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REPORT

Government of Northwest Territories
Department of Infrastructure

Inuvik Airport Drainage Design & Stormwater Management: Civil Infrastructure Improvements & Runway Extension 06-24

FEBRUARY 2023

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1 BACKGROUND

Associated Engineering (B.C.) Ltd. (Associated) was retained by the Government of Northwest Territories (GNWT) to provide planning, detailed design, and construction oversight for various infrastructure improvements at the Inuvik Mike Zubko Airport as part of two projects, the Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension. The drainage design of the two projects aims to increase the Airport's resilience to climate change, extreme weather, and to protect and maintain essential infrastructure. This technical memorandum summarizes the drainage infrastructure improvements recommended as part of both projects to increase the Airport's resilience to extreme rainfall. While the projects are separate, the drainage infrastructure has been designed such that the efficiency of the system relies on the design of the two projects as a whole and will not function as intended with only the infrastructure components of either project implemented. **Map 1-1** shows an overview of the airport and project area that is relevant to the drainage design.

2 DESIGN CRITERIA

Associated developed a set of drainage criteria for the Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension projects based on a detailed review of relevant design criteria guidelines, standards and recommendations. The detailed design criteria review is provided in Associated's *Inuvik Airport – Drainage Design Criteria* technical memorandum dated November 30, 2020. The following sections summarize the design criteria for the two projects.

2.1 Design Criteria Background Review

We reviewed several design manuals, guidelines, and standards for airports and northern municipalities to identify and develop drainage criteria that would be relevant to the Inuvik Airport design. Documents reviewed included those which were outlined as design criteria guides for the overall civil works of this project, documents received from the Government of the Northwest Territories (GNWT), and other design criteria or design guidelines available online through open source. The documents reviewed are as follows:

- TP312 – Aerodrome Standards and Recommended Practises 5th edition (Transport Canada, 2015).
- Draft Airports Drainage Guide (Government of Northwest Territories Department of Transportation Airports Division, 2017).
- AK70-16-000 Airport Drainage Manual (Transport Canada Airports and Construction Airport Facilities Surface Structure Division, 1984).
- Drainage Improvements Study – Inuvik Airport Improvements (Stantec Inc., 2014).
- Community Drainage System Planning, Design, and Maintenance in Northern Communities (CSA Group, 2015).
- Unified Facilities Criteria (UFC) Surface Drainage Design (U.S. Department of Transportation, Federal Aviation Administration (FAA), 2006).
- City of Whitehorse Servicing Standards Manual (City of Whitehorse, 2007).

Subsequent to the original submission of the *Inuvik Airport – Drainage Design Criteria*, it was observed through hydraulic modelling results, discussed further in **Section 4**, that there is a risk of erosion within the airport ditches due to high velocities. We reviewed the following documents to develop design criteria for erosion control measures:

- Erosion and Sediment Control Manual (Government of the Northwest Territories, Department of Transportation, 2013).

- BC Supplement to TAC Geometric Design Guide for Canadian Roads 3rd Edition (British Columbia Ministry of Transportation and Infrastructure, 2019).

2.2 Key Factors Influencing Drainage Criteria

The following key factors influenced the development of the project specific design criteria:

- The drainage system at the Inuvik airport conveys local runoff from runways, taxiways, and other airport surfaces. In addition, the airport's drainage system collects upslope runoff from an area north of the airport. There are no defined watercourses connecting to the airport drainage system. Therefore, based on a review of applicable drainage documents a design return period of 25-yr is appropriate for sizing culverts.
- A factor of safety should be considered to ensure adequate drainage and continued system functionality during intense storm events. Further, ice and snow buildup within culverts are a common seasonal issue that may cause partial or full blockage of culverts. Culverts should be sized to account for occasional ice or snow buildup that may occur prior to regular maintenance and snow clearing activities. Culverts are to be sized such that the design flow event is 80% of their capacity (i.e. a 25% factor of safety) to account for potential snow and ice buildup prior to regular maintenance activities.

2.3 Applicable Design Criteria

The following design criteria were developed and applied to the Inuvik Airport drainage design:

- Culverts and ditches will be designed to convey the 25-year return period storm (4% Annual Exceedance Probability (AEP)) event with consideration for increased precipitation due to climate change, to the year 2070.
- Culverts should be designed to convey flow at a maximum capacity of 80% during peak flow.
- Culverts should be a minimum of 600 mm diameter.
- A minimum cover of 600 mm over the crown of the culvert is required. An increase in minimum height of cover may be required for heavy aircraft loading.
- Culverts should be placed at a minimum gradient of 0.5% to mitigate sedimentation within the barrel.
- Ditches should be a minimum width of 1.5 m.
- A maximum ditch side slope of 1V:4H should be constructed. This criterion was informed by the geotechnical recommendations. Further geotechnical recommendations are discussed in **Section 5**.
- Ditches should have a minimum grade of 0.3% to promote positive drainage and mitigate standing water.
- Erosion control measures are required where channel degradation and erosion are concerns. Ditches with velocities greater than 1 m/s should have erosion control measures, such as graded riprap or check dams, to mitigate erosion of the ditch invert and side slopes.

2.4 Water Quality Design Criteria

Design criteria and targets for water quality have not currently been established for the Inuvik Airport. Water quality criteria will likely be established by the Gwich'in Land and Water Board (GLWB) through the Water Licence application process. There is no existing water quality data from the Inuvik Airport. Further, GNWT does not have pre-defined water quality standards for water bodies in NWT and they are decided on a site-specific basis. The Canadian Council of Ministers of the Environment (CCME) Guidelines are often used as a reference for defining water quality guidelines. Associated may complete further analysis to suggest water quality criteria, which would be included in the Water Licence application. The results would be discussed and reviewed with GNWT prior to submitting the Water Licence application. Regardless, the requirement for water quality monitoring and water quality criteria will be reviewed, discussed, and ultimately assigned by GLWB as part of the issuance of the Water Licence.

During construction, surface water quality will be maintained by the Contractor as per their Construction Environmental Management Plan (CEMP). The CEMP for these works will include a water quality monitoring program that includes the locations and frequency of monitoring and targets for turbidity. The water quality monitoring program will comply with the requirements stated within the environmental specifications, and relevant legislation and best management practices. The contractor's CEMP will also include an erosion and sediment control plan.

Erosion control measures have been incorporated into the design in the form of ditch armouring and gabion basket check dams, this is discussed further in **Section 5**. Despite installing erosion and sediment control measures in the ditch design, it is understood that some sediment transport will occur after construction, particularly following construction until ground conditions stabilize, and perhaps after significant rainfall events. Sediment is expected to attenuate within the ditch systems over time as the ditches stabilize. As the ditches stabilize the water quality is expected to continue to improve. Data collection will be required to confirm that both acute and long-term water quality criteria in the receiving environment will not be exceeded.

3 CLIMATE CHANGE

A review of climate change data and information was completed to support this project and project the impacts of climate change on the airport's infrastructure. Analysis of temperature and precipitation in the vicinity of Inuvik Mike Zubko Airport climate for a 50-year time horizon, to the year 2070, was completed as part of the preliminary design of the project.

Design storms were calculated at the airport for return periods of 2, 5, 10, 25, 50, and 100 years, with durations of 5, 15, 30, 60, 120, 720, and 1440 minutes using the IDF_CC Tool 4.0 and CanRCM4 simulations. IDF curves were developed for both historical and future periods and were fitted using the Generalized Extreme Value (GEV) distribution. Historical and future precipitation intensities for the Airport are shown in **Table 3-1** and **Table 3-2**, respectively.

