharge in the summer. During lagoon discharge, the lagoon is slowly discharged by gravity to a downstream natural system consisting of a depression that acts as a secondary treatment cell, and existing wetland. The primary cell will be designed assuming anaerobic treatment with the settling of solids to the bottom, given that the lagoon will be under ice cover a significant portion of the year. Design guidelines (CSA W203:19) classify a lagoon with a depth of 2 to 5 m as an anaerobic lagoon with a negligible amount of oxygen in the water column. Biological activity would be primarily limited to the sludge layer, and in the upper zone of the water column during the open water months where oxygen may be available from wind and wave action on the open water surface, similar to a facultative lagoon.

The Organic Loading Rate (OLR) of sub-options 3A, 3B and 3C is presented in **Table 1**, and describes the daily loading rate of organic material per hectare (Ha) of lagoon surface area. While the CSA W203:19 guidelines classifies a "facultative lagoon cell" as having an operating water depth of 1-2 m, and an OLR of less than 22 kg cBOD/ha/d, the proposed primary cell will act as an anaerobic cell for the majority of the year as stated above. Thus, the primary cell will not be designed to achieve an OLR less than 22 kg cBOD/ha/d for the design year, as it is anticipated that the majority of treatment will occur in the downstream natural depression and wetland. Decant from the primary cell will also have a long path to travel down the wall of the valley where it will experience aeration prior to entering the downstream treatment system.

Schematic drawings for sub-options 3A, 3B and 3C are attached. The valley floor at the proposed location slopes downward towards the Arctic Ocean. Sub-option 3A, 3B and 3C require an expanded footprint for the primary cell in the location of the sloped valley, and to accommodate this, the lagoon floor is sloped at 0.5% to reduce the overall cut volume. In general, sub-options 3B and 3C are deeper compared to sub-option 3A. **Table 1** compares characteristics of each primary cell sub-option. The working volume of the lagoon includes wastewater holding capacity, sludge accumulation, precipitation, surface runoff and ice cover.

Table 1 – Characteristics of Sub-Options 3A, 3B and 3C

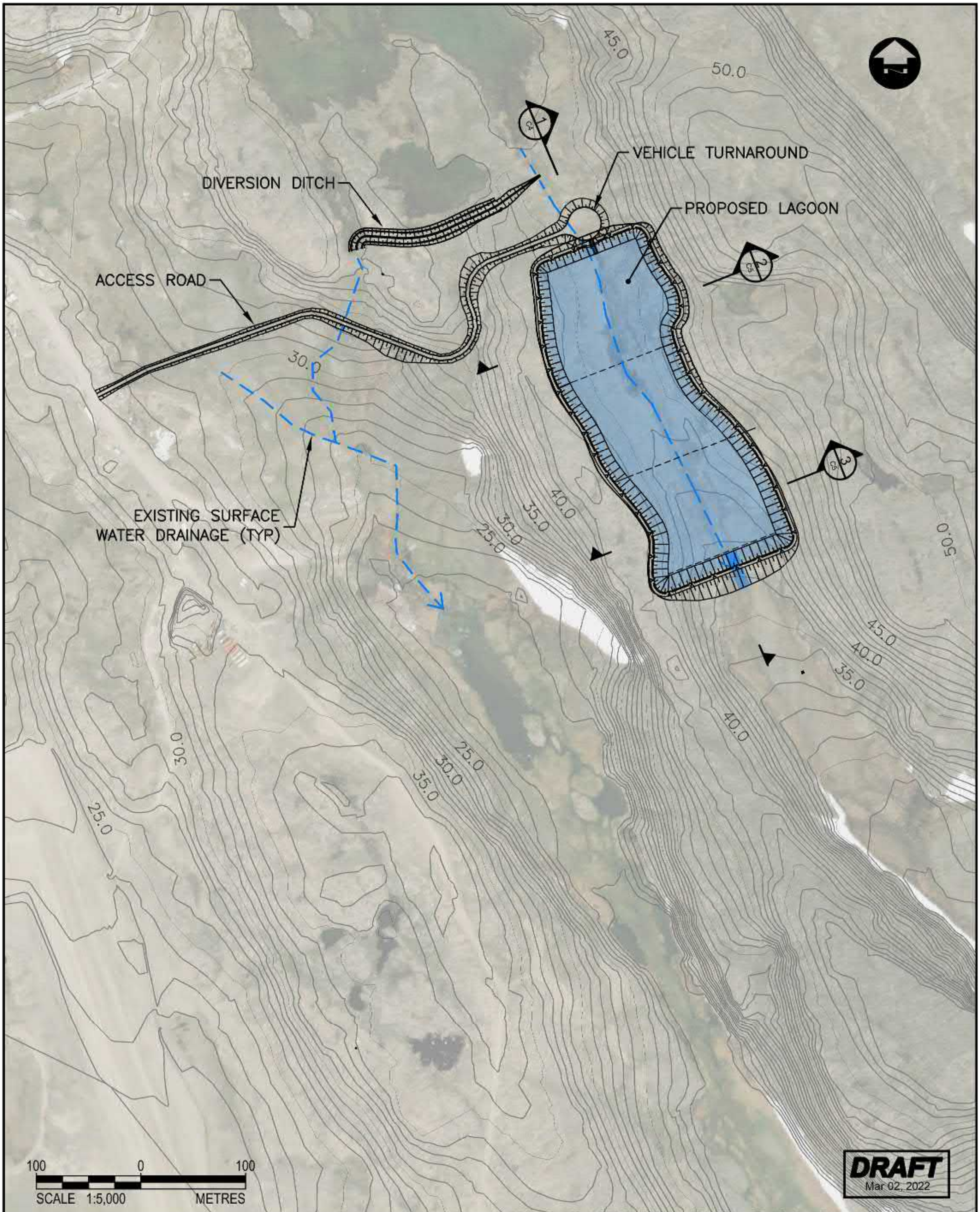
	Sub-Option 3A	Sub-Option 3B	Sub-Option 3C
Storage Capacity	10 months	12 months	10 months
Working Volume	105,000 m^3	130,000 m^3	105,000 m^3
Liquid Surface Area	38,880 m^2	34,564 m^2	26,050 m^2
OLR (2022)	16.7 kg cBOD/ha/d	18.8 kg cBOD/ha/d	20.7 kg cBOD/ha/d
OLR (2043)	31.3 kg cBOD/ha/d	35.2 kg cBOD/ha/d	46.1 kg cBOD/ha/d
Average Depth	3 m	4.5 m	4.5 m

In general, a deeper primary lagoon cell (sub-option 3B and 3C) will not provide additional meaningful treatment compared to a more shallow cell (sub-option 3A). However, the storage zone is larger with sub-option 3B which will provide more flexibility with respect to seasonal discharge scheduling. Because the stored contents of the lagoon will be seasonally discharged to the treatment wetland, treatment performance within the lagoon is not considered to play a critical role in the decision between these three sub-options.

The advantages and disadvantages of each sub-option are presented in **Table 2**.

Table 2 – Advantages and Disadvantages of Sub-Options 3A, 3B and 3C

	Advantages	Disadvantages
Sub-Option 3A – 10 Month Storage, 3 m Depth	• Less expensive compared to sub-option 3B • lower berm elevation, geotechnical needs to confirm limits of design	• Less storage capacity, and tighter timelines to plan for seasonal discharge • Larger footprint than Option 3B, with 2 months less storage • Wetland vegetation may not be fully developed at the start of seasonal discharge, impacting treatment efficiency
Sub-Option 3B – 12 Month Storage, 4.5 m Depth	• Greatest storage capability meeting CSA W203:19 guidelines for recommended 12 month storage capacity • More flexibility to plan for annual lagoon discharge • May allow for a higher degree of final treatment with extra time for growth of wetland vegetation prior to lagoon discharge.	• Most expensive alternative • Higher berm elevation, geotechnical needs to confirm limits of design
Sub-Option 3C – 10 Month Storage, 4.5 m Depth	• Least expensive alternative • Smallest footprint and lowest volume of excavation required	• Less storage capacity, and tighter timelines to plan for seasonal discharge • Wetland vegetation may not be fully developed at the start of seasonal discharge, impacting treatment efficiency • Higher berm elevation, geotechnical needs to confirm limits of design



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DATE **February 2022**	TITLE **SITE PLAN**	FIGURE NO. **1**

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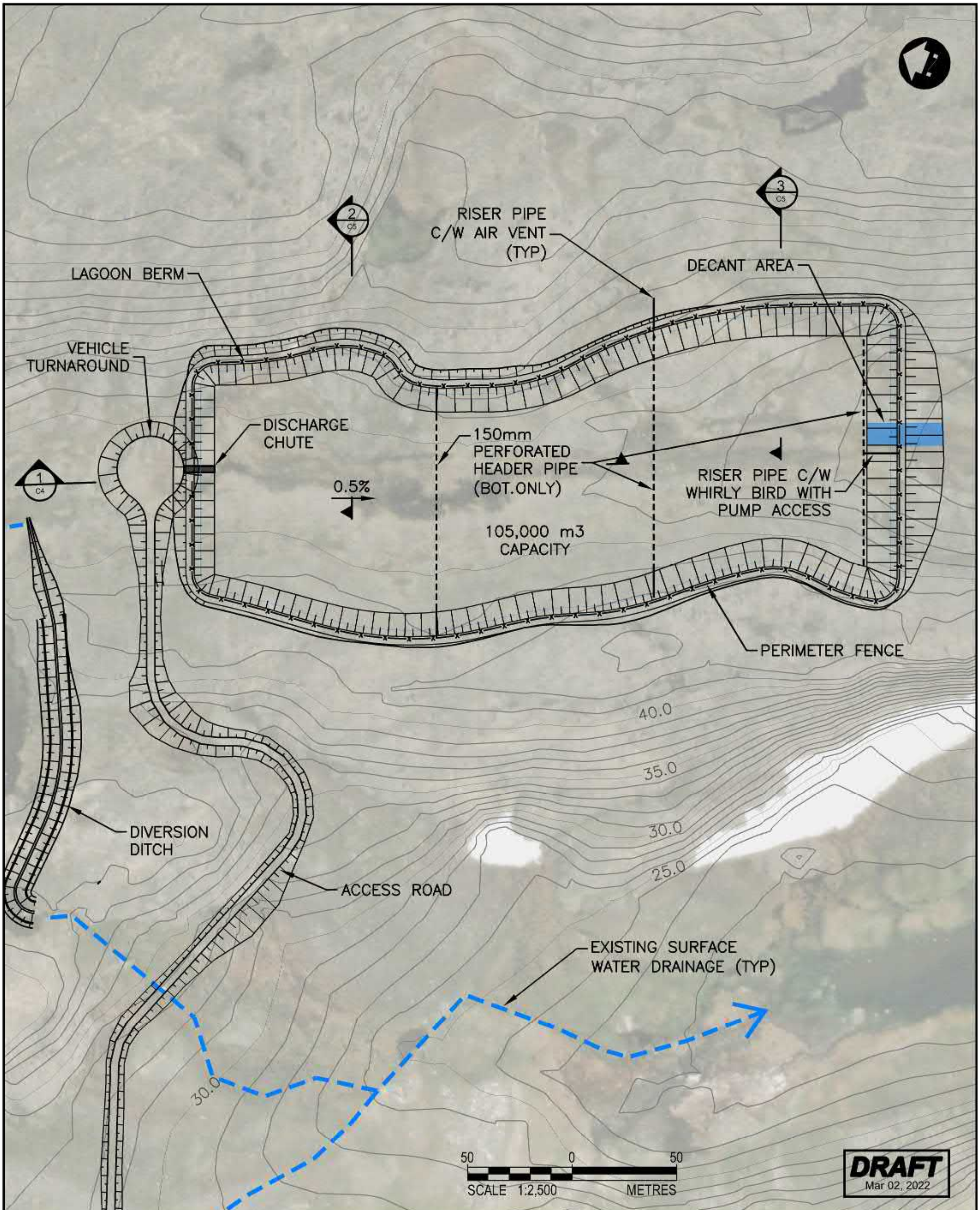

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3A**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

DATE **February 2022**

TITLE **LAGOON PLAN**

FIGURE NO. **2**

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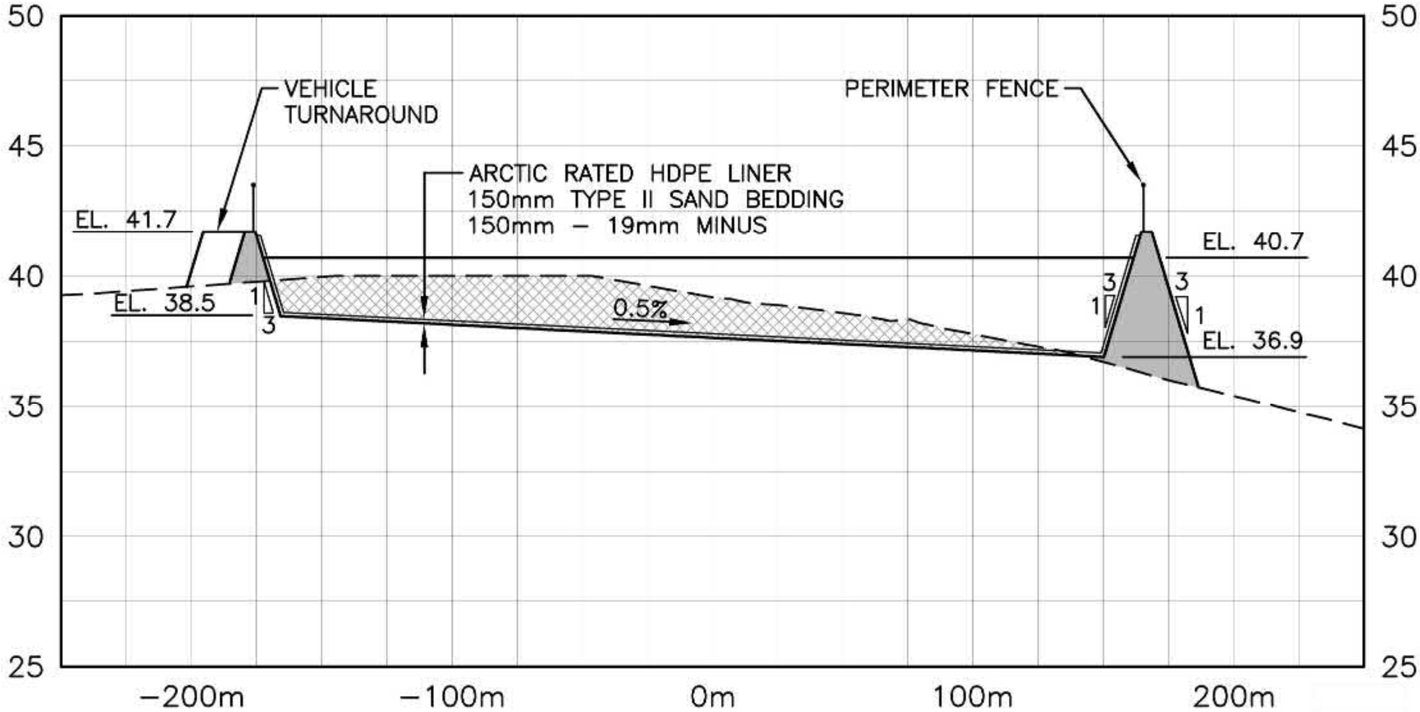

1 / C4 SECTION
HOR. 1:3000 VER. 1:300

DRAFT
Mar 02, 2022

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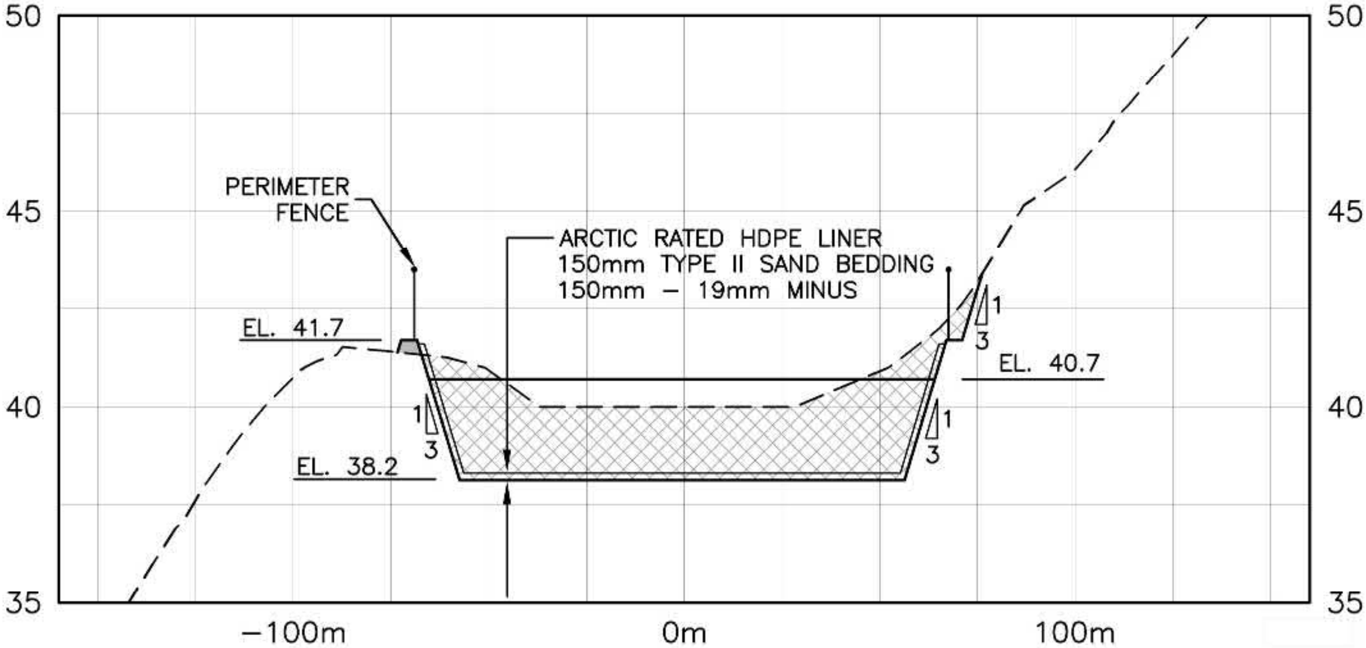
DILLON CONSULTING

DATE February 2022	PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3A HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
	TITLE SECTION 1	FIGURE NO. 3