Table 3-1 Historical (1976–2005) Precipitation Intensities (mm/hour) for Various Storm Durations and Selected Return Periods Based on ECCC Weather Station Data

	Return Period, T (years)					
Storm Duration (minutes)	**2**	**5**	**10**	**25**	**50**	**100**
5	24.60	42.65	58.61	84.91	110.09	141.15
15	14.31	25.49	36.44	56.27	77.04	104.73
30	9.21	15.87	22.68	35.54	49.54	68.85
60	6.32	10.15	13.79	20.20	26.73	35.24
120	4.22	6.74	9.09	13.16	17.26	22.53
720	1.38	2.07	2.61	3.41	4.08	4.84
1440	0.76	1.15	1.46	1.91	2.29	2.73

Table 3-2 Future (2056–2085) Precipitation Intensities (mm/hour) for Various Storm Durations and Selected Return Periods

	Return Period, T (years)					
Storm Duration (minutes)	**2**	**5**	**10**	**25**	**50**	**100**
5	33.50	57.02	79.75	114.88	148.78	196.45
15	19.48	33.75	48.80	74.08	101.42	139.05
30	12.56	20.99	30.20	46.03	63.91	88.09
60	8.61	13.55	18.62	26.77	35.43	47.99
120	5.76	9.01	12.30	17.53	22.99	30.92
720	1.89	2.82	3.61	4.70	5.72	6.89
1440	1.05	1.57	2.01	2.63	3.21	3.89

Precipitation intensities and frequency are projected to increase under future climate change conditions. The percent increase in precipitation intensity varies based on return period and duration with projected increases ranging from 30%-42%. For example, the historical 100-year return period (1% AEP) for a five-minute design storm is 141 mm/h, by 2070s the value is 196 mm/h, an increase of +39 %. The projected effects of climate change also show that a 100-year return period storm in the historical period (141.15 mm/h) may become a 50-year return period (2% AEP) storm (148.78 mm/h) in 2070s with the effects of climate change. This implies that the current drainage and stormwater management strategies and infrastructure at the Airport may not be effective or sustainable in a wetter and more extreme future horizon (2070s).

Additional details pertaining to the projected changes for temperature, precipitation and other hydrologic variables in the vicinity of Inuvik Mike Zubko Airport are provided in Associated's *Climate Baseline and Projections to Support Inuvik Mike Zubko Airport Civil Infrastructure Improvements* report dated March 2020 and Associated's *Hydrologic Variables for Drainage Design and Thermal Analysis at Inuvik Airport* technical memorandum dated April 8, 2020.

4 HYDROLOGICAL AND HYDRAULIC MODELLING

To assess the existing groundside drainage system and proposed airside drainage system at the airport we built a hydrologic and 1D hydraulic model of the study area in PCSWMM 7.4 Professional 2D software to represent the varying stormwater flow conditions. PCSWMM is a hydrologic / hydraulic routing modelling program developed by Computational Hydraulics International (CHI) which is based on the US EPA's SWMM 5 engine. The models utilize SWMM Version 5.0.013 – 5.1.015 and EPANET Version 2.00.12 – 2.2. This model incorporates the drainage design for both the Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension projects, due to the need for the drainage approaches to be consistent between the two projects as well as the interconnectivity between the design of the two projects. We developed models to assess existing conditions, future development conditions, and future development conditions with climate change.

4.1 Sub-Catchment Characteristics

We applied automated GIS algorithms to the GNWT's 2017 LiDAR surface data to delineate the sub-catchments. We generated stream lines, delineated catchments developed from the surface, and assembled sub-catchments based on the existing and proposed drainage infrastructure on the site, including the existing culverts below Taxiway C, Taxiway B, Taxiway D, the existing groundside ditches, the existing ditch around the east side of Taxiway E, and the proposed culvert below Taxiway A. GNWT's 2022 LiDAR surface data was used to delineate the sub-catchments south-west of the airport around the North Quarry, Main Quarry, and Dolomite Lake. **Map 4-1** shows the delineated sub-catchments.

Sub-catchments outside of the airport property have been modeled to represent the undisturbed land characterized by mossy ground with low brush and forest. Tetra Tech's *Supplementary Geotechnical Evaluation for Runway Extension, Inuvik, NT* (2016), indicates "the dominant subsurface soils are clay till and… claystone (shale) bedrock". Additionally, Tetra Tech's *Figure 2 Terrain Map* in the report shows the majority of surficial material within the area surrounding the proposed drainage paths to be composed of till (morainal deposit), fluvial deposit, or organic deposit.

Sub-catchment parameters including average slopes, Manning's Roughness coefficients for overland flow, depression storage, and Horton infiltration rates were estimated based on our interpretation of aerial imagery, background reports, and site visits. We reviewed CHI's "*Users Guide to SWMM 5*" (2020) and selected the sub-catchment model parameters based on standard values defined within the document which best reflect the site conditions, specifically slow draining clay soils with a cover of low brush and forest in naturalized areas and impervious coverage in developed areas. For the design event, we have considered that antecedent ground condition will be saturated. For smaller, more frequent rainfall events, we have considered the antecedent ground condition will be partially saturated. **Table 4-1** outlines key hydrologic sub-catchment parameters applied in the PCSWMM model.

Table 4-1 Model Hydrologic Parameters

Hydrologic Model Parameters	
Manning's Roughness Coefficient for Overland Flow	
Impervious Surface	0.013
Pervious Surface	0.24
Depression Storage	
Impervious Surface (mm)	1
Pervious Surface (mm)	5
Horton's Infiltration Parameters	
Maximum Infiltration Rate (mm/hr)	1.5 (saturated) 2.5 (partially saturated)
Minimum Infiltration Rate (mm/hr)	0.5
Decay Constant (h^{-1})	4

4.1.1 Existing Conditions

Sub-catchments within the airport property, both groundside and airside, have been modeled to represent the existing development conditions at the airport, as observed during site visits and observed in LiDAR and Orthoimages. Lots that are developed, both on groundside and airside, with roofs, roadways, and other impervious surfaces, will have approximately 70-90% effective impervious coverage. Under existing conditions, many of the sub-catchments are undeveloped with 0% impervious coverage.

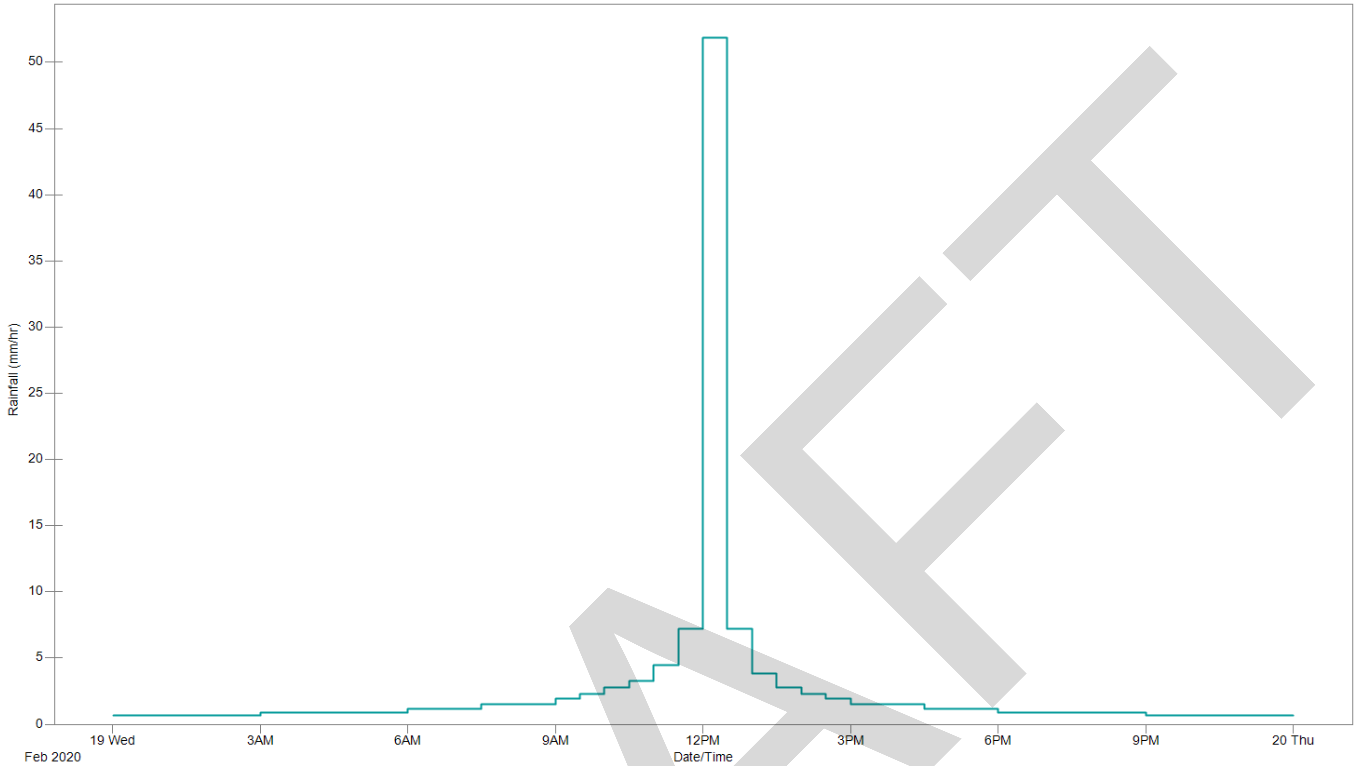
4.1.2 Future Development Conditions

Sub-catchments within the airport property, both groundside and airside, have been modeled to represent the future development conditions described in GNWT's *Inuvik Mike Zubko Airport Master Plan*, (Government of the Northwest Territories, Department of Transportation Airports Division, 2014). While the phasing of these developments is not fully defined at the time of writing this report, they are expected to be completed within a maximum long-term time horizon of 20 years. As the expected lifespan of the infrastructure included in this project is 50 years we have anticipated that Phase 1, Phase 2, and Phase 3 of the groundside development will be completed during the project lifespan. We estimate that development on these lots, such as roofs, roadways, and other impervious surfaces, will have approximately 70-90% impervious coverage, similar to existing development. The groundside developments will increase the impervious coverage at the airport. Additionally, there will be an increase in impervious coverage due to the Runway extension. We have not accounted for future development beyond that outlined within the Master Plan. While further development may occur in the long-term there is no information on which to develop drainage infrastructure contingency plans, and any impacts will need to be addressed at the time of those future activities. We note that care in drainage management planning and design will be necessary to properly manage stormwater from future developments given the hydrological and geological conditions in this area.

4.2 Design Rainfall Event

We developed design rainfall events for the 25-year return period (4% AEP) using the historic IDF data as well as the future projected climate data and IDF. A 24-hour All Duration Storm (ADS) was developed for the 25-year return period. The ADS distribution was selected as it is designed to inherently encompass several different storm durations with equivalent individual intensities centered around the peak of the storm. We reviewed the storm distributions with both a 30-minute duration at the peak intensity and a 60-minute duration at the peak intensity. The results of the 30-minute peak time step were almost identical to those of the 60-minute time step. Therefore, we modeled the design rainfall with a 30-minute peak intensity duration. The resulting 25-year return period 24-hour storm event developed from the IDF and applied to the model is presented in **Figure 4-1**.

Figure 4-1 25-Year All Duration Storm Distribution from Future IDF



We have also developed rainfall events for two higher-frequency rainfall events, the 2-year return period (50% AEP) and the 5-year return period (20% AEP). Both return periods were developed using the historic IDF as well as the future projected climate data and IDF. A 24-hour ADS was developed for the 2-year return period and the 5-year return period. The higher-frequency rainfall events were modelled with a 30-minute time step. These rainfall events are intended to provide a general understanding of the conditions associated with smaller more frequent events at the airport. **Table 4-2** compares the 24-hour ADS peak rainfall intensities for the 2-year, 5-year, and 25-year return periods for historic rainfall conditions and future rainfall conditions.

Table 4-2 24-hour Peak Rainfall Intensities

	2-Year (mm/hr)	5-Year (mm/hr)	25-Year (mm/hr)
Historic	9.72	16.55	31.29
Future	13.29	22.21	51.87

4.3 Hydrologic and Hydraulic Analysis

We estimated the 25-year peak flows for the airport's drainage system using the PCSWMM model. The peak flow is a function of the catchment length, catchment width, manning's roughness coefficient, and rainfall intensity. From the model results, we estimated the required culvert and ditch dimensions to safely convey the future flows experienced within the vicinity of the airside portion of the airport.

High runoff response is seen in the model. The runoff rates are an effect of the increase in impervious coverage associated with the groundside developments and the runway extension. The increase in impervious surface causes a more rapid collection and conveyance of runoff resulting in a large peak in runoff rates as precipitation intensity increases, thus increasing net runoff captured in the system, quicker collection of flows along the surface, and a more rapid conveyance of flows across the surface.

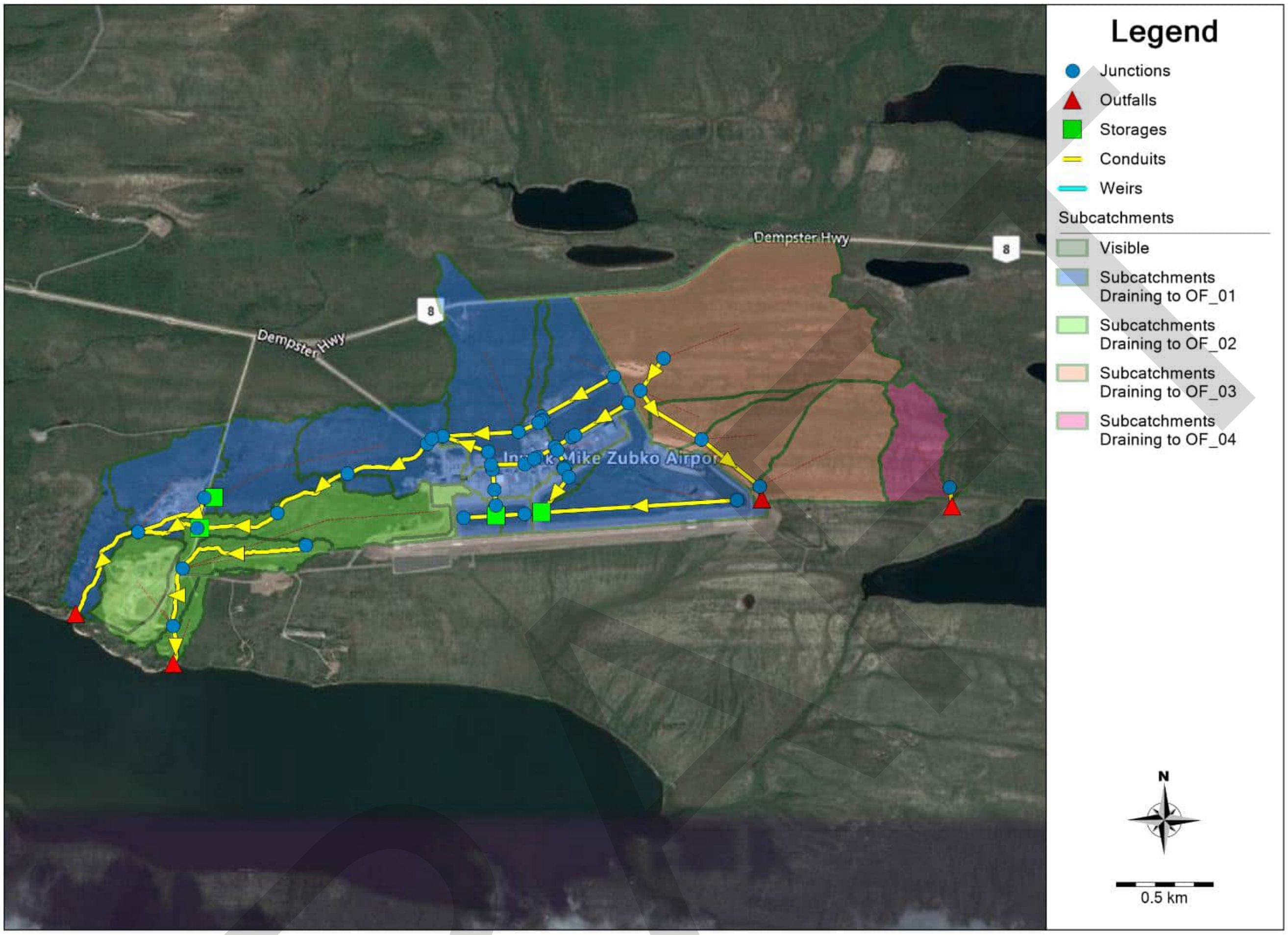
Initial analysis with the model with the existing culverts below Taxiway D and Taxiway C indicated that these existing culverts would be undersized for the future condition storm events. The Taxiway D culvert would be surcharged at the inlets with upstream ponding occurring within the infield area between Taxiway D and Taxiway E that would last for longer than 12 hours following the storm. The Taxiway C culvert would flood at the inlet in future conditions. In addition to being undersized for future conditions, the Taxiway D culvert appears to be damaged at the inlet and outlet, likely due to maintenance and snow and ice clearing. A formal condition assessment of the culvert has not been completed, however it is likely that the culvert would not be in a suitable condition to provide an effective drainage pathway for the remainder of the required lifespan. As such, both locations require adjustments to the drainage system, through realignment of the Taxiway C drainage and through upsizing of the Taxiway D culvert. **Map 4-2** shows the infrastructure modelled for the proposed design of the two projects.