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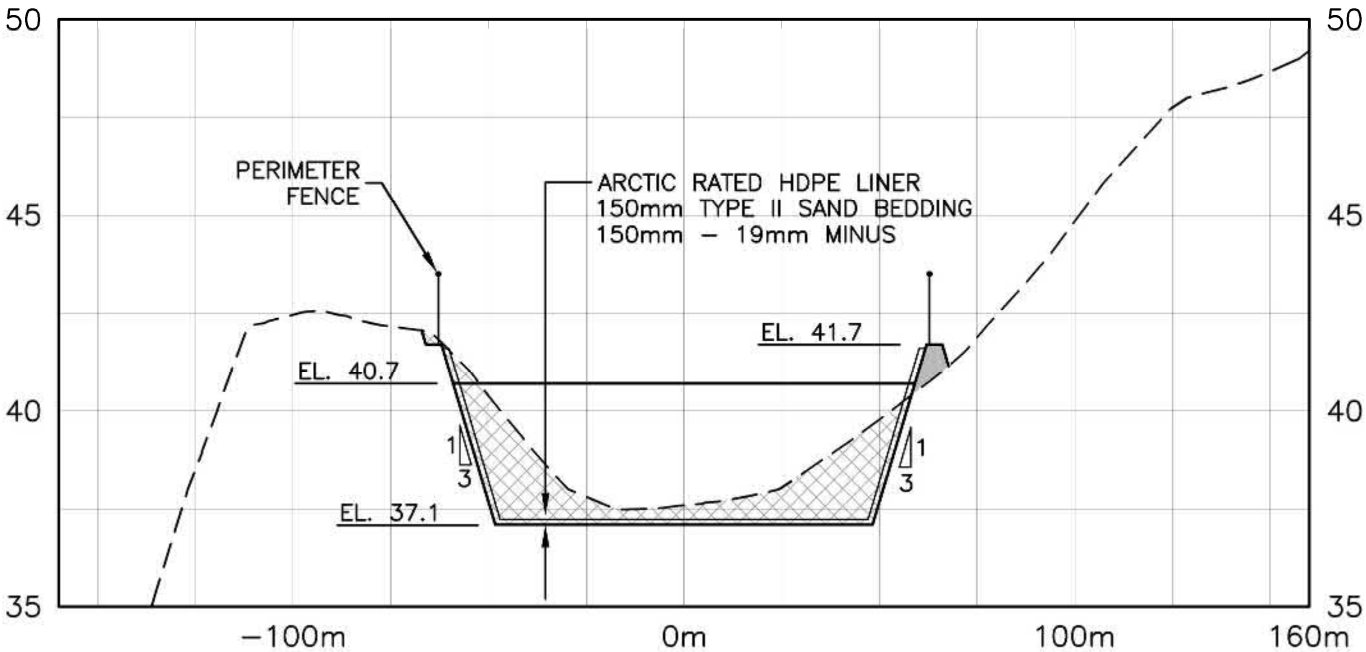

3 C5 SECTION
HOR. 1:2000 VER. 1:200

DRAFT
Mar 02, 2022

DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3A** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **February 2022**	TITLE **SECTIONS 2 AND 3**	FIGURE NO. **4**

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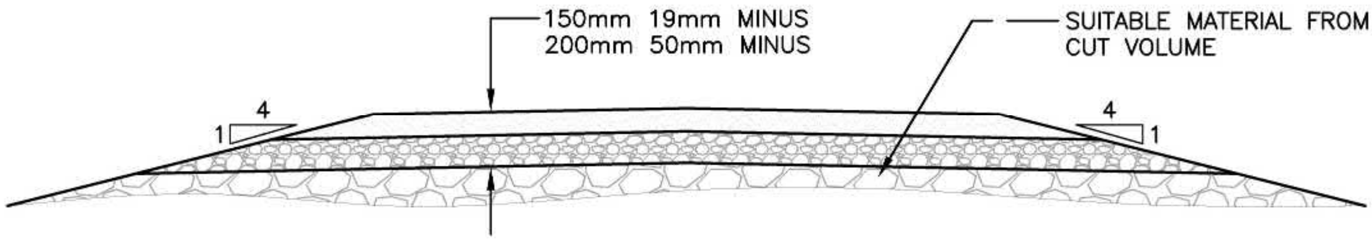

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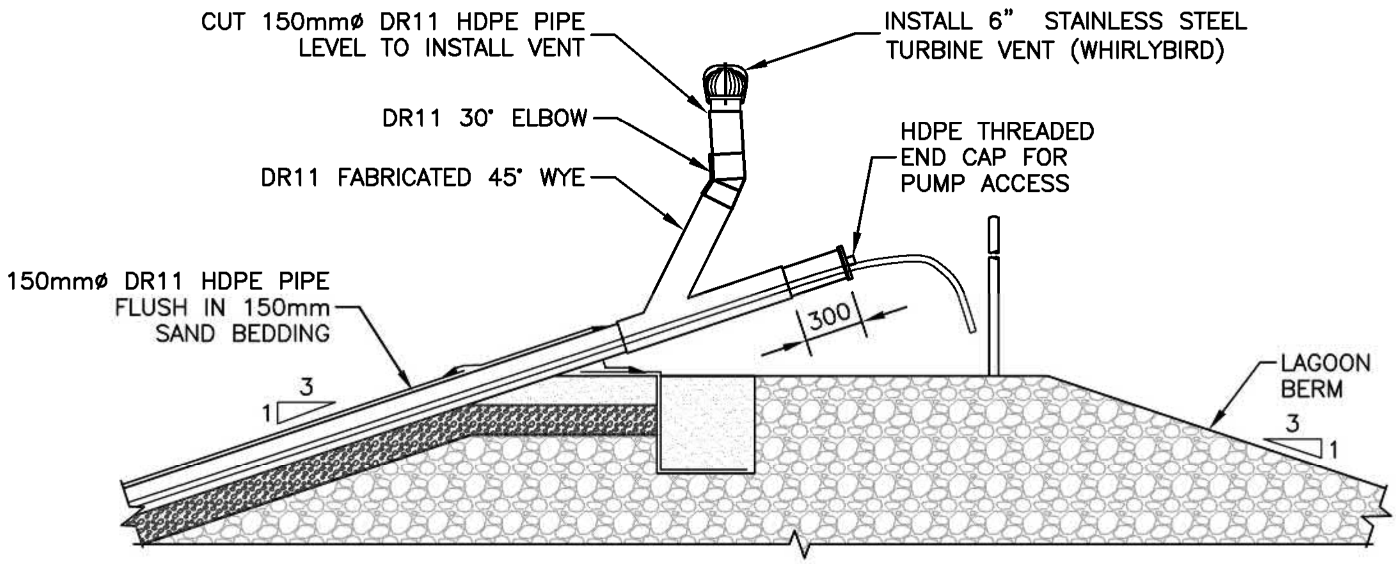
NTS



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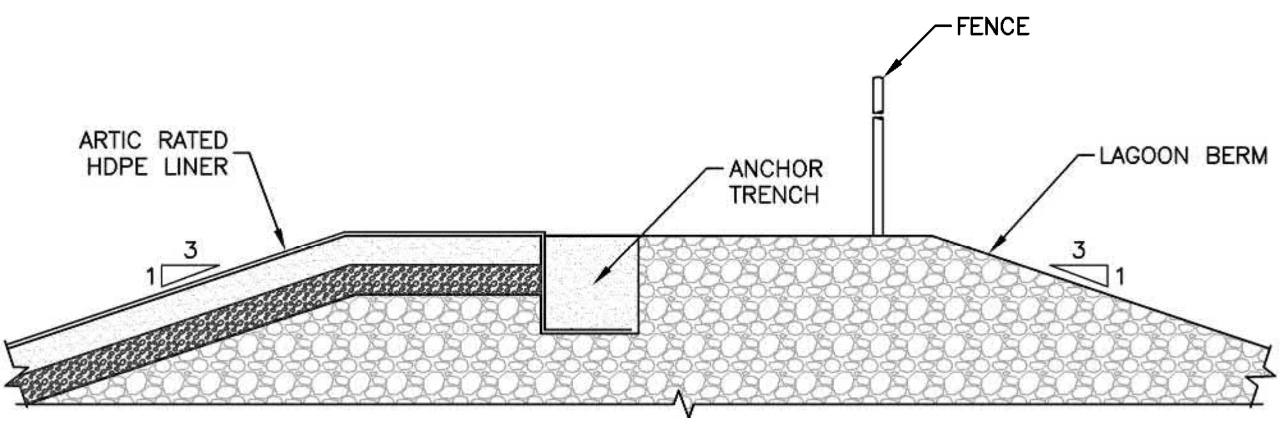

ANCHOR TRENCH DETAIL

NTS

DRAFT
Mar 02, 2022

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3A** **HAMLET OF NAUJAAT, NUNAVUT**		PROJECT NO. **21-2233**
DATE **February 2022**	TITLE **DETAILS**	FIGURE NO. **5**

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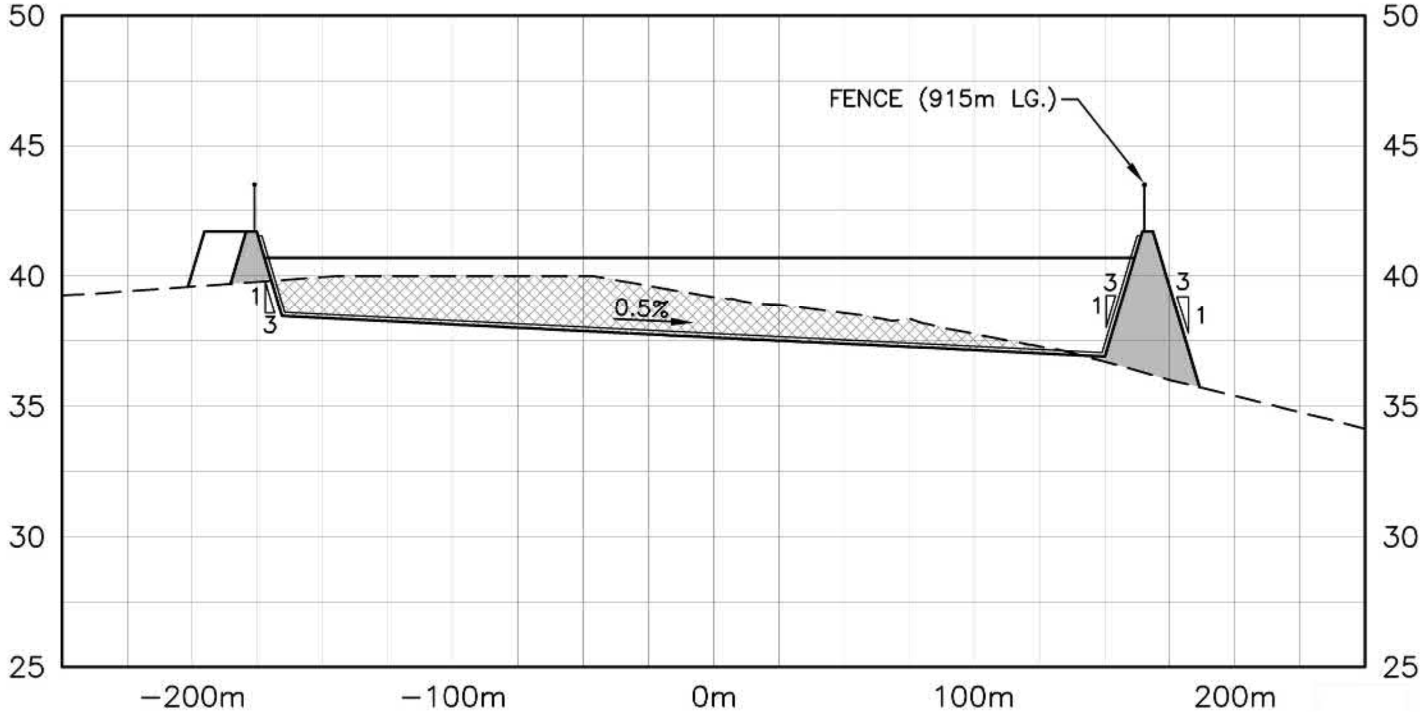

1 C4 SECTION
HOR. 1:3000 VER. 1:300

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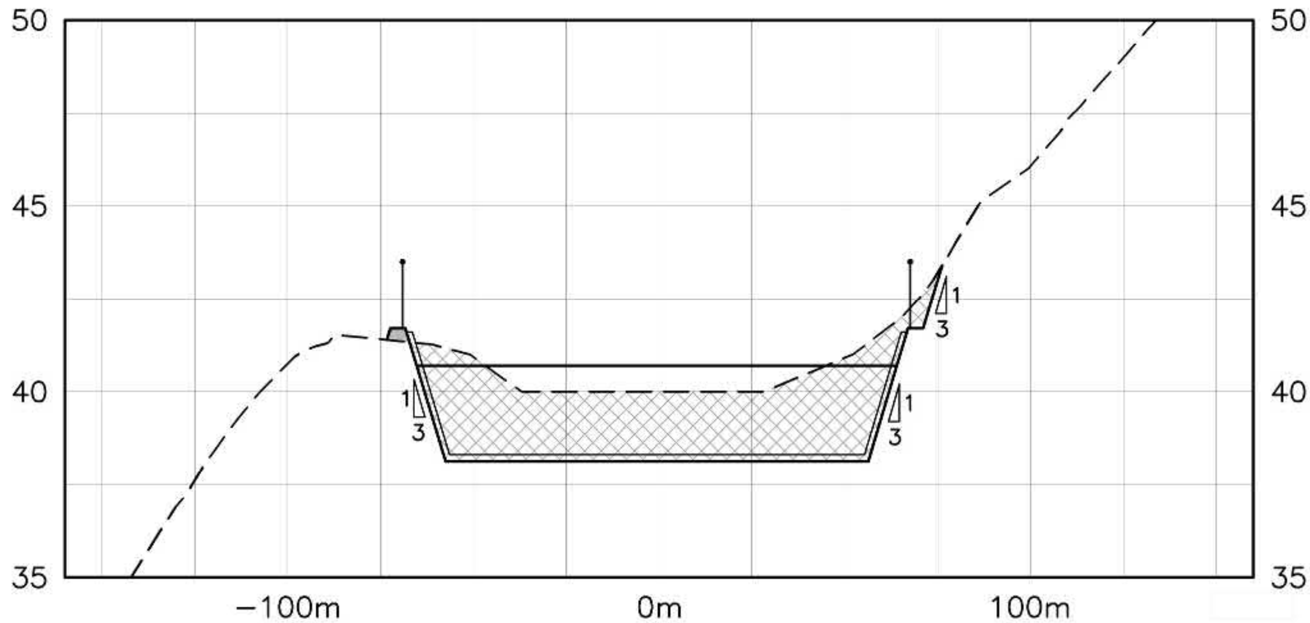
TYPE II 19mm MINUS..6,480m3

150mm HDPE PIPE (PERFORATED)..............295m
150mm HDPE PIPE (SLOPES)........................50m
150mm HDPE PIPE (ABOVE T/O BERM)..........9m

LAGOON CUT.....................................71,900m3
LAGOON CONSTRUCTION FILL...........12,900m3
NET (CUT)...59,000m3

DRAFT
Mar 02, 2022



2 C5 SECTION
HOR. 1:2000 VER. 1:200

DILLON CONSULTING

PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3A
HAMLET OF NAUJAAT, NUNAVUT

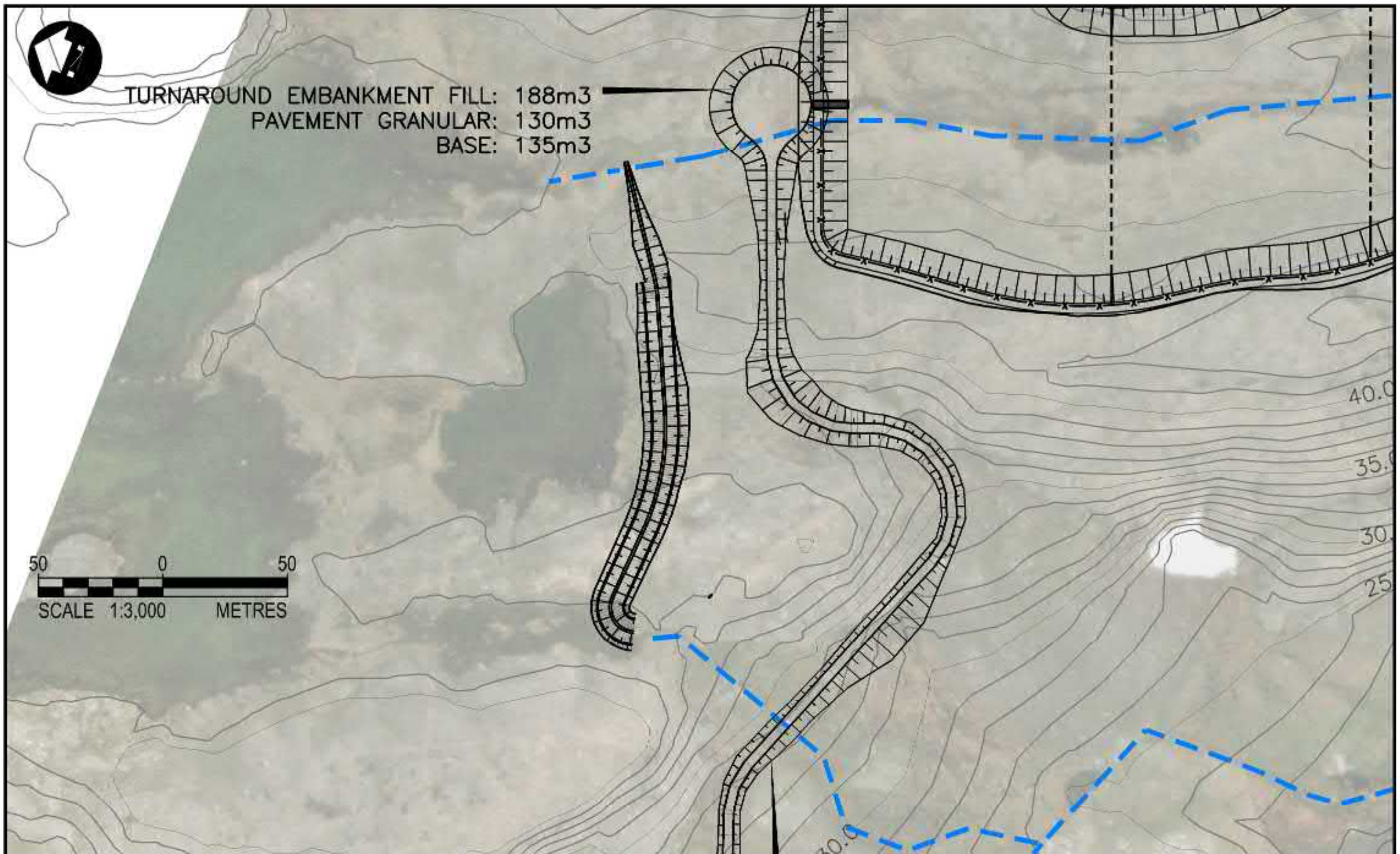
PROJECT NO. 21-2233

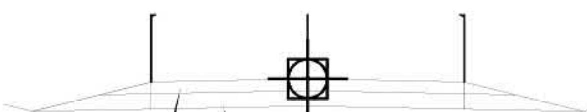
TITLE QUANTITIES
LAGOON SECTIONS

FIGURE NO. 6

DATE February 2022

FileName:c:\users\40skb\documents\projects\212233 naujaat\export\212233-02-site-opt3-10-month - 0.5 percent bottom.dwg





MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	0.70	0.00	0.00
3+020.00	0.70	13.96	13.96
3+040.00	0.70	13.96	27.91
3+060.00	0.70	13.96	41.87
3+070.00	0.70	6.98	48.85
3+080.00	0.70	6.98	55.83
3+090.00	0.70	6.98	62.80
3+100.00	0.70	6.98	69.78
3+110.00	0.70	6.98	76.76
3+120.00	0.70	6.98	83.74
3+130.00	0.70	6.98	90.72
3+140.00	0.70	6.98	97.70
3+150.00	0.70	6.98	104.67
3+160.00	0.70	6.98	111.65
3+170.00	0.70	6.98	118.63
3+180.00	0.70	6.98	125.61
3+190.00	0.70	6.98	132.59
3+200.00	0.70	6.98	139.57
3+210.00	0.70	6.98	146.54
3+220.00	0.70	6.98	153.52
3+230.00	0.70	6.98	160.50
3+240.00	0.70	6.98	167.48
3+250.00	0.70	6.98	174.46
3+260.00	0.70	6.98	181.43
3+270.00	0.70	6.98	188.41
3+280.00	0.70	6.98	195.39
3+290.00	0.70	6.98	202.37
3+300.00	0.70	6.98	209.35
3+310.00	0.70	6.98	216.33
3+320.00	0.70	6.98	223.30
3+330.00	0.70	6.98	230.28
3+340.00	0.70	6.98	237.26
3+350.00	0.70	6.98	244.24
3+360.00	0.70	6.98	251.22
3+380.00	0.70	13.96	265.17
3+400.00	0.70	13.96	279.13
3+420.00	0.70	13.96	293.09
3+440.00	0.70	13.96	307.04
3+445.70	0.70	3.98	311.02

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m^3)
3+000.00	1.23	0.00	0.00
3+020.00	1.23	24.70	24.70
3+040.00	1.23	24.70	49.39
3+060.00	1.23	24.70	74.09
3+070.00	1.23	12.35	86.43
3+080.00	1.23	12.35	98.78
3+090.00	1.23	12.35	111.13
3+100.00	1.23	12.35	123.48
3+110.00	1.23	12.35	135.83
3+120.00	1.23	12.35	148.17
3+130.00	1.23	12.35	160.52
3+140.00	1.23	12.35	172.87
3+150.00	1.23	12.35	185.22
3+160.00	1.23	12.35	197.57
3+170.00	1.23	12.35	209.91
3+180.00	1.23	12.35	222.26
3+190.00	1.23	12.35	234.61
3+200.00	1.23	12.35	246.96
3+210.00	1.23	12.35	259.30
3+220.00	1.23	12.35	271.65
3+230.00	1.23	12.35	284.00
3+240.00	1.23	12.35	296.35
3+250.00	1.23	12.35	308.70
3+260.00	1.23	12.35	321.04
3+270.00	1.23	12.35	333.39
3+280.00	1.23	12.35	345.74
3+290.00	1.23	12.35	358.09
3+300.00	1.23	12.35	370.43
3+310.00	1.23	12.35	382.78
3+320.00	1.23	12.35	395.13
3+330.00	1.23	12.35	407.48
3+340.00	1.23	12.35	419.83
3+350.00	1.23	12.35	432.17
3+360.00	1.23	12.35	444.52
3+380.00	1.23	24.70	469.22
3+400.00	1.23	24.70	493.91
3+420.00	1.23	24.70	518.61
3+440.00	1.23	24.70	543.30
3+445.70	1.23	7.04	550.34

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+020	0.00	0.21	0.00	0.00	0.00	0.00
3+040	0.21	0.02	2.08	2.28	2.08	2.28
3+060	0.35	0.01	5.60	0.33	7.68	2.61
3+070	0.54	0.00	4.43	0.09	12.12	2.70
3+080	1.54	0.00	10.39	0.02	22.50	2.71
3+090	2.50	0.00	20.18	0.00	42.68	2.71
3+100	0.81	0.00	16.54	0.00	59.22	2.72
3+110	1.60	0.00	12.04	0.00	71.26	2.72
3+120	1.85	0.00	17.26	0.02	88.52	2.74
3+130	1.62	0.11	17.35	0.54	105.87	3.28
3+140	1.72	0.13	16.69	1.16	122.56	4.44
3+150	1.06	0.38	13.89	2.56	136.46	7.01
3+160	0.67	0.67	8.63	5.26	145.09	12.27
3+170	0.61	0.56	6.42	6.12	151.51	18.39
3+180	0.98	0.28	7.96	4.20	159.47	22.59
3+190	1.15	0.13	10.62	2.07	170.08	24.66
3+200	1.03	0.05	10.90	0.93	180.98	25.58
3+210	0.76	0.16	8.89	1.07	189.88	26.66
3+220	0.97	0.28	8.14	2.40	198.02	29.06
3+230	0.83	1.07	8.32	7.41	206.34	36.47
3+240	1.43	0.66	11.21	8.72	217.55	45.20
3+250	1.90	0.61	16.68	6.39	234.24	51.58
3+260	2.10	0.28	20.00	4.49	254.24	56.08
3+270	2.70	0.22	23.97	2.53	278.21	58.60
3+280	6.35	0.00	45.24	1.11	323.45	59.71
3+290	13.69	0.00	100.22	0.00	423.67	59.71
3+300	18.86	0.00	162.78	0.00	586.45	59.71
3+310	24.55	0.00	217.08	0.00	803.53	59.71
3+320	16.96	0.00	207.58	0.00	1011.11	59.72
3+330	7.98	0.24	124.70	1.21	1135.82	60.93
3+340	5.54	0.00	67.60	1.21	1203.41	62.14
3+350	0.95	0.06	33.36	0.29	1236.77	62.43
3+360	2.07	0.00	15.67	0.29	1252.44	62.71
3+380	1.84	0.00	39.62	0.00	1292.05	62.71
3+400	1.60	0.00	34.04	0.00	1326.09	62.71
3+420	4.06	0.00	56.53	0.00	1382.62	62.71
3+430	5.41	0.00	47.34	0.00	1429.96	62.71
3+440	6.94	0.00	59.48	0.00	1489.45	62.71

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
3+445.70	10.10	0.00	46.17	0.00	1535.62	62.72
3+450	13.06	0.00	47.66	0.00	1583.28	62.72
3+455	17.51	0.00	73.93	0.00	1657.20	62.72
3+456.49	18.81	0.00	26.39	0.00	1683.59	62.72
3+460	22.28	0.00	70.57	0.00	1754.16	62.72
3+465	23.92	0.00	113.84	0.00	1868.00	62.72
3+470	21.01	0.00	112.56	0.00	1980.56	62.72
3+475	13.01	0.01	86.30	0.02	2066.86	62.74
3+480	6.46	0.00	49.03	0.02	2115.89	62.76
3+481.59	5.60	0.00	9.65	0.00	2125.54	62.76
3+490	2.39	0.00	33.55	0.00	2159.09	62.76
3+500	5.35	0.00	38.67	0.00	2197.76	62.76
3+510	11.45	0.00	84.01	0.00	2281.77	62.77
3+520	19.30	0.00	153.79	0.00	2435.55	62.77
3+530	38.41	0.03	288.56	0.14	2724.12	62.91
3+540	66.31	0.00	523.60	0.14	3247.72	63.05
3+546.96	0.00	0.00	230.61	0.00	3478.33	63.05
3+550	0.00	0.00	0.00	0.00	3478.33	63.05
3+560	0.00	0.00	0.00	0.00	3478.33	63.05
3+570	0.00	0.00	0.00	0.00	3478.33	63.05
3+570.74	0.00	0.00	0.00	0.00	3478.33	63.05
3+580	0.00	0.00	0.00	0.00	3478.33	63.05
3+590	0.00	0.00	0.00	0.00	3478.33	63.05
3+600	0.00	0.00	0.00	0.00	3478.33	63.05
3+605.12	0.00	0.00	0.00	0.00	3478.33	63.05

DRAFT
Mar 02, 2022

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3A**
HAMLET OF NAUJAAT, NUNAVUT

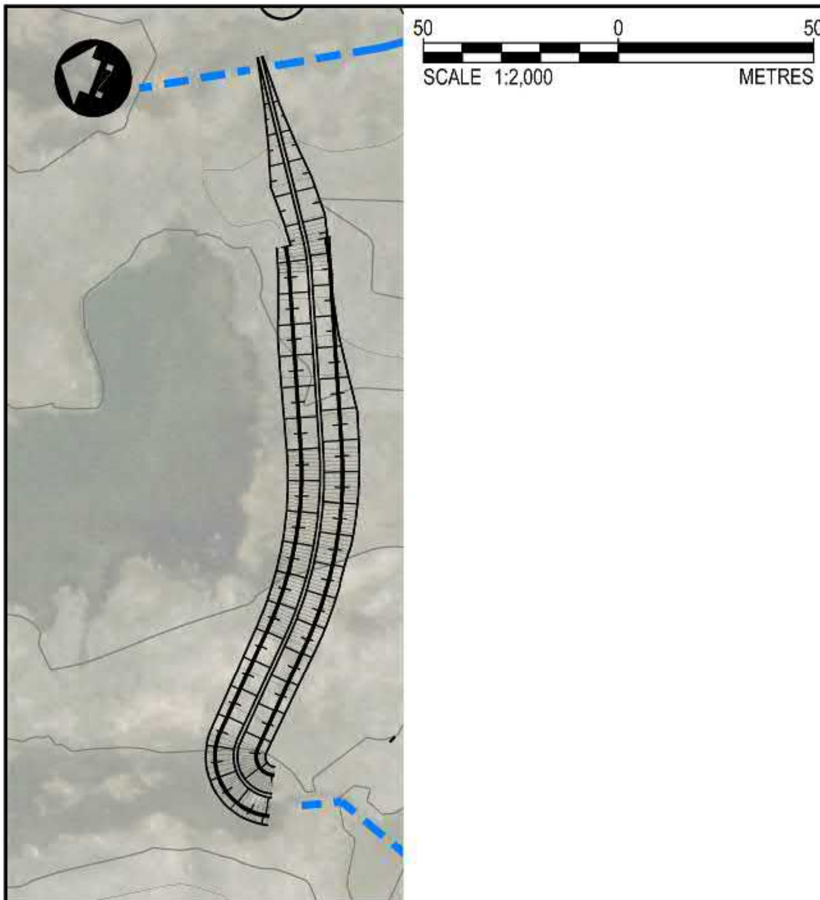
PROJECT NO. **21-2233**

DATE **February 2022**

TITLE **QUANTITIES**
ACCESS ROAD AND TURNAROUND

FIGURE NO. **7**

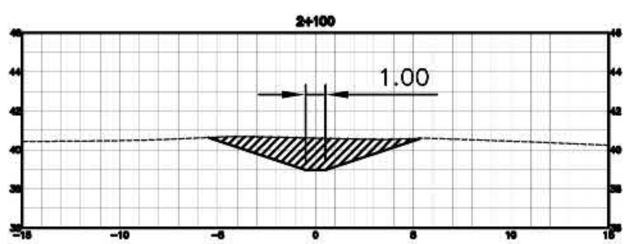
FileName:c:\users\40skb\documents\projects\212233 naujaat\export\212233-02-site-opt3-10-month - 0.5 percent bottom.dwg

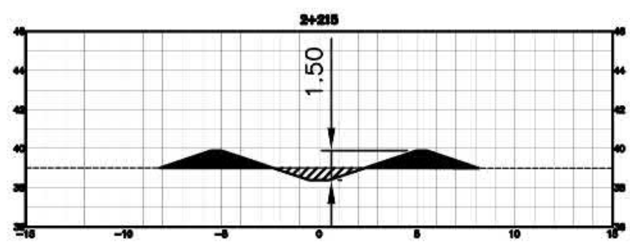


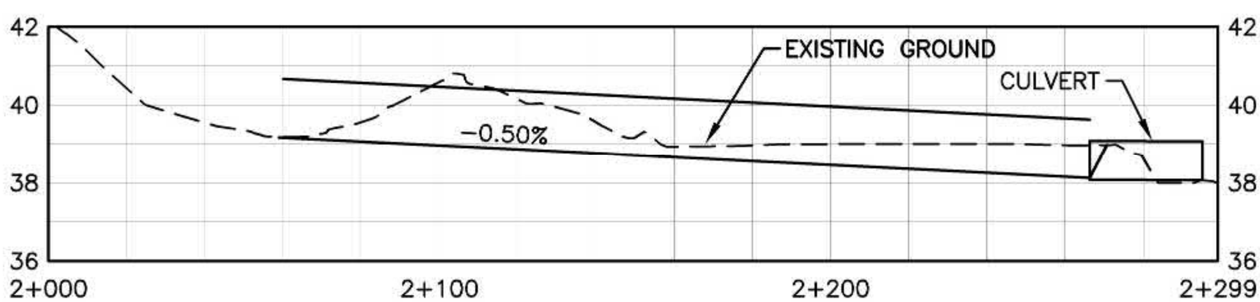
PLAN

ALIGNMENT – DIVERSION DITCH CUT/FILL

STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
2+000	0.00	0.00	0.00	0.00	0.00	0.00
2+010	0.00	0.00	0.00	0.00	0.00	0.00
2+020	0.00	0.00	0.00	0.00	0.00	0.00
2+030	0.00	0.00	0.00	0.00	0.00	0.00
2+040	0.00	0.00	0.00	0.00	0.00	0.00
2+050	0.00	0.00	0.00	0.00	0.00	0.00
2+060	0.00	0.00	0.00	0.00	0.00	0.00
2+070	0.00	0.23	0.00	1.15	0.00	1.15
2+080	0.00	1.24	0.00	7.35	0.00	8.50
2+090	0.01	4.34	0.06	27.89	0.06	36.39
2+100	0.00	9.60	0.06	69.70	0.12	106.09
2+110	0.26	9.36	1.28	94.82	1.40	200.91
2+116.75	1.11	6.97	5.97	71.42	7.37	272.33
2+120	1.12	6.36	0.27	8.85	7.65	281.18
2+130	2.29	5.13	17.06	57.45	24.72	338.63
2+140	4.39	2.89	33.40	40.08	58.13	378.71
2+150	7.38	1.34	58.84	21.14	116.97	399.85
2+160	10.78	0.49	90.80	9.18	207.77	409.03
2+168.71	10.00	0.64	90.53	4.93	298.30	413.96
2+170	9.89	0.66	12.81	0.84	311.11	414.80
2+175	9.42	0.77	48.65	3.57	359.76	418.38
2+180	8.91	0.90	46.17	4.17	405.93	422.55
2+185	8.37	1.05	43.50	4.87	449.43	427.42
2+190	7.81	1.19	40.70	5.60	490.13	433.02
2+193.57	7.35	1.28	27.17	4.40	517.30	437.42
2+195	7.07	1.31	10.32	1.85	527.62	439.27
2+200	6.41	1.41	33.74	6.81	561.36	446.08
2+205	6.17	1.53	31.44	7.37	592.80	453.45
2+210	5.85	1.65	30.03	7.95	622.83	461.39
2+215	5.55	1.77	28.48	8.54	651.31	469.93
2+218.42	5.34	1.85	18.65	6.19	669.95	476.12
2+220	5.25	1.89	8.35	2.95	678.30	479.07
2+230	4.69	2.15	49.69	20.21	727.99	499.28
2+240	4.19	2.40	44.39	22.77	772.38	522.05
2+247.09	3.86	2.59	28.54	17.67	800.92	539.72
2+250	3.75	2.65	11.07	7.64	811.99	547.36
2+255	3.65	2.71	18.52	13.40	830.51	560.76
2+256.51	3.62	2.73	5.52	4.09	836.03	564.85
2+260	3.54	2.78	12.67	9.59	848.70	574.45
2+265	3.37	2.88	17.67	14.12	866.36	588.57
2+265.93	3.35	2.91	3.22	2.69	869.58	591.25
2+270	0.00	0.00	6.81	5.92	876.39	597.17
2+280	0.00	0.00	0.00	0.00	876.39	597.17
2+290	0.00	0.00	0.00	0.00	876.39	597.17
2+299.09	0.00	0.00	0.00	0.00	876.39	597.17





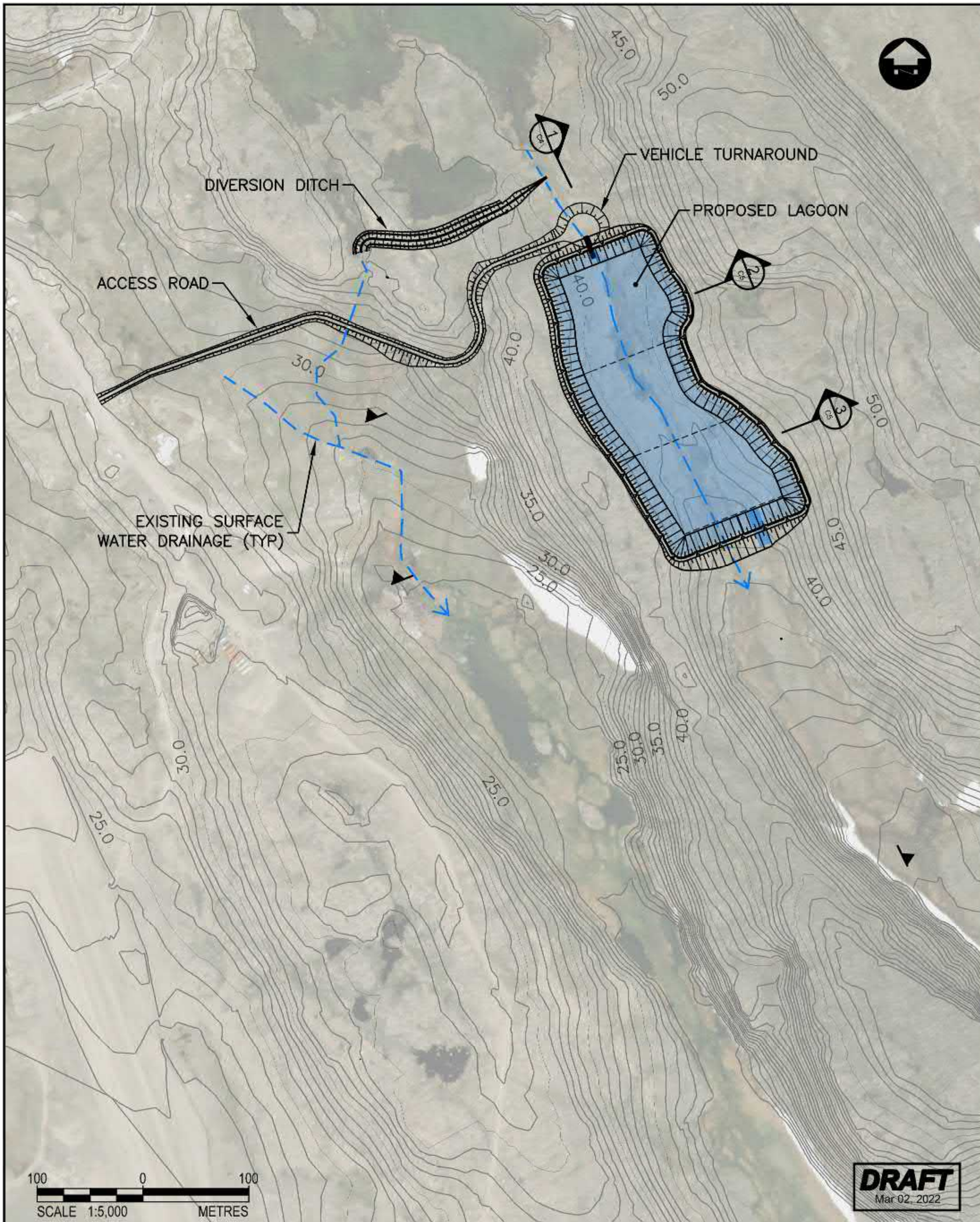


DIVERSION DITCH PROFILE

DRAFT
Mar 02, 2022

FileName:c:\users\40skb\documents\projects\212233 naujaat\export\212233-02-site-opt3-10-month - 0.5 percent bottom.dwg

DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3A** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **February 2022**	TITLE **QUANTITIES DIVERSION DITCH**	FIGURE NO. **8**



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DILLON CONSULTING

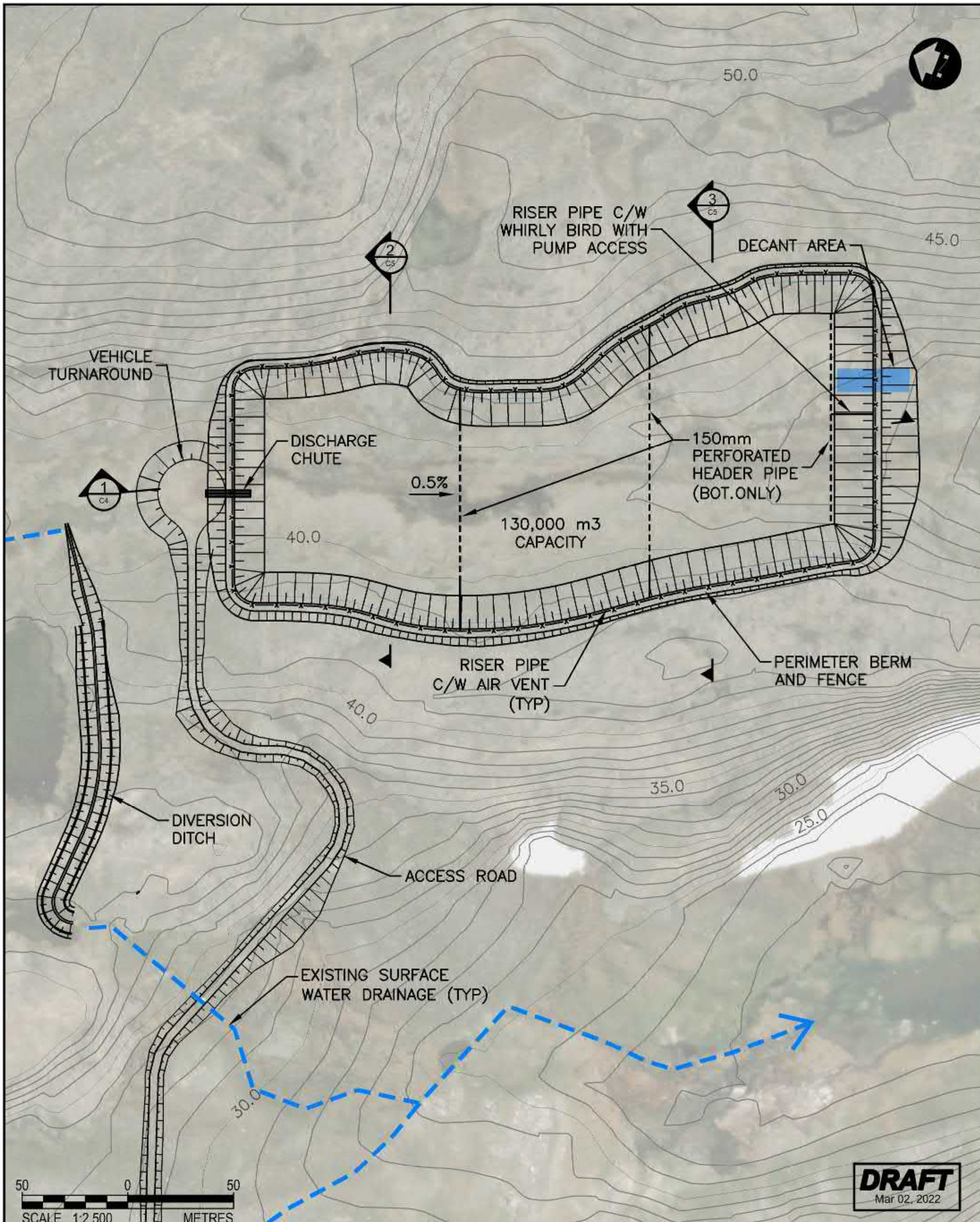
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **SITE PLAN**

FIGURE NO. **1**

DATE **March 2022**



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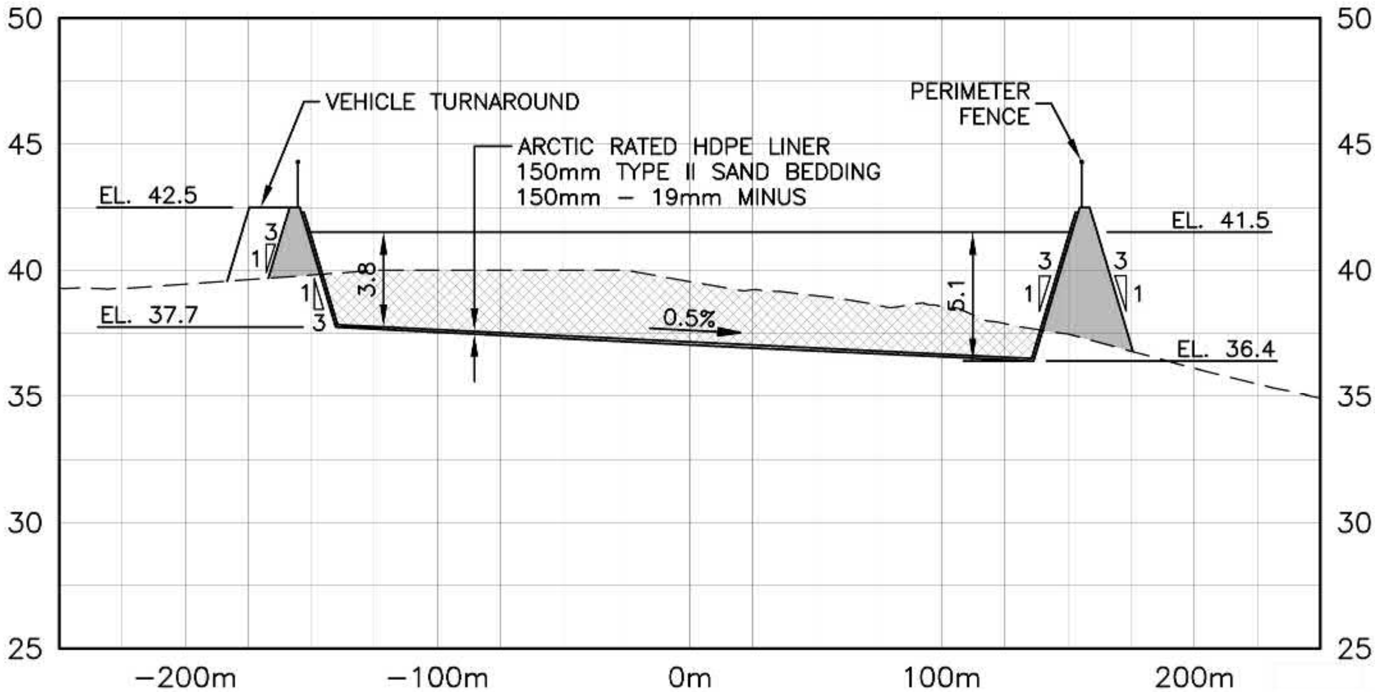
DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
DATE **March 2022**	TITLE **LAGOON PLAN**	FIGURE NO. **2**



1 / C4 SECTION

HOR. 1:3000 VER. 1:300

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Mar 02, 2022

DILLON CONSULTING

PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3B
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. 21-2233

DATE March 2022

TITLE SECTION 1

FIGURE NO. 3

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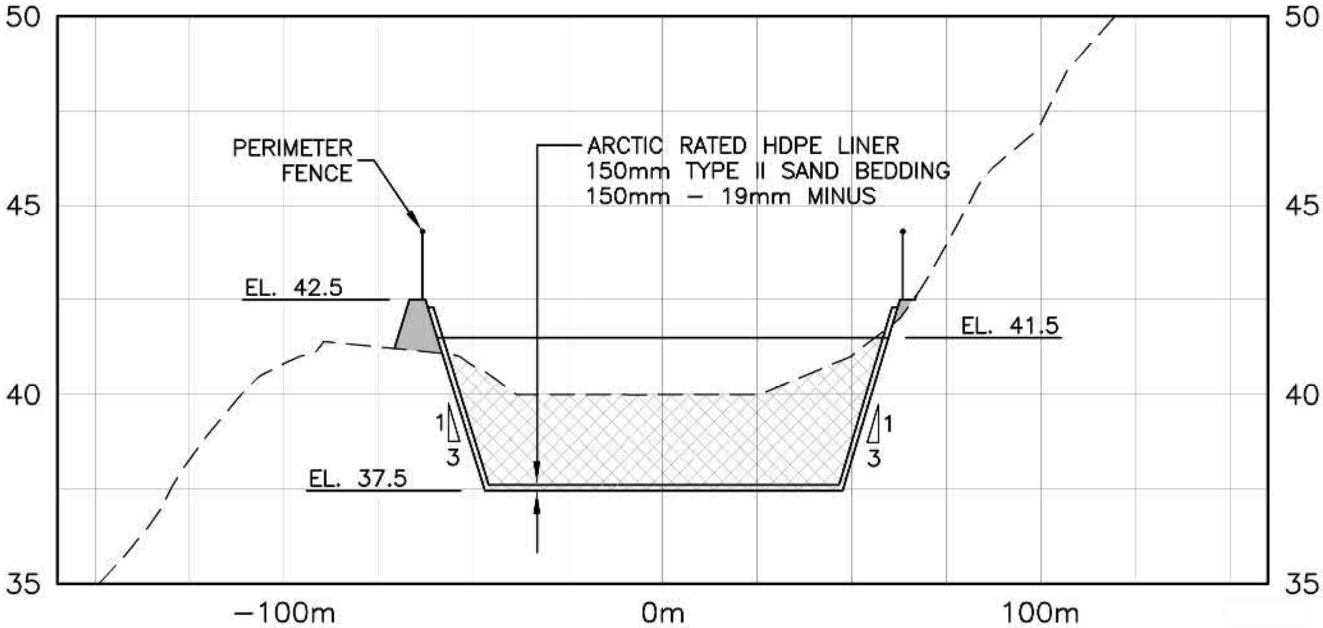
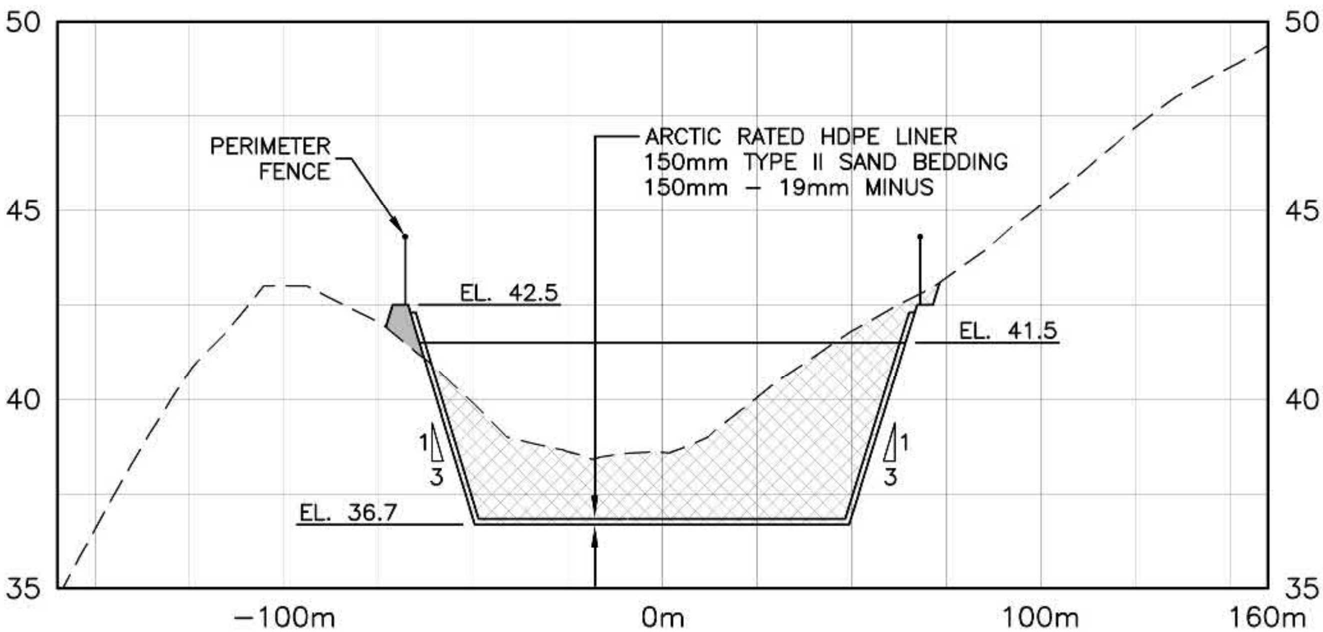


2 / C5 SECTION
HOR. 1:2000 VER. 1:200



3 / C5 SECTION
HOR. 1:2000 VER. 1:200

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Mar 02, 2022

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DILLON CONSULTING	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B** **HAMLET OF NAUJAAT, NUNAVUT**	PROJECT NO. **21-2233**
DATE **March 2022**	TITLE **SECTIONS 2 AND 3**	FIGURE NO. **4**

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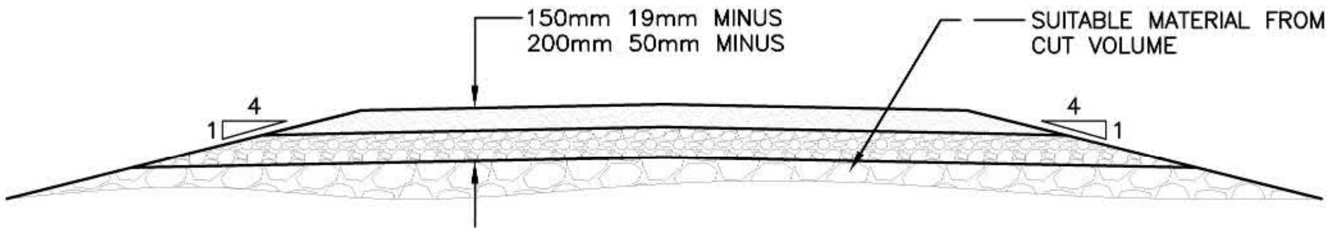
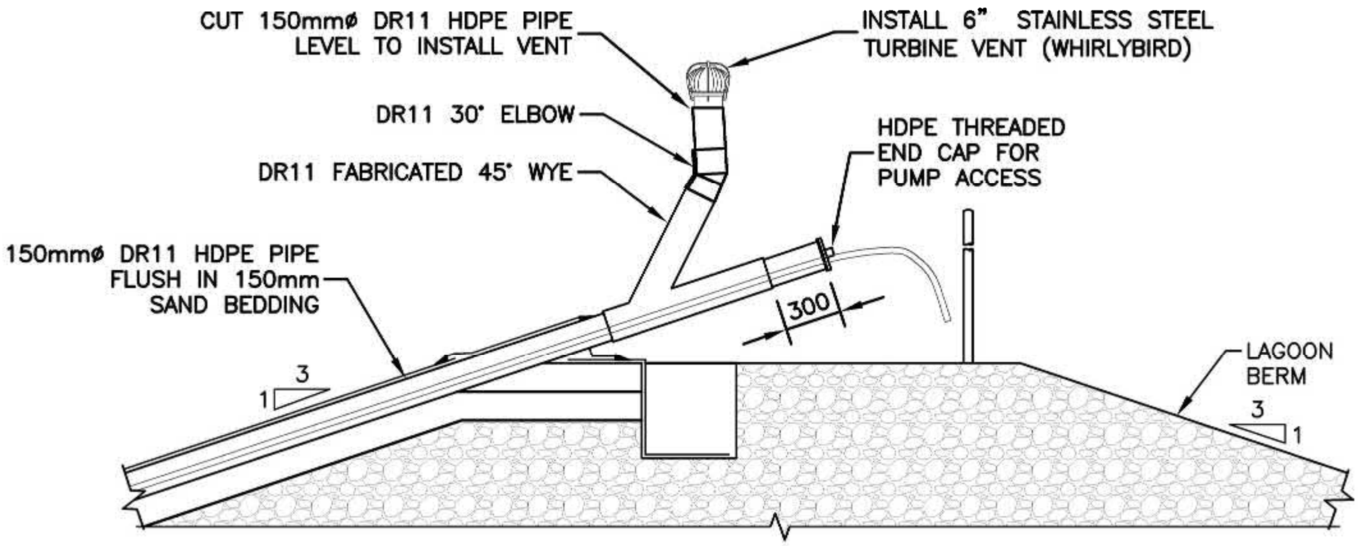
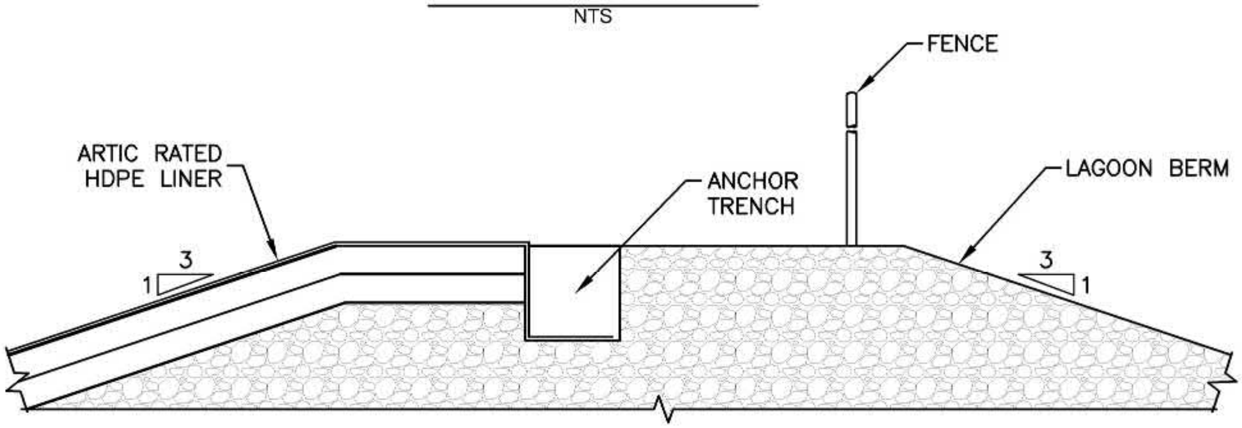