4.3.1 Existing Conditions

The existing conditions model was built to reflect the existing drainage and surrounding natural drainage conditions at the Inuvik Airport. This model uses the historical rainfall conditions at the Inuvik Airport. The outfall locations and the sub-catchments that direct runoff to each outfall in the existing conditions can be seen in **Figure 4-2**. In the existing conditions model scenario the runoff is directed to three outflow locations:

- Through a natural drainage path west of the south quarry that ultimately drains to Dolomite Lake (OF_01),
- Through the ditch on the east side of the public road that drains to Dolomite Lake (OF_02),
- Through the natural drainage ditch east of the airport that drains around Runway 24 and then south to Dolomite Lake (OF_03),
- Directly into the 'east lake' (the unnamed lake located immediately east of the airport) (OF_04).

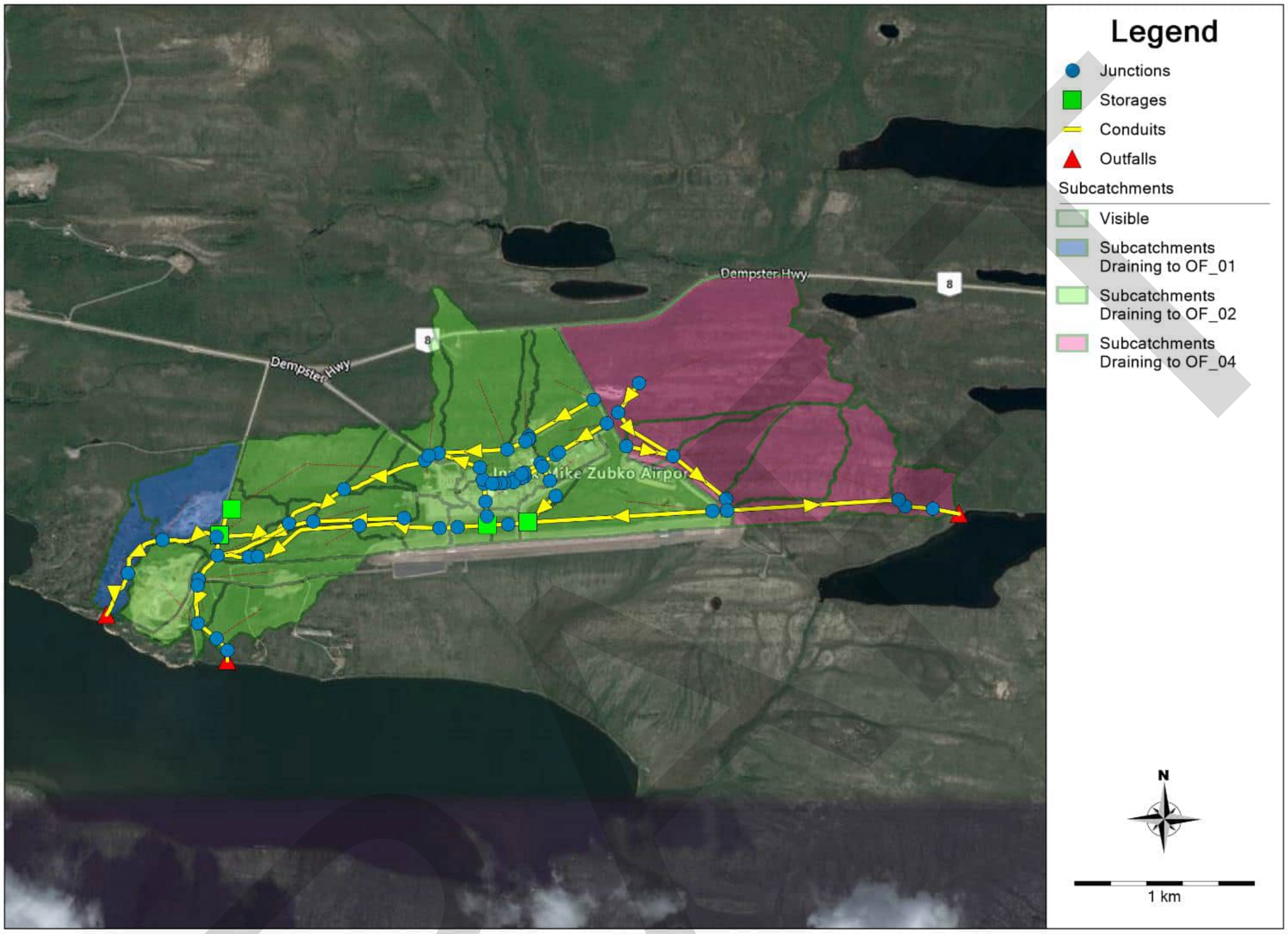
Figure 4-2 Existing Conditions Model Sub-catchments and Conduits



4.3.2 Future Development Conditions

The future development conditions model has been updated to reflect the anticipated future development conditions at the airport, as defined by the Government of Northwest Territories Department of Transportation Airport Division's *Inuvik Mike Zubko Airport Master Plan* (2014). The future conditions also reflect the proposed drainage system associated with this project at and around the airport. The drainage design alters the existing condition drainage routes at each of the outfall locations. This model uses the historical rainfall conditions at the Inuvik Airport. The outfall locations and the sub-catchments that direct runoff to each outfall in future conditions can be seen in **Figure 4-3**.

Figure 4-3 Future Development Conditions Model Sub-catchments and Conduits



The design of a new ditch along the public road diverts runoff from the west of the Airport and drainage from the groundside of the Airport away from the quarry drainage path (OF_01), where it flows in existing conditions by overtopping the public road. The public road ditch alignment flows towards Dolomite Lake (OF_02) on the east side of the public road. Therefore, in future conditions, the peak flow rate and runoff volume decrease at OF_01 and increase at OF_02 in the proposed condition.

The proposed condition also reroutes flows from the ditch which extends around Runway 24 towards Dolomite Lake (OF_03) towards the east lake (OF_04). We note that there is still runoff south of the runway that would drain to OF_03, however this has not been modelled in the future conditions, as the land and drainage south of the runway is not impacted by design.

The increase in impervious coverage due to future development at the airport results in concentration of surface runoff and a reduction of pervious area through which runoff can infiltrate. The impervious coverage leads to higher quantities of runoff and higher flows in the drainage system. A comparison of peak flow and runoff volume at each outfall during the existing conditions and future development conditions are shown in **Table 4-3**.

Outfall OF_02 experiences an approximate increase in peak flow of 5.2 m^3/s and an increase of approximately 71,200 m^3 in the total volume of runoff because of the improvements to the airport and the diversion of flow from the natural drainage path between the quarries to Outfall OF_01. Outfall OF_04 experiences an approximate increase in peak flow of 3.3 m^3/s and an increase of approximately 46,800 m^3 of runoff volume because of the diversion of runoff from the drainage ditch east of the airport around Runway 24 into the new east ditch which outfalls into east lake.

Table 4-3 Peak Flow and Total Runoff Volume at Outfalls (Existing / Future Development)

Outfall	Lake	Existing Conditions Peak Flow (m^3/s)	Future Conditions Peak Flow (m^3/s)	Change in Peak Flow (m^3/s)	Existing Conditions Runoff Volume (m^3)	Future Conditions Runoff Volume (m^3)	Change in Runoff Volume (m^3)
OF_01	Dolomite	2.8	1.7	-1.1	55,100	11,100	-44,000
OF_02	Dolomite	2.9	8.1	+5.2	23,700	94,900	+71,200
OF_03	Dolomite	3.3	0*	-3.3	42,900	0*	-42,900
OF_04	East	0.3	3.7	+3.3	4,800	51,600	+46,800
		Total Change in Peak Flow (m^3/s)		4.1	Total Change in Runoff Volume (m^3)		31,100

**Note that there would be runoff from the sub-catchments south of the airport which would still pass through OF_03 to Dolomite Lake, however this has not been included in the model as it is not specifically being modified by the design.*

4.3.3 Future Development Conditions with Climate Change

In the future development conditions with climate change model, the sub-catchments and drainage system are modeled in the same way as the future development conditions model, as seen in **Figure 4-3**. The rainfall data used for this model is the future precipitation intensities at the Inuvik Airport as discussed in **Section 3**.

Climate change further exacerbates the changes in peak flow and runoff volumes associated with development around the airport. A comparison of peak flow and runoff volume at each outfall during the future development conditions and the future development conditions with climate change are shown in **Table 4-4**.

Outfall OF_02 experiences an approximate increase in peak flow of 5.4 m^3/s and an increase of approximately 35,600 m^3 of runoff, resulting in an increase of 10.6 m^3/s and 106,800 m^3 when compared to the existing condition. Furthermore, climate change doubles the peak flow at OF_01 and OF_04 when compared to future development alone. When compared to the existing condition, climate changes increases the peak flow at OF_01 by 0.3 m^3/s but the rerouting of the upstream runoff from OF_01 to OF_02 decreases runoff volume by 39,600 m^3. At OF_04, climate change increases the peak flow by 3.7 m^3/s and runoff volume increases by 23,400 m^3.

Table 4-4 Peak Flow and Total Runoff Volume at Outfalls (Future Development / Future Development with Climate Change)

Outfall	Lake	Future Conditions Peak Flow (m^3/s)	Future Conditions with Climate Change Peak Flow (m^3/s)	Change in Peak Flow (m^3/s)	Future Conditions Runoff Volume (m^3)	Future Conditions with Climate Change Runoff Volume (m^3)	Change in Runoff Volume (m^3)
OF_01	Dolomite	1.7	3.1	+1.4	11,100	15,500	+4,400
OF_02	Dolomite	8.1	13.5	+5.4	94,900	130,500	+35,600
OF_03	Dolomite	0	0	0	0	0	0
OF_04	East	3.7	6.8	+3.1	51,600	75,000	+23,400
		Total Change in Peak Flow (m^3/s)		9.9	Total Change in Runoff Volume (m^3)		63,400

4.3.4 2-Year and 5-Year Return Period Events

The results of the 2-year (50% AEP) and 5-year (20% AEP) return period events are intended to provide context for the drainage response for events that will happen at a greater frequency than the design event. For the 2-year and 5-year return period events, we have considered that antecedent ground condition will be partially saturated. For more frequent, smaller events, the sub-catchments capacity for infiltration, depression storage, and impervious areas will have a greater influence on the peak flows and volumes at the system outfalls. However, similar to the design event, the increase in impervious areas in future conditions will result in greater volumes of runoff and concentrated peak flows from the developed sub-catchments. A summary of the 2-year return period event peak flows and volumes are shown in **Table 4-5**. A summary of the 5-year return period event peak flows and volumes are shown in **Table 4-6**.

Table 4-5 Q2 Peak Flow and Total Runoff Volume (Existing / Future Development / Future Development with Climate Change)

Outfall	Lake	Existing Conditions Peak Flow (m^3/s)	Future Conditions Peak Flow (m^3/s)	Future Conditions with Climate Change Peak Flow (m^3/s)	Existing Conditions Runoff Volume (m^3)	Future Conditions Runoff Volume (m^3)	Future Conditions with Climate Change Runoff Volume (m^3)
OF_01	Dolomite	0.3	0.2	0.4	8,800	2,000	4,000
OF_02	Dolomite	0.5	1.4	2.5	5,000	21,600	37,400

Outfall	Lake	Existing Conditions Peak Flow (m^3/s)	Future Conditions Peak Flow (m^3/s)	Future Conditions with Climate Change Peak Flow (m^3/s)	Existing Conditions Runoff Volume (m^3)	Future Conditions Runoff Volume (m^3)	Future Conditions with Climate Change Runoff Volume (m^3)
OF_03	Dolomite	0.2	0	0	4,600	0	0
OF_04	East	0.02	0.2	0.7	400	5,700	15,000

Table 4-6 Q5 Peak Flows (Existing / Future Development / Future Development with Climate Change)

Outfall	Lake	Existing Conditions Peak Flow (m^3/s)	Future Conditions Peak Flow (m^3/s)	Future Conditions with Climate Change Peak Flow (m^3/s)	Existing Conditions Runoff Volume (m^3)	Future Conditions Runoff Volume (m^3)	Future Conditions with Climate Change Runoff Volume (m^3)
OF_01	Dolomite	0.9	0.6	1.1	22,600	4,700	7,900
OF_02	Dolomite	1.1	3.3	5.4	10,500	43,200	69,000
OF_03	Dolomite	0.9	0	0	15,500	0	0
OF_04	East	0.07	1.0	2.2	1,600	18,700	34,800

5 SUMMARY OF PROPOSED DESIGN

The proposed drainage infrastructure for the two projects at the Inuvik Mike Zubko Airport consists of culverts and ditches. The overall design intent is to maintain positive drainage through the airport property. The original proposed realignment of the airside drainage system was developed to allow for a more effective network directed to the west which also facilitates inter-connection between the airport drainage proposed as part of the Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension projects respectively. The preliminary design development assumed the runway was to be developed using Option 3D, a 1500 ft runway extension on both Runway 06 and Runway 24 with a ditch around the east of Runway 24 with a connection to the airside drainage below Taxiway E, as outlined in Associated's *Runway 06-24 Extension Options Assessment* report dated August 2020.

Following discussions between GNWT and the construction Contractor, a decision was made by GNWT to change the routing of the drainage east of the airport so that it would flow into the east lake, rather than below Taxiway E and towards the west. This option was noted to be preferred by the Contractor as they think the construction of a 1300 m long, and up to 9 m deep ditch would be simpler and result in cost savings compared to the construction of a culvert below Taxiway E. The option of an eastward ditch was also assessed as part of the preliminary design development at the runway and was Option 1A, a 1300 m long ditch directed towards the east, extending past the runway and then southwards into the east lake, in Associated's *Runway 06-24 Extension Options Assessment* report. In our preliminary assessment this ditch was not preferred for the following reasons:

- The adversely graded ditch does not follow the natural flow path of the area which is directed towards the south-west,
- To accommodate the adverse grade a significant cut would be required to achieve the required ditch profile and grade,
- Geotechnical reviews had not confirmed if the ditch alignment crossed ice-rich areas,
- The depth of the ditch may reach bedrock in some areas, which is found at depths of 4 to 6 m in boreholes north of the runway extension, as noted by Tetra Tech in their *Supplementary Geotechnical Evaluation for Runway Extension, Inuvik, NT*. Report (2016a).
- To construct an outfall from the ditch into the lake a water license would be required,
- Sediment management and erosion protection may be required prior to the outlet into the east lake.

In the current design, the 1300 m long eastward ditch alignment is offset sufficiently from the runway so that it does not have any direct impact on the runway structure through disturbance of permafrost, and elimination of the proposed Taxiway E culvert avoids disturbance to the permafrost under Taxiway E and the potential long-term issues that could arise. As there is now no flow directed west under Taxiway E, the culverts below Taxiway A and Taxiway D can be reduced in diameter.

The eastward ditch has been reconfigured to drain to the east in response to the removal of the Taxiway E culvert from the design. Without a culvert under Taxiway E the only feasible routing of drainage is east and around the end of the runway extension. The eastward ditch is designed to provide conveyance capacity for the runoff from the design event. The ditch ties into the existing ditch along the east side of Taxiway E and then continues eastward on the north side of the Runway 24 extension. From there it will flow into the east lake, descending to the lake by following natural low points in the terrain. The alignment was optimized to reduce the cut volume and to reduce the area required for tree removal.

As part of the airport surface drainage function, it is essential to prevent the drainage system from adversely affecting the permafrost terrain surrounding and below the runway and taxiways. The drainage design directs surface runoff away from the runway structure and collects and conveys it a significant distance from the runway, to protect the permafrost sublayers. The drainage design focuses on preventing long-term ponding around the runway, which could impact the stability of runway structure and embankments as well as support facilities such as buildings.

The west ditch system is intended to improve drainage by reducing ponding around the airport. The reduction of ponding in the airport increases the amount of runoff leaving the site. The increased runoff is conveyed to the west until the ditch reaches the public road accessing Dolomite Lake, and then turns southward (and downslope) towards Dolomite Lake. The ditch follows an alignment away from the public road to avoid impacts to cabins located along the lake shore and reduce excavation volumes. The current routing follows a natural drainage path down to the lake.

A ditch extension runs northward from the point the west ditch reaches the public road, to provide drainage connectivity to low lying drainage paths to the north west of the airport, as shown in **Figure 4-2**.