ACCESS ROAD DETAIL
NTS



AIR VENT DETAIL
NTS



ANCHOR TRENCH DETAIL
NTS

DRAFT
Mar 02, 2022

DILLON CONSULTING

DATE **March 2022**

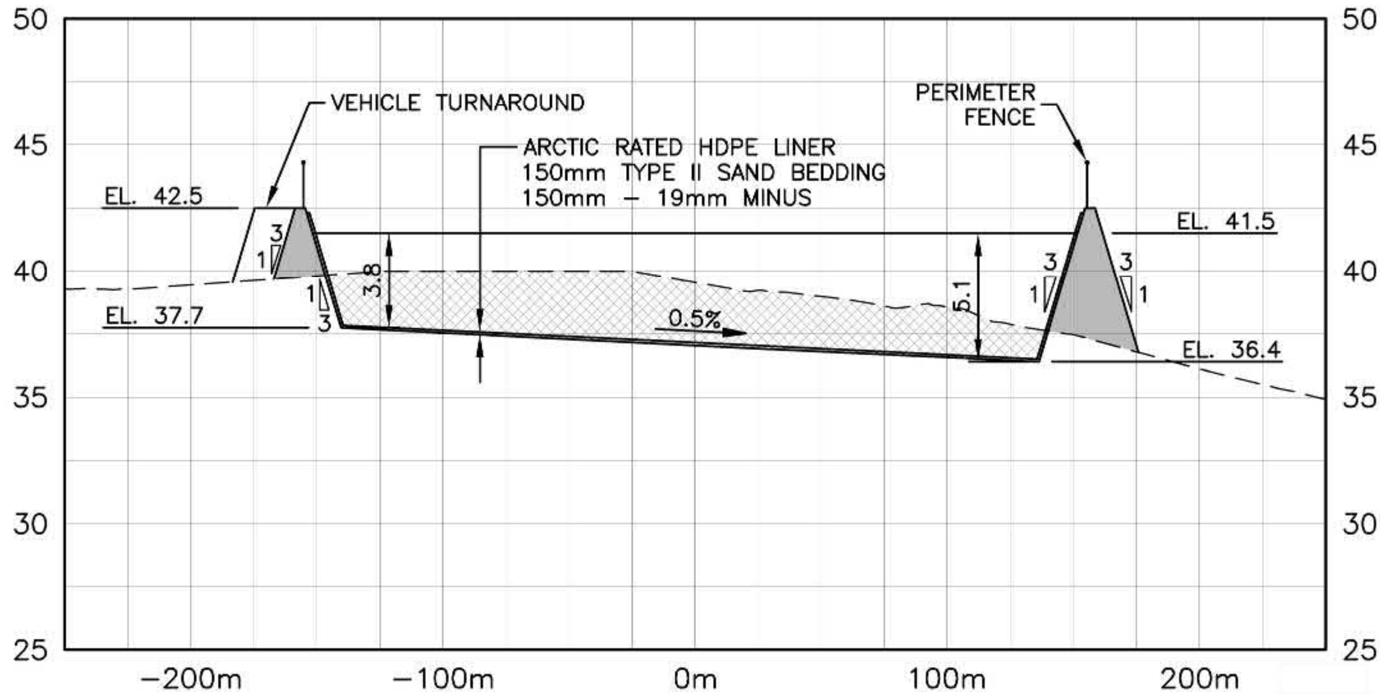
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **DETAILS**

PROJECT NO. **21-2233**

FIGURE NO. **5**

FileName:c:\users\40skb\documents\pojects\212233 naujaat\export\212233-02-site-opt3-12-month0.5 percent bottom.dwg



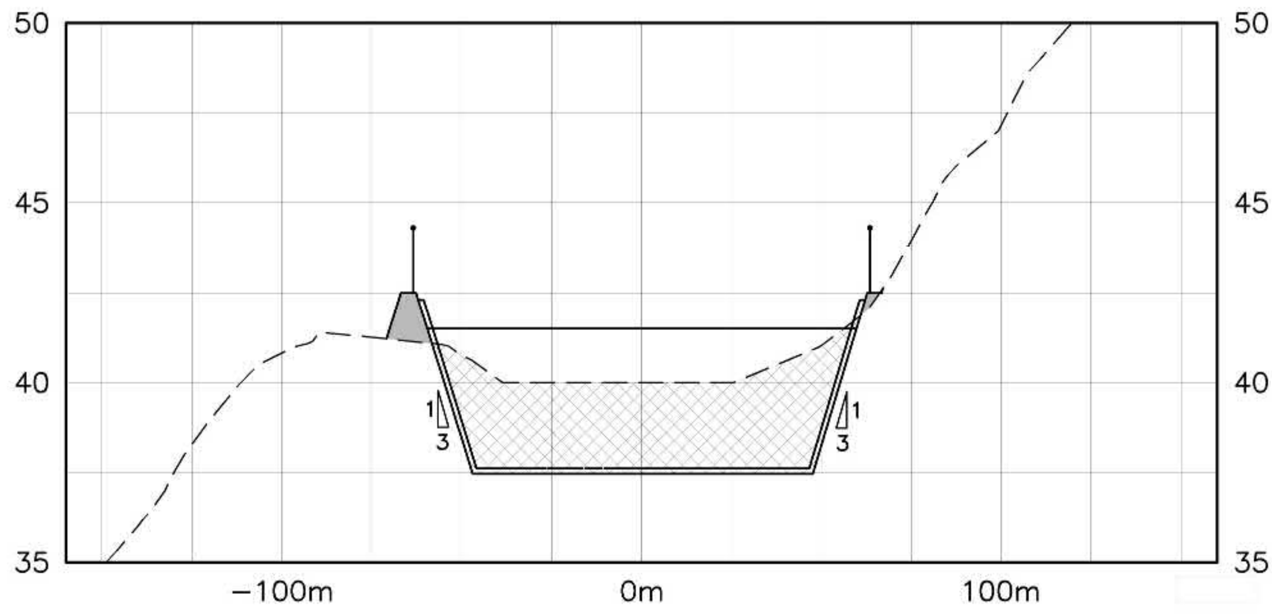
1 C4 SECTION
HOR. 1:3000 VER. 1:300

ARCTIC RATED HDPE LINER:..................................39,500m2
TYPE II SAND BEDDING: 39,500 x 0.15 ....6,000m3
TYPE II 19mm MINUS.......39,,500 x 0.15............6,000m3

LAGOON CUT......................................79,200m3
LAGOON CONSTRUCTION FILL............15,300m3
NET (CUT)...63,900m3

150mm HDPE PIPE (PERFORATED)..............265m
150mm HDPE PIPE (SLOPES).........................70m
150mm HDPE PIPE (ABOVE T/O BERM)........12m

PERIMETER FENCE:....865m



2 C5 SECTION
HOR. 1:2000 VER. 1:200

DRAFT
Mar 02, 2022

DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B**
HAMLET OF NAUJAAT, NUNAVUT

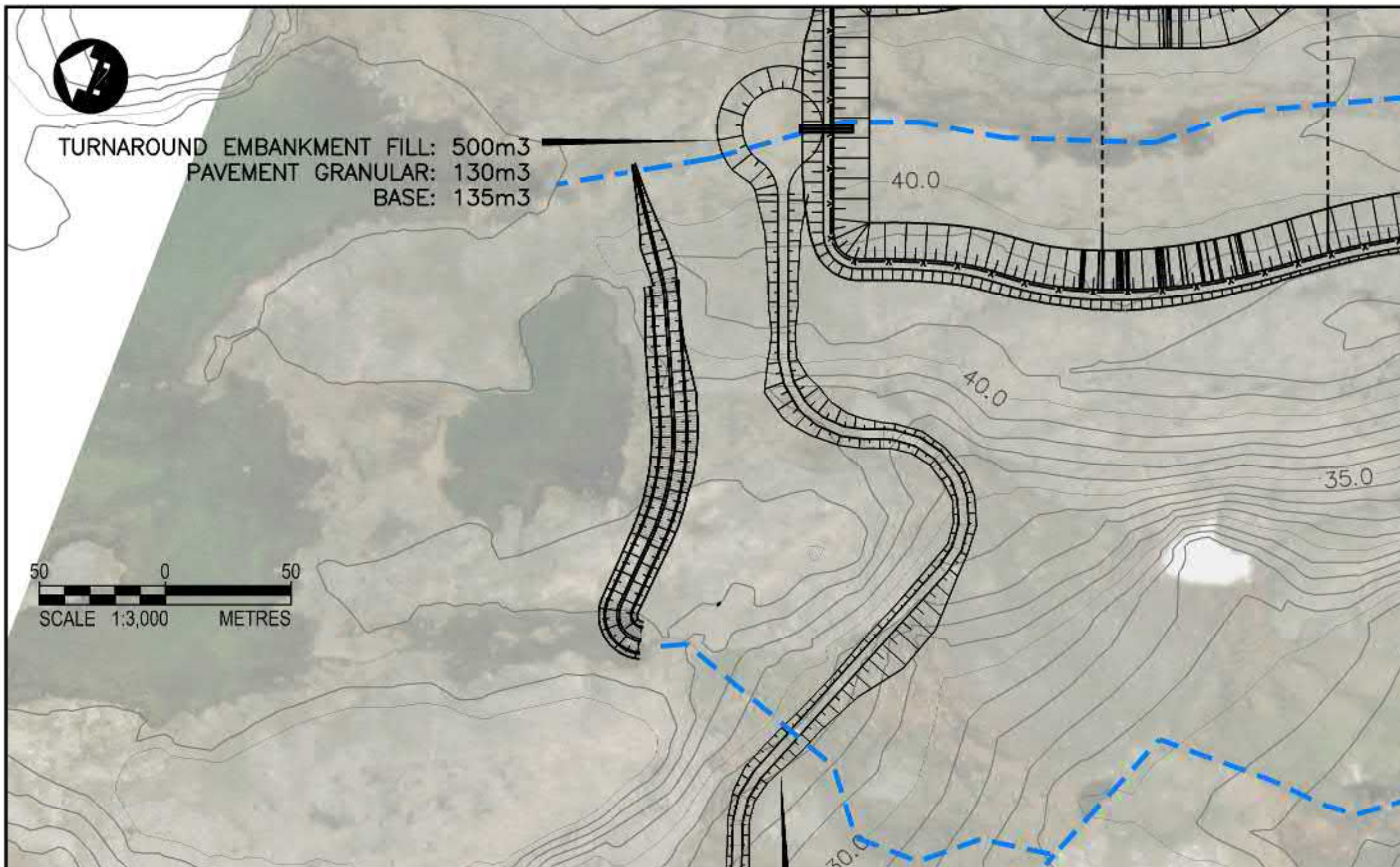
PROJECT NO. **21-2233**

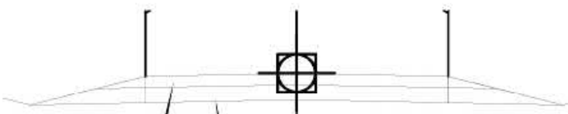
TITLE **QUANTITIES**
LAGOON SECTIONS

FIGURE NO. **6**

DATE **March 2022**

FileName:c:\users\40skb\documents\pojects\212233 naujaat\export\212233-02-site-opt3-12-month0.5 percent bottom.dwg





MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+000.00	0.70	0.00	0.00
3+020.00	0.70	13.96	13.96
3+040.00	0.70	13.96	27.91
3+060.00	0.70	13.96	41.87
3+070.00	0.70	6.98	48.85
3+080.00	0.70	6.98	55.83
3+090.00	0.70	6.98	62.80
3+100.00	0.70	6.98	69.78
3+110.00	0.70	6.98	76.76
3+120.00	0.70	6.98	83.74
3+130.00	0.70	6.98	90.72
3+140.00	0.70	6.98	97.70
3+150.00	0.70	6.98	104.67
3+160.00	0.70	6.98	111.65
3+170.00	0.70	6.98	118.63
3+180.00	0.70	6.98	125.61
3+190.00	0.70	6.98	132.59
3+200.00	0.70	6.98	139.57
3+210.00	0.70	6.98	146.54
3+220.00	0.70	6.98	153.52
3+230.00	0.70	6.98	160.50
3+240.00	0.70	6.98	167.48
3+250.00	0.70	6.98	174.46
3+260.00	0.70	6.98	181.43
3+270.00	0.70	6.98	188.41
3+280.00	0.70	6.98	195.39
3+290.00	0.70	6.98	202.37
3+300.00	0.70	6.98	209.35
3+310.00	0.70	6.98	216.33
3+320.00	0.70	6.98	223.30
3+330.00	0.70	6.98	230.28
3+340.00	0.70	6.98	237.26
3+350.00	0.70	6.98	244.24
3+360.00	0.70	6.98	251.22
3+380.00	0.70	13.96	265.17
3+400.00	0.70	13.96	279.13
3+420.00	0.70	13.96	293.09
3+440.00	0.70	13.96	307.04
3+445.70	0.70	3.98	311.02

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+000.00	1.23	0.00	0.00
3+020.00	1.23	24.70	24.70
3+040.00	1.23	24.70	49.39
3+060.00	1.23	24.70	74.09
3+070.00	1.23	12.35	86.43
3+080.00	1.23	12.35	98.78
3+090.00	1.23	12.35	111.13
3+100.00	1.23	12.35	123.48
3+110.00	1.23	12.35	135.83
3+120.00	1.23	12.35	148.17
3+130.00	1.23	12.35	160.52
3+140.00	1.23	12.35	172.87
3+150.00	1.23	12.35	185.22
3+160.00	1.23	12.35	197.57
3+170.00	1.23	12.35	209.91
3+180.00	1.23	12.35	222.26
3+190.00	1.23	12.35	234.61
3+200.00	1.23	12.35	246.96
3+210.00	1.23	12.35	259.30
3+220.00	1.23	12.35	271.65
3+230.00	1.23	12.35	284.00
3+240.00	1.23	12.35	296.35
3+250.00	1.23	12.35	308.70
3+260.00	1.23	12.35	321.04
3+270.00	1.23	12.35	333.39
3+280.00	1.23	12.35	345.74
3+290.00	1.23	12.35	358.09
3+300.00	1.23	12.35	370.43
3+310.00	1.23	12.35	382.78
3+320.00	1.23	12.35	395.13
3+330.00	1.23	12.35	407.48
3+340.00	1.23	12.35	419.83
3+350.00	1.23	12.35	432.17
3+360.00	1.23	12.35	444.52
3+380.00	1.23	24.70	469.22
3+400.00	1.23	24.70	493.91
3+420.00	1.23	24.70	518.61
3+440.00	1.23	24.70	543.30
3+445.70	1.23	7.04	550.34

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+020	0.00	0.21	0.00	0.00	0.00	0.00
3+040	0.21	0.02	2.08	2.28	2.08	2.28
3+060	0.35	0.01	5.60	0.33	7.68	2.61
3+070	0.54	0.00	4.43	0.09	12.12	2.70
3+080	1.54	0.00	10.39	0.02	22.50	2.71
3+090	2.50	0.00	20.18	0.00	42.68	2.71
3+100	0.81	0.00	16.54	0.00	59.22	2.72
3+110	1.60	0.00	12.04	0.00	71.26	2.72
3+120	1.85	0.00	17.26	0.02	88.52	2.74
3+130	1.62	0.11	17.35	0.54	105.87	3.28
3+140	1.72	0.13	16.69	1.16	122.56	4.44
3+150	1.06	0.38	13.89	2.56	136.46	7.01
3+160	0.67	0.67	8.63	5.26	145.09	12.27
3+170	0.61	0.56	6.42	6.12	151.51	18.39
3+180	0.98	0.28	7.96	4.20	159.47	22.59
3+190	1.15	0.13	10.62	2.07	170.08	24.66
3+200	1.03	0.05	10.90	0.93	180.98	25.58
3+210	0.76	0.16	8.89	1.07	189.88	26.66
3+220	0.97	0.28	8.14	2.40	198.02	29.06
3+230	0.83	1.07	8.32	7.41	206.34	36.47
3+240	1.43	0.66	11.21	8.72	217.55	45.20
3+250	1.90	0.61	16.68	6.39	234.24	51.58
3+260	2.10	0.28	20.00	4.49	254.24	56.08
3+270	2.70	0.22	23.97	2.53	278.21	58.60
3+280	6.35	0.00	45.24	1.11	323.45	59.71
3+290	13.69	0.00	100.22	0.00	423.67	59.71
3+300	18.86	0.00	162.78	0.00	586.45	59.71
3+310	24.55	0.00	217.08	0.00	803.53	59.71
3+320	16.96	0.00	207.58	0.00	1011.11	59.72
3+330	7.98	0.24	124.70	1.21	1135.82	60.93
3+340	5.54	0.00	67.60	1.21	1203.41	62.14
3+350	0.95	0.06	33.36	0.29	1236.77	62.43
3+360	2.07	0.00	15.67	0.29	1252.44	62.71
3+380	1.84	0.00	39.62	0.00	1292.05	62.71
3+400	1.60	0.00	34.04	0.00	1326.09	62.71
3+420	4.06	0.00	56.53	0.00	1382.62	62.71
3+430	5.41	0.00	47.34	0.00	1429.96	62.71
3+440	6.94	0.00	59.48	0.00	1489.45	62.71

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+445.70	10.10	0.00	46.17	0.00	1535.62	62.72
3+450	13.06	0.00	47.66	0.00	1583.28	62.72
3+455	17.51	0.00	73.93	0.00	1657.20	62.72
3+456.49	18.81	0.00	26.39	0.00	1683.59	62.72
3+460	22.28	0.00	70.57	0.00	1754.16	62.72
3+465	23.92	0.00	113.84	0.00	1868.00	62.72
3+470	21.01	0.00	112.56	0.00	1980.56	62.72
3+475	13.01	0.01	86.30	0.02	2066.86	62.74
3+480	6.46	0.00	49.03	0.02	2115.89	62.76
3+481.59	5.60	0.00	9.65	0.00	2125.54	62.76
3+490	2.39	0.00	33.55	0.00	2159.09	62.76
3+500	5.35	0.00	38.67	0.00	2197.76	62.76
3+510	11.45	0.00	84.01	0.00	2281.77	62.77
3+520	19.30	0.00	153.79	0.00	2435.55	62.77
3+530	38.41	0.03	288.56	0.14	2724.12	62.91
3+540	66.31	0.00	523.60	0.14	3247.72	63.05
3+546.96	0.00	0.00	230.61	0.00	3478.33	63.05
3+550	0.00	0.00	0.00	0.00	3478.33	63.05
3+560	0.00	0.00	0.00	0.00	3478.33	63.05
3+570	0.00	0.00	0.00	0.00	3478.33	63.05
3+570.74	0.00	0.00	0.00	0.00	3478.33	63.05
3+580	0.00	0.00	0.00	0.00	3478.33	63.05
3+590	0.00	0.00	0.00	0.00	3478.33	63.05
3+600	0.00	0.00	0.00	0.00	3478.33	63.05
3+605.12	0.00	0.00	0.00	0.00	3478.33	63.05

DRAFT
Mar 02, 2022

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DILLON CONSULTING

DATE March 2022

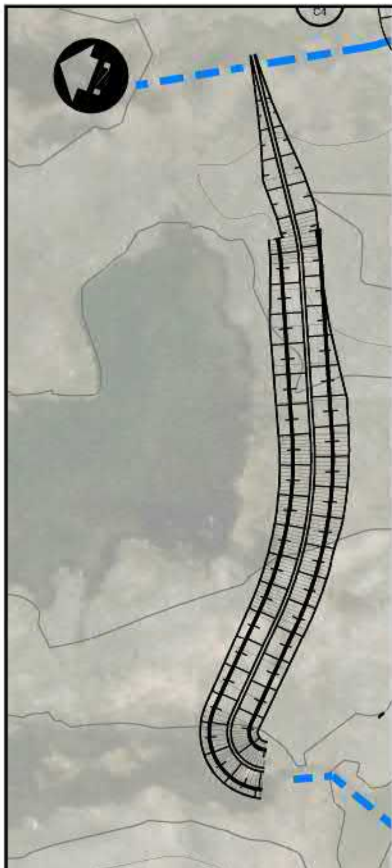
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES**
ACCESS ROAD AND TURNAROUND

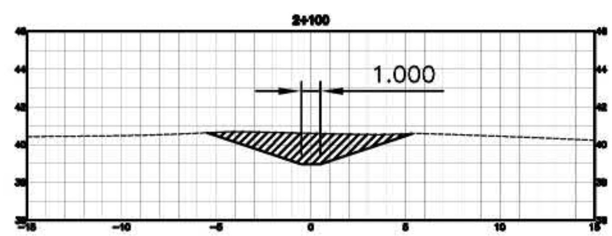
FIGURE NO. **7**

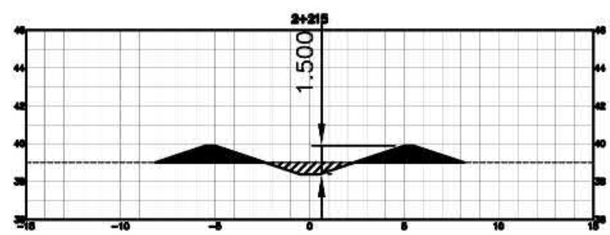
50 0 50
SCALE 1:2,000 METRES

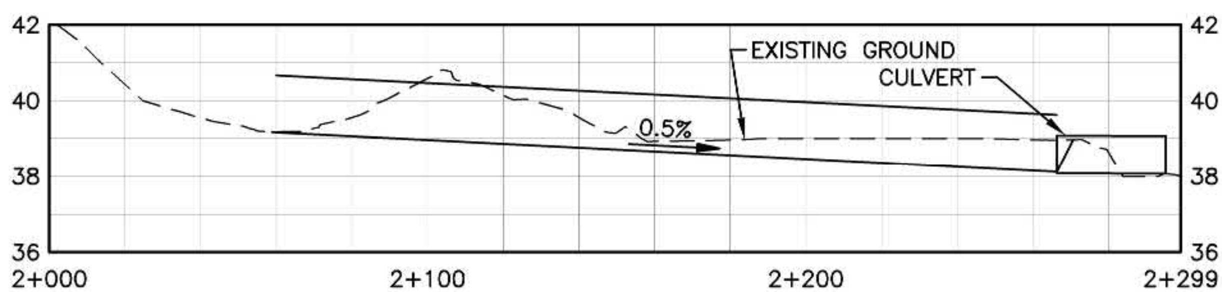


PLAN

ALIGNMENT - DIVERSION DITCH CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
2+000	0.00	0.00	0.00	0.00	0.00	0.00
2+010	0.00	0.00	0.00	0.00	0.00	0.00
2+020	0.00	0.00	0.00	0.00	0.00	0.00
2+030	0.00	0.00	0.00	0.00	0.00	0.00
2+040	0.00	0.00	0.00	0.00	0.00	0.00
2+050	0.00	0.00	0.00	0.00	0.00	0.00
2+060	0.00	0.00	0.00	0.00	0.00	0.00
2+070	0.00	0.23	0.00	1.15	0.00	1.15
2+080	0.00	1.24	0.00	7.35	0.00	8.50
2+090	0.01	4.34	0.06	27.89	0.06	36.39
2+100	0.00	9.60	0.06	69.70	0.12	106.09
2+110	0.26	9.36	1.28	94.82	1.40	200.91
2+118.75	1.11	6.97	5.97	71.42	7.37	272.33
2+120	1.12	6.36	0.27	8.85	7.65	281.18
2+130	2.29	5.13	17.06	57.45	24.72	338.63
2+140	4.39	2.89	33.40	40.08	58.13	378.71
2+150	7.38	1.34	58.84	21.14	116.97	399.85
2+160	10.78	0.49	90.80	9.18	207.77	409.03
2+168.71	10.00	0.64	90.53	4.93	298.30	413.96
2+170	9.89	0.66	12.81	0.84	311.11	414.80
2+175	9.42	0.77	48.65	3.57	359.76	418.38
2+180	8.91	0.90	46.17	4.17	405.93	422.55
2+185	8.37	1.05	43.50	4.87	449.43	427.42
2+190	7.81	1.19	40.70	5.60	490.13	433.02
2+193.57	7.35	1.28	27.17	4.40	517.30	437.42
2+195	7.07	1.31	10.32	1.85	527.62	439.27
2+200	6.41	1.41	33.74	6.81	561.36	446.08
2+205	6.17	1.53	31.44	7.37	592.80	453.45
2+210	5.85	1.65	30.03	7.95	622.83	461.39
2+215	5.55	1.77	28.48	8.54	651.31	469.93
2+218.42	5.34	1.85	18.65	6.19	669.95	476.12
2+220	5.25	1.89	8.35	2.95	678.30	479.07
2+230	4.69	2.15	49.69	20.21	727.99	499.28
2+240	4.19	2.40	44.39	22.77	772.38	522.05
2+247.09	3.86	2.59	28.54	17.67	800.92	539.72
2+250	3.75	2.65	11.07	7.64	811.99	547.36
2+255	3.65	2.71	18.52	13.40	830.51	560.76
2+256.51	3.62	2.73	5.52	4.09	836.03	564.85
2+260	3.54	2.78	12.67	9.59	848.70	574.45
2+265	3.37	2.88	17.67	14.12	866.36	588.57
2+265.93	3.35	2.91	3.22	2.69	869.58	591.25
2+270	0.00	0.00	6.81	5.92	876.39	597.17
2+280	0.00	0.00	0.00	0.00	876.39	597.17
2+290	0.00	0.00	0.00	0.00	876.39	597.17
2+299.09	0.00	0.00	0.00	0.00	876.39	597.17







DIVERSION DITCH PROFILE

DRAFT
Mar 02, 2022

DILLON CONSULTING

DATE March 2022

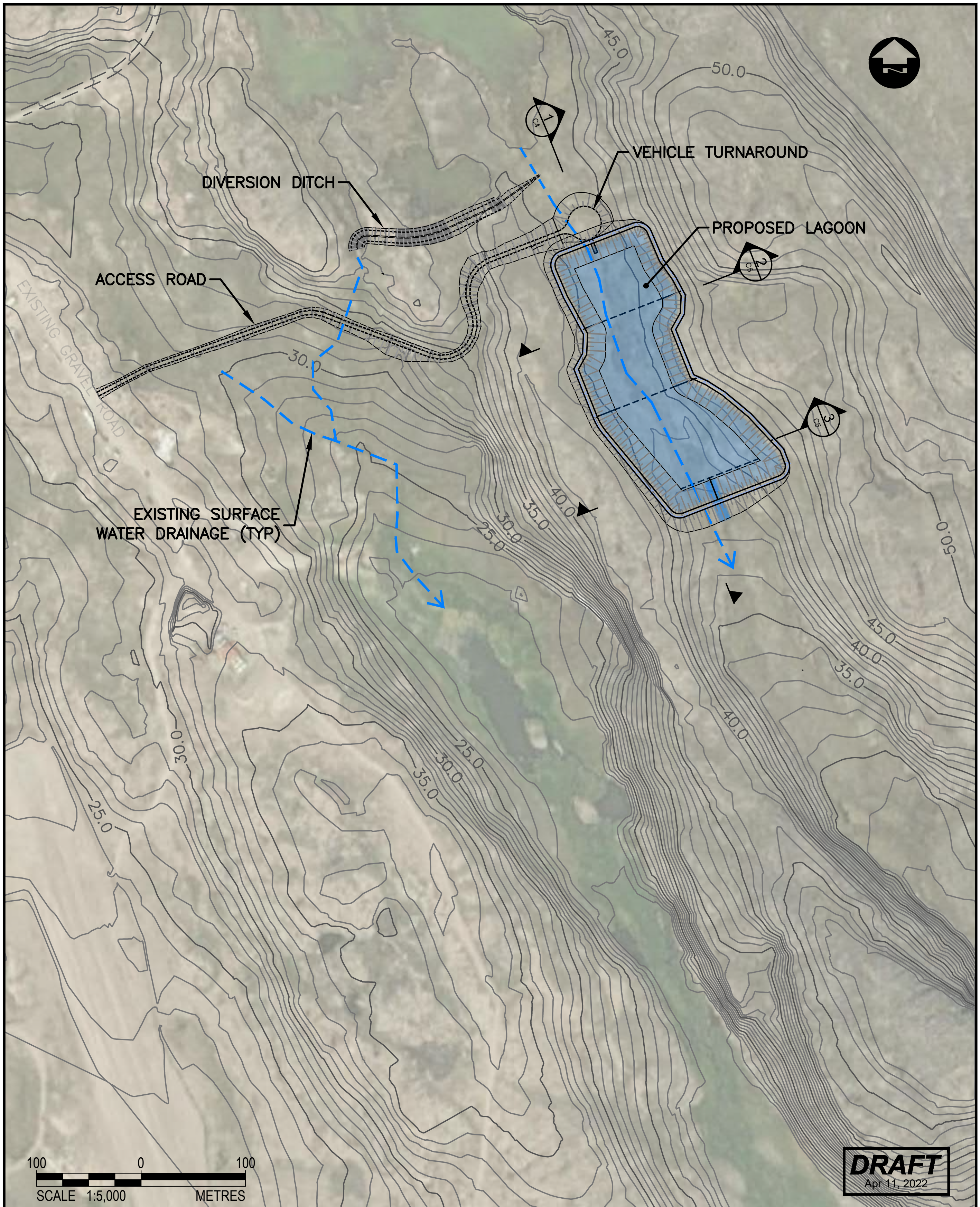
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3B**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES DIVERSION DITCH**

FIGURE NO. **8**

FileName:c:\users\40skb\documents\pojects\212233 naujaat\export\212233-02-site-opt3-12-month0.5 percent biottom.dwg



DILLON CONSULTING

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C**
HAMLET OF NAUJAAT, NUNAVUT

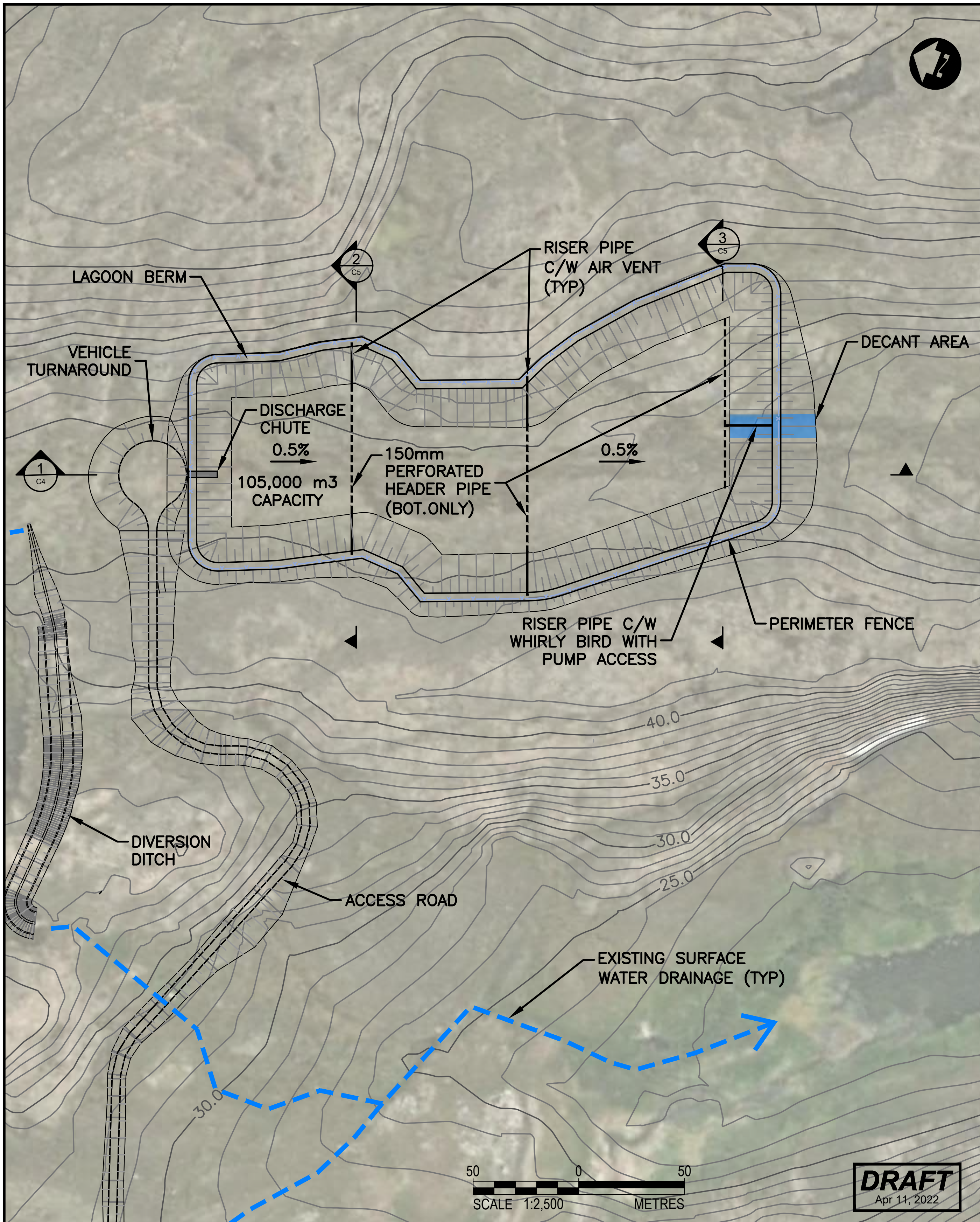
PROJECT NO. **21-2233**

TITLE **SITE PLAN**

FIGURE NO. **1**

DATE **APRIL 2022**

FileName:c:\pw working directory\projects 2021\4\1tpw\dms94319\21233-02-site-opt3-10-month - opt3c - 04-11-22.dwg



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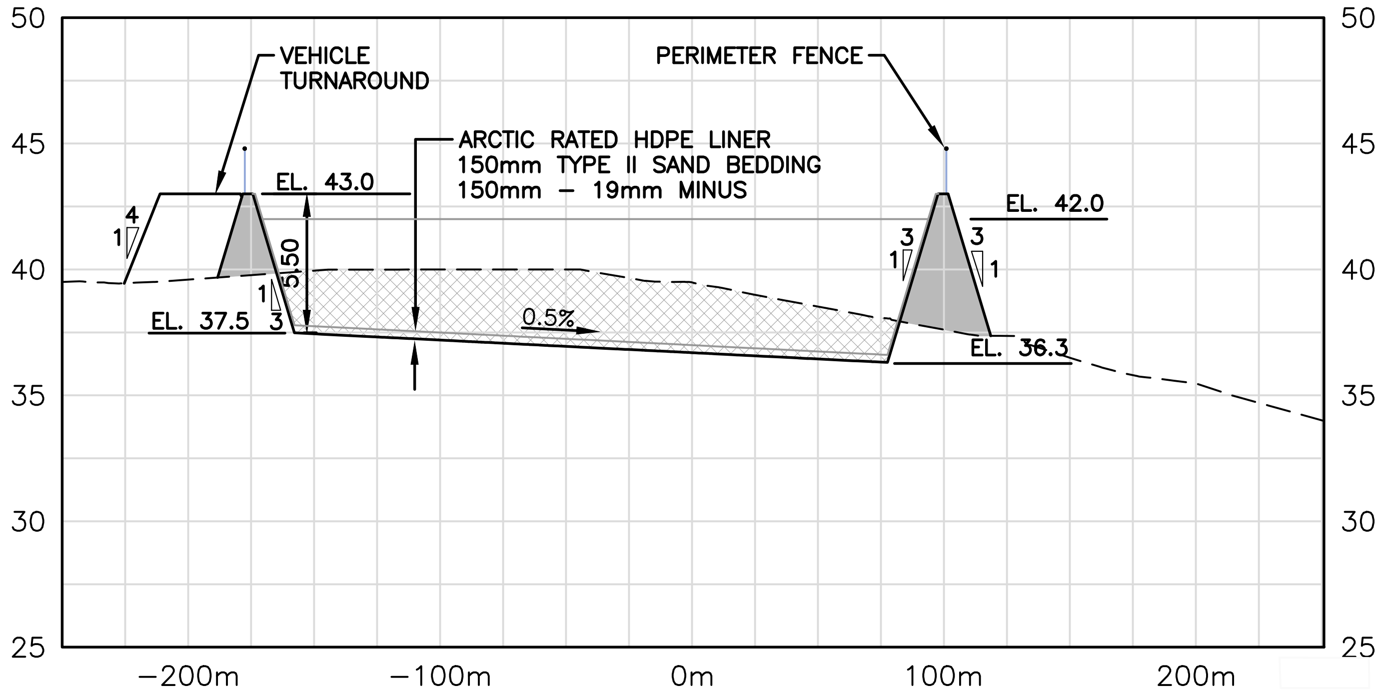
DILLON CONSULTING