The airport drainage, both groundside and airside, is currently directed under Airport Road and disperses into a large wet area northwest of the airport that ponds and overtops the public road near the entrance to the North Quarry. It has been anecdotally reported that the overtopping flows both into the quarries, and also along the public road. The approximately 275 m extension of the ditch towards the north is intended to capture runoff and ponding west of the airport, that is both from groundside drainage directed under Airport Road through the existing two offset 800 mm diameter CSP culverts and surface runoff from the sub-catchments west of the Inuvik Airport. The ditch will aid in reducing ponding in the sub-catchments immediately west of the airport and will mitigate overtopping of the public road in the design event.

Additionally, the redirection of flow and mitigation of flow overtopping the public road reduces the quantity of flow conveyed in the drainage channel between the North Quarry and the Main Quarry. This reduction may allow for greater expansion or a potential merge of the North and Main Quarries. A Stormwater Management Plan for the quarries is being developed as part of a separate scope of work for GNWT.

The updated detailed design progressed using a similar configuration as that assessed during the preliminary design development. **Table 5-1** summarizes the drainage infrastructure that is associated with the two airport projects.

Table 5-1 Proposed Airport Drainage Infrastructure

Project	Drainage Infrastructure
Inuvik Airport – Civil Infrastructure Improvements	Taxiway D Culvert
	Taxiway C Ditch
	Infield DE Ditch
	Infield AD Ditch
Inuvik Mike Zubko Airport Runway 06-24 Extension	Taxiway A Culvert
	East Runway Extension Ditch
	West Runway Extension Ditch
	Access Road Culvert
	South Access Road Culvert

5.1 Ditches

Ditches are proposed along the north edge of the Runway Safety Area (RSA) along the existing runway as well as the runway extensions. There are two ditch systems, one is the west ditch system which outlets into Dolomite Lake; the other is the east ditch system which outlets into the east lake.

The ditches have been designed to minimize the required excavation volume and exposed surface area of the ditches so as to protect the permafrost, while still maintaining sufficient hydraulic capacity for flow during future development and climate change conditions. The proposed ditches have not been sized to be used for snow storage or filled during normal snow-clearing activities.

5.1.1 The West Ditch

The west ditch conveys runoff from east to west beginning at the east end of Infield DE, below Taxiway D, Taxiway A, and extending west towards the public road, at which point the ditch alignment is redirected southwards to ultimately outlet into Dolomite Lake.

The ditch located in the infield area between Taxiway D and Taxiway E will be realigned to border the north edge of the RSA. The proposed ditch alignment will allow for positive drainage through the airside site which will aid in mitigating issues with ponding and infiltration of runoff through the base of the runway pavement structure. The existing ditch within the infield area will be retained and connected to the proposed ditch at a downstream location. The ditch extending from Taxiway C to Taxiway D will be regraded and realigned.

The ditch in the infield area between Taxiway A and Taxiway D will be regraded and will extend parallel to the northern RSA boundary to Taxiway A. The existing ditches and culverts in the infield area between Taxiway D and Taxiway A extending to the north of Taxiway B and the Apron will be retained as an overflow ditch that can provide relief in both directions for the connected airside and groundside drainage paths during times of high flows.

West of Taxiway A, a new ditch will be excavated along the Runway 06 extension. The ditch will be located between the access road and Runway 06. The ditch extends below the access road and will be directed southwards along the public road through the alignment of an existing drainage channel that outfalls into Dolomite lake.

5.1.2 The East Ditch

The east ditch ties into the existing ditch that was constructed east of Taxiway E. The tie in point will be on the north side of the Runway 24 extension. The ditch will extend east for the full length of the Runway 24 extension and will continue east past the Runway 24 Localizer. The ditch will extend along a low point in the topography until it drains into the east lake.

5.1.3 Groundside Ditches

The groundside areas of the airport are outside of the scope of the current project, however to reduce the required conveyance capacity of the airside culverts and ditches a groundside cut-off ditch extending past lot parcels F, G, E, and D, as outlined in the Inuvik Mike Zubko Airport Master Plan (Government of the Northwest Territories Department of Transportation Airports Division, 2014), has been assumed as part of the future development. Design and implementation of a groundside cutoff ditch is discussed further in **Section 6** Recommendations.

5.2 Erosion Control

Erosion control measures are proposed within the west ditch and east ditch to mitigate erosion potential and reduce velocities within the ditch systems before the outlet into Dolomite Lake and the east lake, respectively. The erosion control measures are in place to mitigate erosion on the banks of the ditches and subsequent transport of sediment into the two lakes where velocities are greater than 1 m/s.

We recommend that a 1M class / 10 kg riprap (350 mm nominal diameter) or 1 class / 25 kg riprap (450 mm nominal diameter) be used to protect the ditch from erosion during the future conditions 25-year return period storm event. However at this time GNWT considers the use of riprap to be cost prohibitive as it cannot be sourced locally. It has been requested that an alternative protective measure be used, therefore, we have proposed that 150 mm diameter and 250 mm screened rock be used to line the ditches as ditch armouring. This rock can be sourced with the other granular material used for the projects. In addition to the screened rock ditch armouring we have proposed that the ditch be hydroseeded with a short wild grass seed mix to provide additional protection to the ditch. We have proposed 250 mm screened rock ditch armouring to be placed for approximately 1000 m along the west ditch before the outfall to Dolomite Lake and for 150 mm ditch armouring to be placed for approximately 450 m along the east ditch before the outfall to the east lake. Ditch armouring has also been proposed in localized areas where there are more abrupt bends in the ditch alignment which would lead to impinging flows on the ditch banks.

We recommend that headwalls be placed at the inlets and outlets of culverts. However, concrete headwalls are considered by GNWT to be cost prohibitive as they cannot be sourced locally. Therefore, as an alternative we have proposed the use of a screened rock apron at the inlets and outlets of culverts, in the place of all headwalls. The screened rock apron will be a means to mitigate scour and erosion around the culvert inlets and outlets.

The screened rock ditch armouring and the screened rock aprons may not provide the same level of protection as a well-graded riprap or a concrete headwall would. As such, we recommend that regular maintenance and monitoring of the ditches be completed by GNWT to assess if there comes a time that further erosion control measures are needed. This is discussed further in **Section 6**.

In addition to the ditch armouring, we have proposed the use of gabion basket check dams along the west ditch to reduce the velocity and erosion potential in the channel where velocities are greater than 2 m/s and where the ditches terminate in advance of Dolomite Lake and the east lake. The gabion baskets have been designed to reduce local ditch velocities below 2 m/s. A gabion basket check dam consists of various sized rocks inside a 1.0 m high wire basket. The gabion baskets are situated to a height of 0.55 m above ditch grade. Gabion basket check dams were selected as an erosion control measure because they:

- resist movement on high slopes while requiring minimal maintenance;
- are fairly porous and free draining preventing failure due to frost heaving and hydrostatic pressure;
- create a pooling of flow behind the dam that allows for a settling of sediment and reduction of velocity.

Gabion basket check dams in the ditch will begin downstream of the proposed 1800 mm diameter circular culvert below the south access road and continuing south towards the outfall into Dolomite Lake. The gabion basket check dams are to be excavated 0.3 m into the existing terrain. The dams are to have a low flow channel constructed at the top, approximately 0.15 m deep, 2.0 m wide with 3H:1V side slopes to allow for major storm flows to pass over the dam. On the downstream side of the dam, we have a proposed a gabion mat splash pad excavated 0.3 m into the ground at ditch grade to provide energy dissipation for flow that overtops the dam.

Erosion control measures have not been proposed for the other ditches at this time. Further recommendations for erosion control measures are discussed in **Section 6**.

5.3 Culverts

Assessments completed at the onset of the project have shown that the existing drainage infrastructure within the airside portion of the airport does not meet capacity requirements under future development and climate conditions. To facilitate the westward drainage system an upgraded culvert has been proposed at Taxiway D. The proposed culvert below Taxiway D will be maintained at a similar alignment to the existing culverts to limit disturbance to the surrounding permafrost. A new culvert is proposed below Taxiway A to maintain a positive drainage path out of the airside grounds.