DATE April 2022	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
	TITLE **LAGOON PLAN**	FIGURE NO. **2**

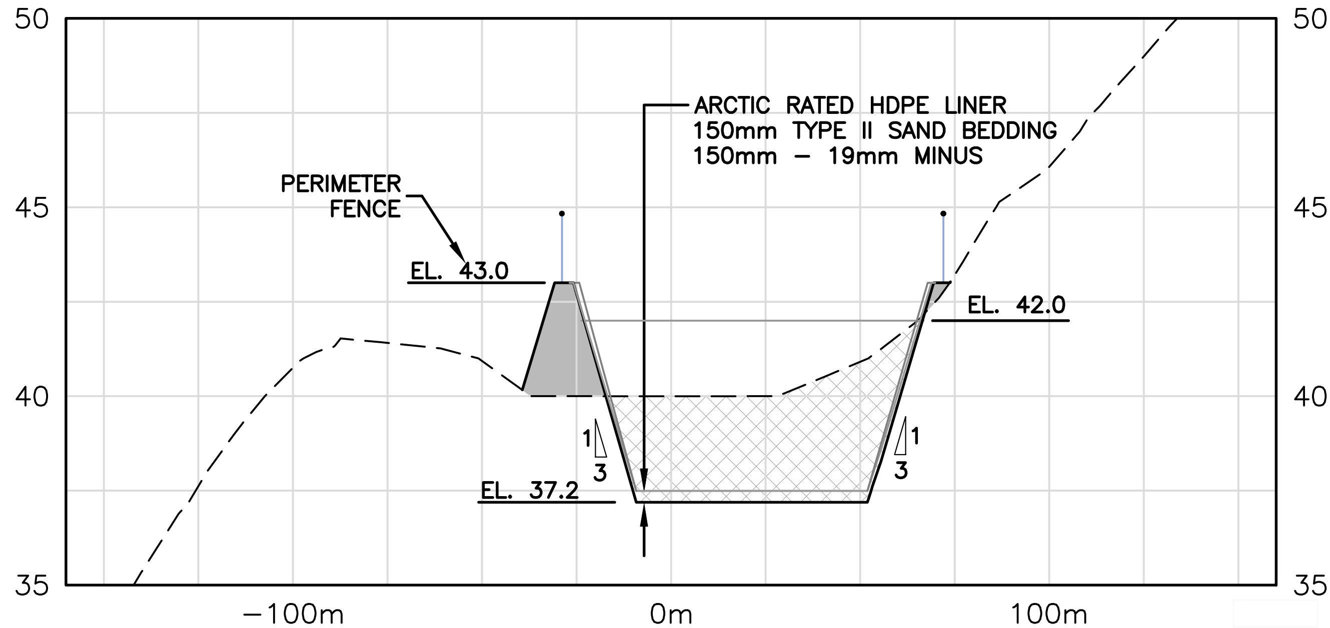


1 C4 SECTION
HOR. 1:3000 VER. 1:300

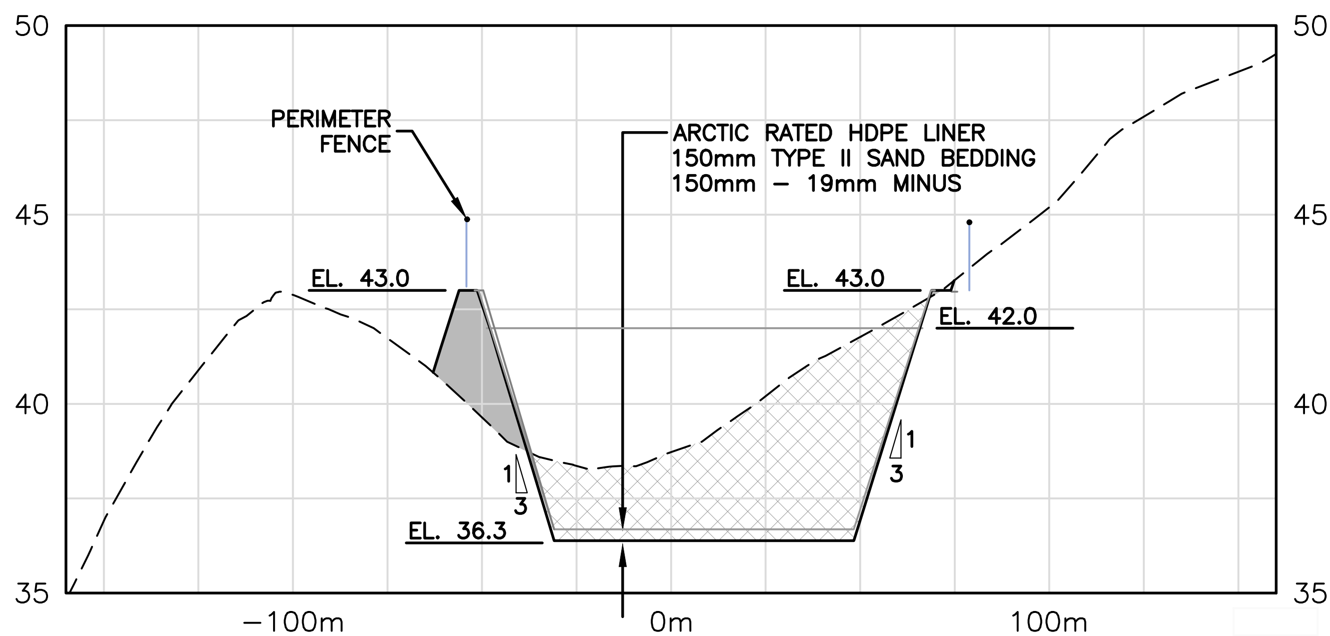
DRAFT
Apr 11, 2022

FileName:c:\pw working directory\projects 2021\41tpw\dms94319\212233-02-site-opt3-10-month - opt3c - 04-11-22.dwg

DILLON CONSULTING	PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3C HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
DATE April 2022	TITLE SECTION 1	FIGURE NO. 3



2 C5 SECTION
HOR. 1:2000 VER. 1:200



3 C5 SECTION
HOR. 1:2000 VER. 1:200

DRAFT
Apr 11, 2022

DILLON CONSULTING

DATE April 2022

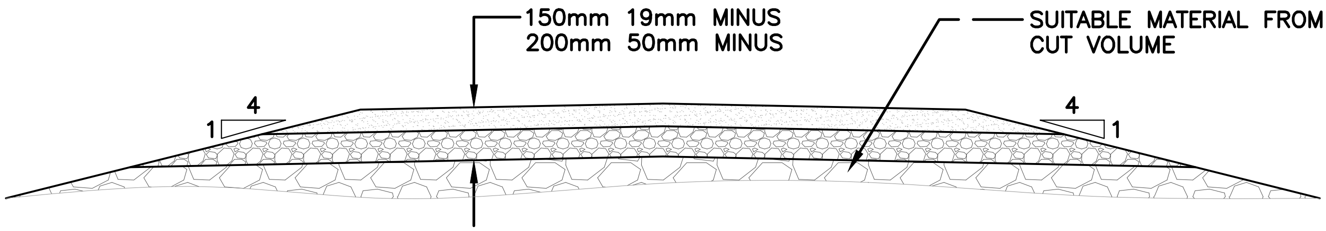
PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **SECTIONS 2 AND 3**

PROJECT NO. **21-2233**

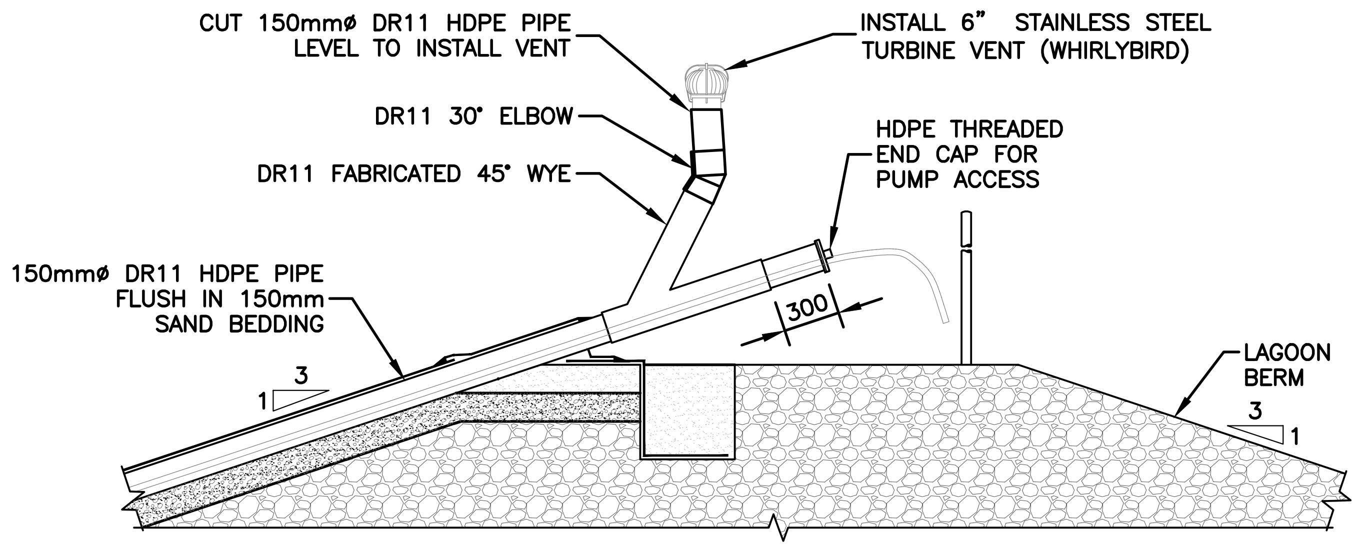
FIGURE NO. **4**

FileName:c:\pw working directory\projects 2021\41tpw\dms94319\21233-02-site-opt3-10-month - opt3c - 04-11-22.dwg



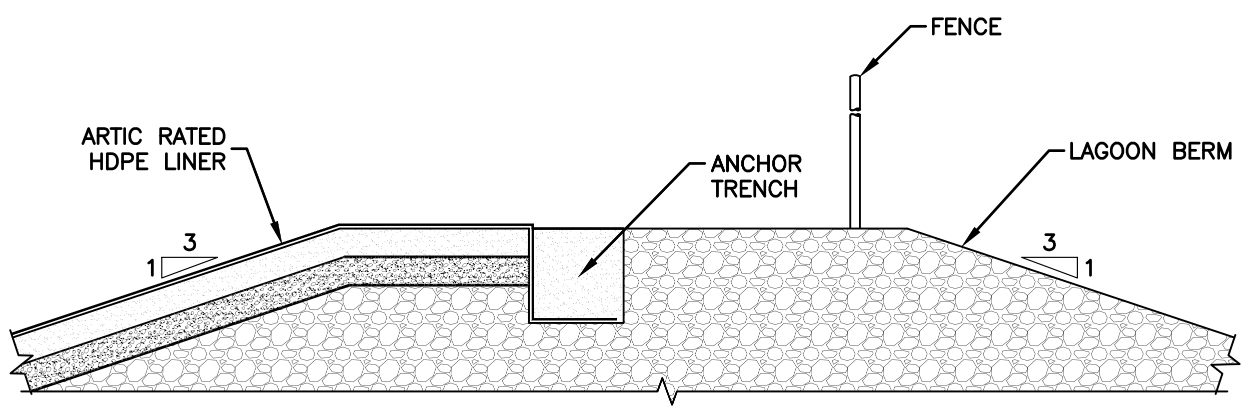
ACCESS ROAD DETAIL

NTS



AIR VENT DETAIL

NTS



ANCHOR TRENCH DETAIL

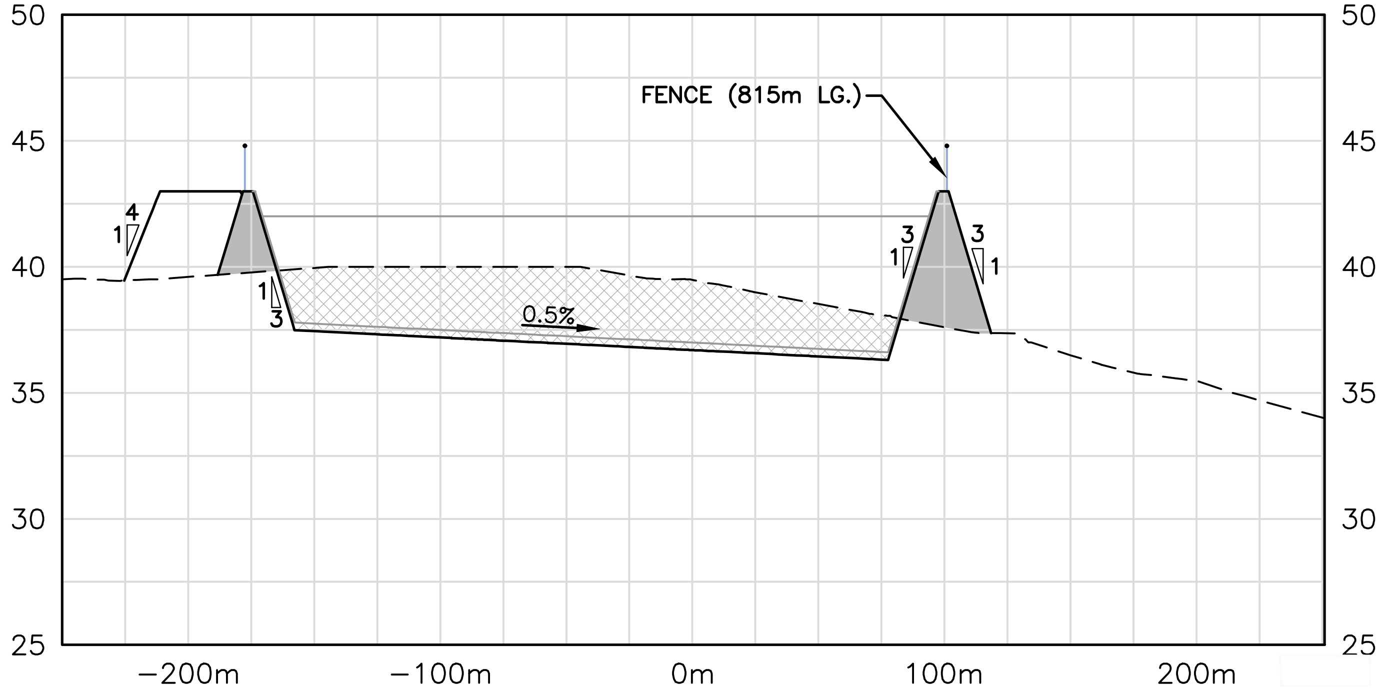
NTS

DRAFT
Apr 11, 2022

DILLON CONSULTING

DATE April 2022	PROJECT LAGOON SCHEMATIC DESIGN - OPTION 3C HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. 21-2233
	TITLE DETAILS	FIGURE NO. 5

FileName:c:\pw working directory\projects 2021\4\1tpw\dms94319\212233-02-site-opt3-10-month - opt3c - 04-11-22.dwg



1 SECTION
C4 HOR. 1:3000 VER. 1:300

ARCTIC RATED HDPE LINER:................................30,000m2
TYPE II SAND BEDDING: (34,000 x 0.15).............4,500m3
TYPE II 19mm MINUS..4,500m3

150mm HDPE PIPE (PERFORATED).............200m
150mm HDPE PIPE (SLOPES).......................90m
150mm HDPE PIPE (ABOVE T/O BERM)..........9m

LAGOON CUT...................................58,000m3
LAGOON CONSTRUCTION FILL...........22,000m3
NET (CUT).......................................36,000m3

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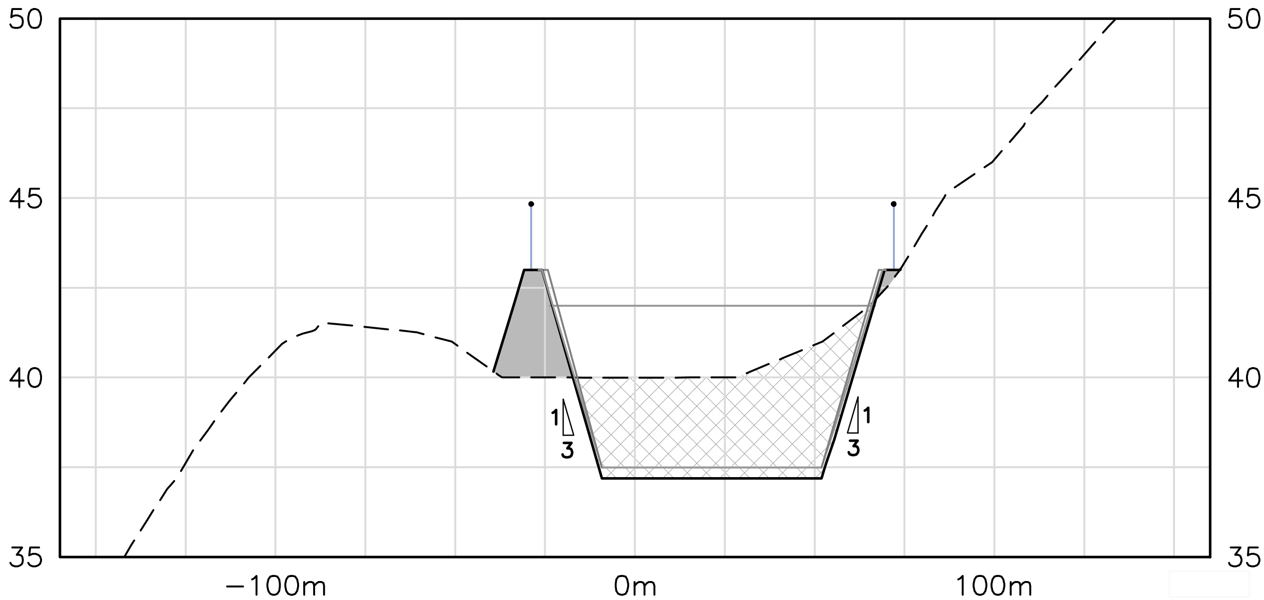

2 SECTION
C5 HOR. 1:2000 VER. 1:200

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DATE April 2022

PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C**
HAMLET OF NAUJAAT, NUNAVUT

TITLE **QUANTITIES**
LAGOON SECTIONS

PROJECT NO. **21-2233**

FIGURE NO. **6**

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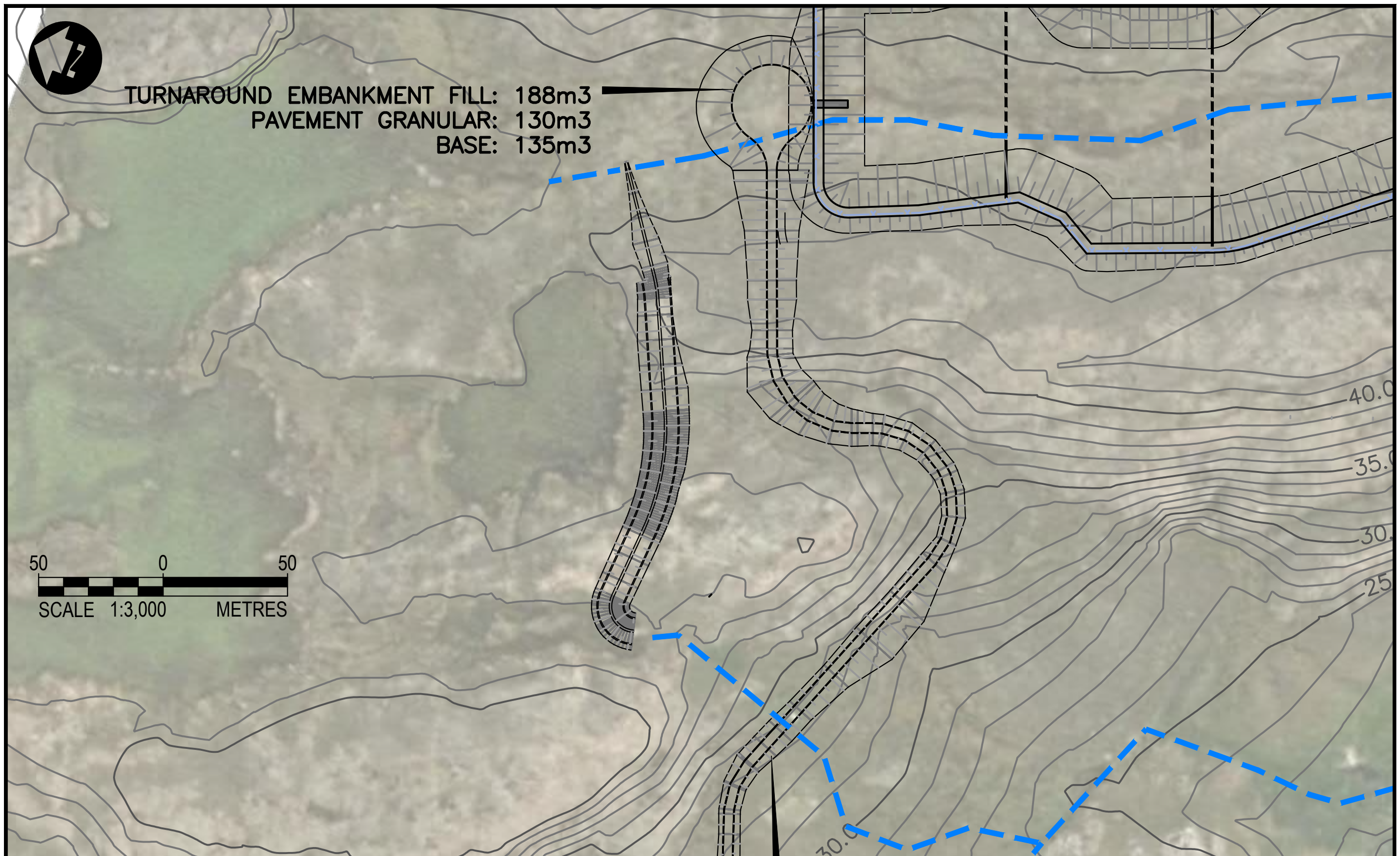

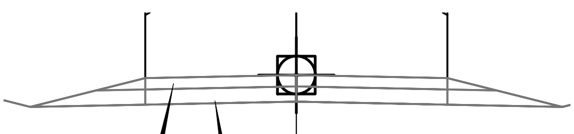

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+000.00	0.70	0.00	0.00
3+020.00	0.70	13.96	13.96
3+040.00	0.70	13.96	27.91
3+060.00	0.70	13.96	41.87
3+070.00	0.70	6.98	48.85
3+080.00	0.70	6.98	55.83
3+090.00	0.70	6.98	62.80
3+100.00	0.70	6.98	69.78
3+110.00	0.70	6.98	76.76
3+120.00	0.70	6.98	83.74
3+130.00	0.70	6.98	90.72
3+140.00	0.70	6.98	97.70
3+150.00	0.70	6.98	104.67
3+160.00	0.70	6.98	111.65
3+170.00	0.70	6.98	118.63
3+180.00	0.70	6.98	125.61
3+190.00	0.70	6.98	132.59
3+200.00	0.70	6.98	139.57
3+210.00	0.70	6.98	146.54
3+220.00	0.70	6.98	153.52
3+230.00	0.70	6.98	160.50
3+240.00	0.70	6.98	167.48
3+250.00	0.70	6.98	174.46
3+260.00	0.70	6.98	181.43
3+270.00	0.70	6.98	188.41
3+280.00	0.70	6.98	195.39
3+290.00	0.70	6.98	202.37
3+300.00	0.70	6.98	209.35
3+310.00	0.70	6.98	216.33
3+320.00	0.70	6.98	223.30
3+330.00	0.70	6.98	230.28
3+340.00	0.70	6.98	237.26
3+350.00	0.70	6.98	244.24
3+360.00	0.70	6.98	251.22
3+380.00	0.70	13.96	265.17
3+400.00	0.70	13.96	279.13
3+420.00	0.70	13.96	293.09
3+440.00	0.70	13.96	307.04
3+445.70	0.70	3.98	311.02

MATERIAL VOLUME			
STATION	AREA	VOLUME	CUM. VOLUME (m³)
3+000.00	1.23	0.00	0.00
3+020.00	1.23	24.70	24.70
3+040.00	1.23	24.70	49.39
3+060.00	1.23	24.70	74.09
3+070.00	1.23	12.35	86.43
3+080.00	1.23	12.35	98.78
3+090.00	1.23	12.35	111.13
3+100.00	1.23	12.35	123.48
3+110.00	1.23	12.35	135.83
3+120.00	1.23	12.35	148.17
3+130.00	1.23	12.35	160.52
3+140.00	1.23	12.35	172.87
3+150.00	1.23	12.35	185.22
3+160.00	1.23	12.35	197.57
3+170.00	1.23	12.35	209.91
3+180.00	1.23	12.35	222.26
3+190.00	1.23	12.35	234.61
3+200.00	1.23	12.35	246.96
3+210.00	1.23	12.35	259.30
3+220.00	1.23	12.35	271.65
3+230.00	1.23	12.35	284.00
3+240.00	1.23	12.35	296.35
3+250.00	1.23	12.35	308.70
3+260.00	1.23	12.35	321.04
3+270.00	1.23	12.35	333.39
3+280.00	1.23	12.35	345.74
3+290.00	1.23	12.35	358.09
3+300.00	1.23	12.35	370.43
3+310.00	1.23	12.35	382.78
3+320.00	1.23	12.35	395.13
3+330.00	1.23	12.35	407.48
3+340.00	1.23	12.35	419.83
3+350.00	1.23	12.35	432.17
3+360.00	1.23	12.35	444.52
3+380.00	1.23	24.70	469.22
3+400.00	1.23	24.70	493.91
3+420.00	1.23	24.70	518.61
3+440.00	1.23	24.70	543.30
3+445.70	1.23	7.04	550.34

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+020	0.00	0.21	0.00	0.00	0.00	0.00
3+040	0.21	0.02	2.08	2.28	2.08	2.28
3+060	0.35	0.01	5.60	0.33	7.68	2.61
3+070	0.54	0.00	4.43	0.09	12.12	2.70
3+080	1.54	0.00	10.39	0.02	22.50	2.71
3+090	2.50	0.00	20.18	0.00	42.68	2.71
3+100	0.81	0.00	16.54	0.00	59.22	2.72
3+110	1.60	0.00	12.04	0.00	71.26	2.72
3+120	1.85	0.00	17.26	0.02	88.52	2.74
3+130	1.62	0.11	17.35	0.54	105.87	3.28
3+140	1.72	0.13	16.69	1.16	122.56	4.44
3+150	1.06	0.38	13.89	2.56	136.46	7.01
3+160	0.67	0.67	8.63	5.26	145.09	12.27
3+170	0.61	0.56	6.42	6.12	151.51	18.39
3+180	0.98	0.28	7.96	4.20	159.47	22.58
3+190	1.15	0.13	10.62	2.07	170.08	24.66
3+200	1.03	0.05	10.90	0.93	180.98	25.58
3+210	0.76	0.16	8.89	1.07	189.88	26.66
3+220	0.97	0.28	8.14	2.40	198.02	29.06
3+230	0.83	1.07	8.32	7.41	206.34	36.47
3+240	1.43	0.66	11.21	8.72	217.55	45.20
3+250	1.90	0.61	16.68	6.39	234.24	51.58
3+260	2.10	0.28	20.00	4.49	254.24	56.08
3+270	2.70	0.22	23.97	2.53	278.21	58.60
3+280	6.35	0.00	45.24	1.11	323.45	59.71
3+290	13.69	0.00	100.22	0.00	423.67	59.71
3+300	18.86	0.00	162.78	0.00	586.45	59.71
3+310	24.55	0.00	217.08	0.00	803.53	59.71
3+320	16.96	0.00	207.58	0.00	1011.11	59.72
3+330	7.98	0.24	124.70	1.21	1135.82	60.93
3+340	5.54	0.00	67.60	1.21	1203.41	62.14
3+350	0.95	0.06	33.36	0.29	1236.77	62.43

ALIGNMENT – ACCESS ROAD CUT/FILL						
STATION	FILL AREA (m²)	CUT AREA (m²)	FILL VOLUME (m³)	CUT VOLUME (m³)	CUM. FILL VOLUME (m³)	CUM. CUT VOLUME (m³)
3+360	2.96	0.00	20.20	0.29	1256.97	62.71
3+380	4.62	0.00	76.38	0.00	1333.36	62.71
3+400	6.56	0.00	110.78	0.00	1444.13	62.71
3+420	12.26	0.00	187.81	0.00	1631.94	62.71
3+430	16.48	0.00	141.72	0.00	1773.66	62.71
3+440	23.37	0.00	192.65	0.00	1966.32	62.71
3+445.70	29.47	0.00	145.79	0.00	2112.10	62.71
3+447.49	31.74	0.00	53.45	0.00	2165.56	62.72
3+450	34.95	0.00	82.11	0.00	2247.67	62.72
3+455	39.65	0.00	185.07	0.00	2432.74	62.72
3+460	38.57	0.00	199.20	0.00	2631.95	62.72
3+465	27.17	0.02	170.85	0.04	2802.79	62.76
3+470	17.12	0.00	114.57	0.04	2917.37	62.80
3+472.59	15.33	0.00	42.88	0.00	2960.24	62.80
3+475	14.62	0.00	36.02	0.00	2996.27	62.80
3+480	13.14	0.00	69.38	0.00	3065.65	62.80
3+490	18.80	0.01	159.66	0.05	3225.31	62.85
3+500	21.33	0.00	200.63	0.05	3425.94	62.90
3+510	21.34	0.08	213.38	0.41	3639.32	63.31
3+520	27.01	0.00	241.75	0.41	3881.08	63.72
3+530	40.42	0.00	337.14	0.00	4218.22	63.72
3+540	51.37	0.00	458.95	0.00	4677.17	63.72
3+546.96	0.00	0.00	178.65	0.00	4855.82	63.72
3+550	0.00	0.00	0.00	0.00	4855.82	63.72
3+560	0.00	0.00	0.00	0.00	4855.82	63.72
3+569.74	0.00	0.00	0.00	0.00	4855.82	63.72
3+570	0.00	0.00	0.00	0.00	4855.82	63.72
3+580	0.00	0.00	0.00	0.00	4855.82	63.72
3+590	0.00	0.00	0.00	0.00	4855.82	63.72
3+595.12	0.00	0.00	0.00	0.00	4855.82	63.72

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PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C**
HAMLET OF NAUJAAT, NUNAVUT

PROJECT NO. **21-2233**

TITLE **QUANTITIES**
ACCESS ROAD AND TURNAROUND

FIGURE NO. **7**

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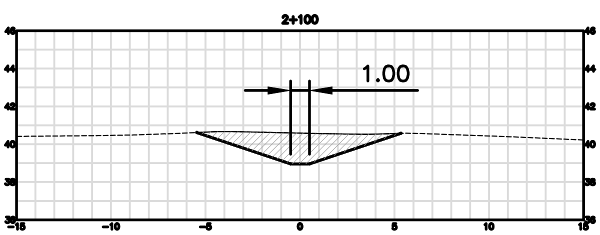
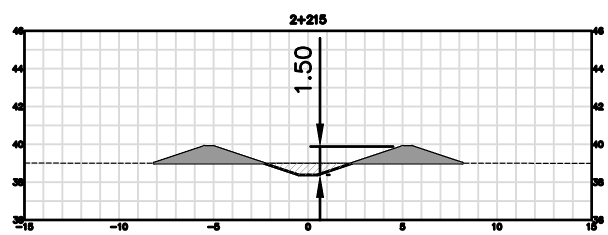
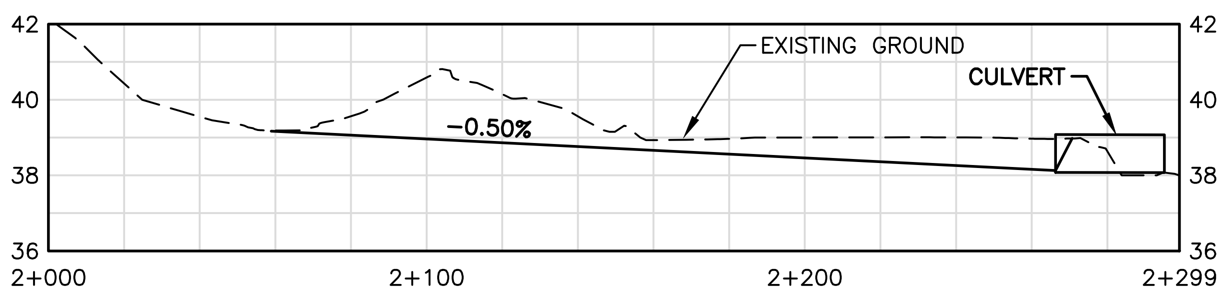
50 0 50
SCALE 1:2,000 METRES

PLAN

ALIGNMENT – DIVERSION DITCH CUT/FILL						
STATION	FILL AREA (m^2)	CUT AREA (m^2)	FILL VOLUME (m^3)	CUT VOLUME (m^3)	CUM. FILL VOLUME (m^3)	CUM. CUT VOLUME (m^3)
2+000	0.00	0.00	0.00	0.00	0.00	0.00
2+010	0.00	0.00	0.00	0.00	0.00	0.00
2+020	0.00	0.00	0.00	0.00	0.00	0.00
2+030	0.00	0.00	0.00	0.00	0.00	0.00
2+040	0.00	0.00	0.00	0.00	0.00	0.00
2+050	0.00	0.00	0.00	0.00	0.00	0.00
2+060	0.00	0.00	0.00	0.00	0.00	0.00
2+070	0.00	0.23	0.00	1.15	0.00	1.15
2+080	0.00	1.24	0.00	7.35	0.00	8.50
2+090	0.00	4.34	0.00	27.89	0.00	36.39
2+100	0.00	9.60	0.00	69.70	0.00	106.09
2+110	0.00	9.43	0.00	95.14	0.00	201.23
2+114	0.00	8.40	0.00	35.65	0.00	236.88
2+120	1.26	6.33	3.36	44.61	3.36	281.50
2+130	2.30	5.13	17.13	57.44	20.49	338.93
2+140	4.40	2.88	33.48	40.02	53.97	378.95
2+150	7.39	1.34	58.95	21.11	112.92	400.06
2+160	10.78	0.49	90.85	9.19	203.76	409.25
2+168.69	10.00	0.64	90.29	4.92	294.05	414.17
2+170	9.89	0.66	13.04	0.85	307.09	415.03
2+175	9.42	0.77	48.65	3.58	355.74	418.60
2+180	8.91	0.90	46.16	4.17	401.90	422.77
2+185	8.37	1.05	43.49	4.88	445.40	427.65
2+190	7.81	1.19	40.69	5.60	486.09	433.25
2+193.54	7.35	1.28	26.98	4.38	513.07	437.63
2+195	7.07	1.31	10.49	1.88	523.56	439.51
2+200	6.42	1.41	33.73	6.80	557.29	446.31
2+205	6.17	1.53	31.44	7.37	588.73	453.68
2+210	5.84	1.65	30.02	7.95	618.75	461.63
2+215	5.55	1.77	28.47	8.54	647.23	470.17
2+218.40	5.35	1.85	18.52	6.15	665.74	476.32
2+220	5.25	1.89	8.47	2.99	674.22	479.31
2+230	4.68	2.15	49.68	20.22	723.89	499.53
2+240	4.19	2.40	44.38	22.78	768.27	522.31
2+247.06	3.86	2.59	28.44	17.61	796.71	539.92
2+250	3.74	2.65	11.16	7.70	807.87	547.62
2+255	3.64	2.71	18.52	13.40	826.39	561.02
2+256.48	3.62	2.73	5.44	4.03	831.83	565.05
2+260	3.53	2.78	12.75	9.66	844.58	574.70
2+265	3.37	2.88	17.66	14.12	862.24	588.83
2+265.91	3.35	2.91	3.14	2.62	865.38	591.45
2+270	0.00	0.00	6.85	5.95	872.23	597.40
2+280	0.00	0.00	0.00	0.00	872.23	597.40
2+290	0.00	0.00	0.00	0.00	872.23	597.40
2+299.07	0.00	0.00	0.00	0.00	872.23	597.40







DIVERSION DITCH PROFILE

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DATE April 2022	PROJECT **LAGOON SCHEMATIC DESIGN - OPTION 3C** HAMLET OF NAUJAAT, NUNAVUT	PROJECT NO. **21-2233**
	TITLE **QUANTITIES DIVERSION DITCH**	FIGURE NO. **8**

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