Due to the realignment of the drainage of the east side of the airport, a new culvert is no longer proposed below Taxiway E. An upgraded culvert was previously proposed at Taxiway C, however a decision was made to regrade the ditch north of Taxiway C to the groundside area of the airport, as it appeared that there was minimal flow through Taxiway C and anecdotal reports from GNWT stated that the existing culvert below Taxiway C does not currently convey significant flows. We recognize that there will be an increase in runoff towards this area in the future as the impacts of climate change increase the precipitation intensity and frequency experienced within the area. The future increase in runoff and flows will now flow into the groundside system. The existing Taxiway C culvert will be sealed and filled. Two culverts within the ditches upstream of the Taxiway C are proposed to be upsized as they do not have capacity to convey future flows and would cause flooding within the vicinity of Taxiway C. These culverts will now flow into the groundside ditches. The proposed culverts provide capacity to convey flows and meet the project design criteria.

We have proposed the use of spiral welded steel pipe (SWSP) at the taxiways which are considered to be critical locations where there is significant loading from aircraft and where future removal or replacement of the culvert would be a costly and difficult endeavor. The durability and strength of SWSP would reduce the potential for damage to the culverts due to equipment used for snow and ice removal and could withstand aircraft loadings. Corrugated Steel Pipe (CSP) has been proposed in less critical locations, such as driveway culverts, or culverts below maintenance roads, where replacement of culverts, if necessary due to external damage or corrosion, would be more feasible. CSP culverts will have headwalls located at the inlet and outlet. **Table 5-2** summarizes the culvert locations, diameters, and lengths proposed within the design.

Table 5-2 Proposed Culvert Dimensions

Location	Existing Diameter	Proposed Diameter	Proposed Length	Proposed Material
Taxiway D	600 mm	1219 mm (48")	115 m	SWSP
Taxiway A	N/A	1524 mm (60")	97 m	SWSP
Airport Access Road	N/A	1600 mm	49 m	CSP
Airport Access Road Entrance	Unknown	1800 mm	37 m	CSP
Taxiway C Ditch	600 mm	800 mm	20 m	CSP
Taxiway C Maintenance Road Driveway Culvert	600 mm	800 mm	12 m	CSP

Additional minor culverts, less than 1 m diameter and sized for the 25-year storm event, are located on roadways on the west side of the runway where the roadways have caused enclosed areas, creating pocket storage. The purpose of these culverts is to drain the enclosed areas that may fill like basins without an outlet.

5.4 Geotechnical Input

Golder Associates Ltd. (Golder) provided geotechnical design analysis and recommendations to the drainage design as part of the Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension projects. Recommendations for the drainage design at the Inuvik Airport are summarized in Golder's *Inuvik Airport – Civil Infrastructure Improvements and Inuvik Mike Zubko Airport Runway 06-24 Extension* Report dated March, 2021 and Golder's *Geotechnical Data Report, Civil Infrastructure Improvement and Runway Extension Project, Inuvik Mike Zubko Airport, Inuvik, Northwest Territories* Geotechnical Data Report dated December, 2020. The geotechnical reporting should be reviewed to understand the full context of the geotechnical analysis and recommendations associated with the drainage design.

These reports provide recommendations for the drainage design (including both a culvert at Taxiway E and Taxiway C that has since been removed from the design) and commentary on expected geotechnical conditions during the design life of the drainage system. The 4H:1V ditch side slopes have been proposed within the design based on geotechnical recommendation. Golder's reporting states "Given the reported adequate performance of ditches with 4H:1V side slopes [(e.g. east of Taxiway E)], we recommend a similar geometry for new ditches, recognizing that there will be areas where maintenance and reshaping may be required, especially within 2 to 7 years after construction as newly exposed permafrost thaws".

Golder provided additional recommendations for the management of the stormwater drainage system. These recommendations are referenced within **Section 6**.

6 STORMWATER MANAGEMENT

6.1 Maintenance

Regular maintenance will be critical to the success and function of the proposed drainage system. During the winter appropriate and thorough snow management practices will need to be undertaken to ensure that the drainage infrastructure is in functional condition, specifically before the spring melt, or freshet. Recommendations for maintenance of the airport drainage system were developed in concert with Golder.

Proper snow removal and storage practices are critical in maintenance activities to ensure the effective operation of the airport drainage system. Snow removal and storage recommendations are supported by the guidance and best practices outlined in *The Airport Drainage Guide* published by the GNWT Department of Transportation Airport Division (2017) and *Community drainage system planning, design, and maintenance in northern communities* published by CSA Group National Standard of Canada (2015). Inappropriate placement of snow stockpiles can cause drainage issues by blocking culverts or ditches, leading to ponding or saturated areas. Snow storage should be kept away from culvert inlets/outlets and ditches to reduce the risk of blockage. Snow and ice removal from culverts and ditches should aid in mitigating long-term ponding within the two infield areas, which will reduce attractants to wildlife such as birds.

Headwalls are recommended at the inlet and outlet of all CSP culverts, however as discussed in **Section 5** screened rock aprons have been proposed within the design as an alternative to headwalls. Screened rock aprons are also proposed at the inlet and outlet of all SWSP culverts. Regular vegetation removal at the inlets and outlets of all culverts should be completed to prevent debris buildup at the culvert inlets and minimize attractants for wildlife.

There is a significant risk of settlement on either side of the proposed culverts due to the organic soils and permafrost materials located below the proposed runway extension. The will likely require a risk allowance for future runway surface monitoring and maintenance with ongoing runway surface regrading and resurfacing on a regular basis.

6.1.1 Ditch Maintenance and Monitoring

Golder's *Geotechnical Data Report, Civil Infrastructure Improvement and Runway Extension Project, Inuvik Mike Zubko Airport, Inuvik, Northwest Territories* Geotechnical Data Report states that "there will be areas where maintenance and reshaping may be required [within the ditches], especially within the 2 to 7 years after construction as newly exposed permafrost thaws". Following construction, the airside ditches should be maintained regularly, following a maintenance plan. Additionally, the groundside ditches should be maintained and regraded, specifically the ditch which extends around the airport parking lot.

Monitoring practices will ensure that the ditches are functioning as intended, that minimum ditch grades are maintained, and that sediment and/or significant vegetation buildup does not cause ponding within the ditches. Ditch maintenance should be undertaken, at a minimum after spring freshet, following large storm events, and before yearly snowfall. Monitoring prior to winter snowfall will aid in mitigating erosion issues during the following season's freshet. Increased monitoring may be necessary during the freshet season, around May and June, as the melting of snow in the area and increase in precipitation in the form of rainfall may increase erosion potential in the ditches. Currently, at the Inuvik airport, slumping and vegetation overgrowth can be seen at many of the ditches. See **Figure 6-1** and **Figure 6-2**.

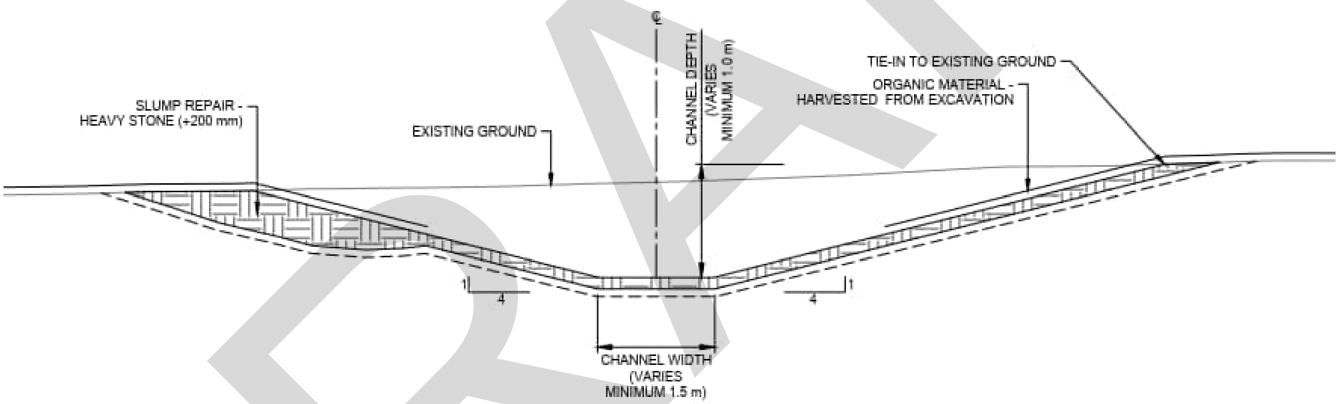
Figure 6-1 Ditch Slumping at Taxiway E Ditch

Figure 6-2 Vegetation Overgrowth at Infield Ditch

Erosion protection has not been proposed for most of the ditches at the airport. Golder states that "the [ditch] side slopes may slump or become irregular in shape". Ditches should be monitored regularly to check if slumping or erosion has occurred along the ditches, specifically after large storm events. Golder recommends that "where slumps develop, the slumped material should be removed and replaced with drained, fine-graded soil from common excavation, or alternatively coarse, angular stone (>200 mm) that does not require significant compaction when placed". If slumping or erosion has occurred, the following repair and protection options may be considered in addition to the recommendation noted above, and implemented based on the severity of observed erosion and ditch slumping:

- Ditch slump repair with heavy stone of 200+ mm nominal diameter with a thickness of 0.4 m to 0.5 m. See **Figure 6-3**.
- Hydroseeding using a short wild grass seed mix. (20% of each of Creeping Red Fescue, Rocky Mountain Fescue, Slender Wheatgrass, Violet Wheatgrass, Perennial Rye Grass)
- Screened Rock: 150 mm nominal diameter or 250 mm nominal diameter.
- Riprap: 10 kg or 25 kg.

Figure 6-3 Ditch Slump Repair



6.2 Snow Management

Snow clearing at the Inuvik Mike Zubko Airport is accomplished by plowing and blowing the snow beyond the edges of each cleared surface. The airport maintenance crews attempt to evenly distribute the snow to either side of the surface except for Taxiway C, where the majority of the snow must be blown to the south due to the proximity of the tenants on the north side of the taxiway.

Graded areas adjacent to the runway are maintained with 50 to 75 mm of compacted snow throughout the winter. The plows and snowblowers maintain this condition for two to three widths of the equipment beyond the airfield signs, and from there the snow is gradually tapered and increases in depth from the snow being blown by the equipment. There is no hauling and stockpiling of snow currently being performed at the Inuvik Mike Zubko Airport.

6.2.1 Future Considerations for Snow Management

Proper snow removal storage practices are both critical considerations in maintenance activities to ensure the proper operation of the airport drainage system. It is critical that snow clearing operations are undertaken to ensure that the drainage infrastructure is in functional condition before the spring melt, or freshet.

Detailed snow removal and storage practices are outlined in *The Airport Drainage Guide* published by the GNWT Department of Transportation Airport Division (2017) and *Community drainage system planning, design, and maintenance in northern communities* published by CSA Group National Standard of Canada (2015). A summary of the critical considerations can be found in Associated's *Preliminary Design Report* for the Inuvik Mike Zubko Airport Civil Infrastructure Improvements in **Section 3.7.3**.

The impacts and risks from snow clearing, storage, and runoff can be mitigated through the creation and implementation of a Snow Management Plan specific to the airport. The plan should include mapping which shows required clearing areas, acceptable/unacceptable storage areas, and all drainage infrastructure. Implementing a plan provides the following benefits:

- Meet safety, zoning, and aviation requirements regarding snow clearing and storage.
- Avoid negatively impacting the performance of the airport drainage system.
- Minimize snow removal operation and maintenance costs.
- Minimize on-site ponding due to snowmelt.
- Minimize damage to infrastructure from snow clearing activities.
- Mitigate impacts to the permafrost regime.

Clearing the snow from the graded areas promotes frost penetration, and it is recommended that the entirety of the flat graded areas is cleared to encourage airflow and natural snow removal. Formation of small berms might cause additional snow to accumulate and should be avoided.

We recommend that snow stockpile areas be maintained in areas outside of the existing drainage system. Anecdotal information received from GNWT indicates that the ditch north of Taxiway B located to the west of the Aklak Hangar is used as a snow stockpile area during the winter. Consequently, the culvert below Taxiway B becomes completely blocked with ice and acts as a barrier within the drainage system. We recommend the stockpiling practice within this ditch be eliminated as this ditch will provide an overflow path for groundside drainage into the infield area. This will help to mitigate future flooding of the groundside lease lots and groundside road.

As an alternate location for snow stockpiles, we recommend the north east area of the infield between Taxiway D and Taxiway E, along the edge of Taxiway C. As the west side of the infield area will be required for short-term stormwater storage, snow placed in that area would reduce the available storage which could potentially lead to flooding of the taxiways, the north east portion of the infield area is at a higher elevation with minimal function for stormwater storage and could be used as a snow stockpile location. Additional stockpile locations could be proposed outside of the airside area, however this would require longer hauls.

6.3 Additional Review and Recommendations for the Airport Drainage System

The drainage systems outside of the airside area are not within the scope of this project unless their upgrades directly benefit airside drainage. Further, Taxiway B and the Apron are not included within the scope of this project. However, our modelling of the airport's drainage system to the 50-year future time horizon indicates that much of the airport's existing groundside drainage infrastructure will be undersized for future development and future climate conditions. As such, where possible, we have incorporated potential future drainage upgrades in the groundside and airside areas which are out of scope so to provide recommendations for future analysis and upgrades in these areas. We recommend that further analysis be completed to assess and upgrade the following infrastructure:

- Culvert below Taxiway B
- Groundside road culverts
- Groundside road ditch systems
- Groundside ditch extending around the airport parking lot
- Culverts below Airport Road

6.3.1 Groundside Recommendations

The groundside areas of the airport are outside of the scope of the current project, however to reduce the required conveyance capacity of the airside culverts and ditches a groundside cut-off ditch extending past lot parcels F, G, E, and D, has been assumed as part of the future groundside development. This is consistent with what is seen at the existing groundside lots, which each have a ditch extending along the front of the lot.

We also understand from communications with GNWT and from field visits that much of the groundside drainage infrastructure is in poor condition, driveway culverts are crushed and damaged at both the inlets and outlets, ditches are poorly graded causing pooling and stagnant water, and flooding is not uncommon along the ditches on the north side of the existing groundside road.

To provide a reliable drainage system for the groundside area and reduce the runoff into the airside portion of the airport we recommend a defined drainage system be constructed in conjunction with future groundside land development. Should the groundside lots not be developed a ditch may still be needed to mitigate exceeding the airside drainage infrastructure's capacity.

The groundside drainage currently flows through the ditch that extends north-west around the airport parking lot and passes under Airport Road. Two offset 800 mm diameter CSP culverts currently exist at Airport Road. Preliminary modelling indicates that these culverts will be undersized for future development conditions and future climate conditions. A formal analysis and design should be completed to upsize the culverts.

The CSP culvert located at the groundside road, currently approximately 900 mm diameter, may need to be upsized to accommodate increased flows due to future development and future climate conditions. A formal assessment should be completed to determine the required culvert size to accommodate future conditions.

In addition to the groundside culverts, the groundside ditches should be assessed and possibly upsized and graded to accommodate future flows under combined future development and climate conditions.

6.3.2 Airside Recommendations

The 800 mm CSP culvert below Taxiway B and the ditches north of Taxiway B currently convey water from the infield areas north around the airport parking lot and towards the west. The drainage system planned as part of this current project will redirect drainage so that this is no longer the primary drainage path for the airport. We recommend that the existing ditches and culvert below Taxiway B be retained as an overflow path that can provide relief in either direction for the connected airside and groundside drainage paths during times of high flows.

Assessment of the existing conditions also indicate that the Taxiway B culvert is undersized for future development and climate change conditions. We recommend that further analysis be completed to assess the Taxiway B culvert so that it can be upsized to provide sufficient capacity to the system.

CERTIFICATION PAGE

This memo was prepared for the Government of Northwest Territories Department of Infrastructure to summarize the drainage design for the Inuvik Airport – Civil Infrastructure Improvements project.

The services provided by Associated Engineering (B.C.) Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,

Associated Engineering (B.C.) Ltd.
Engineers & Geoscientists BC Permit Number 1000163

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Enclosures:

- Figure 1-1: Study Area
- Figure 4-1: Sub-catchments
- Figure 4-2: Modelled Infrastructure

NO.	DATE	ENG	BY	SUBJECT

REVISIONS

Data Sources
1. Orthographic imagery courtesy of ESRI Satellite.
2. Existing, watercourse, waterbodies, and infrastructure shapefiles provided by the Government of Northwest Territories ATLAS.

Associated Engineering

Northwest Territories

Project No.	2020-2886-00
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Drawn:	S. HALEY
Approved:	M. MACLATCHY
Projection:	UTM ZONE 8N
Date:	2021/01/19

INUVIK AIRPORT - CIVIL INFRASTRUCTURE IMPROVEMENTS & INUVIK MIKE ZUBKO AIRPORT RUNWAY 06-24 EXTENSION

STUDY AREA

DRAWING	REV NO.	SHEET
MAP 1-1	A	

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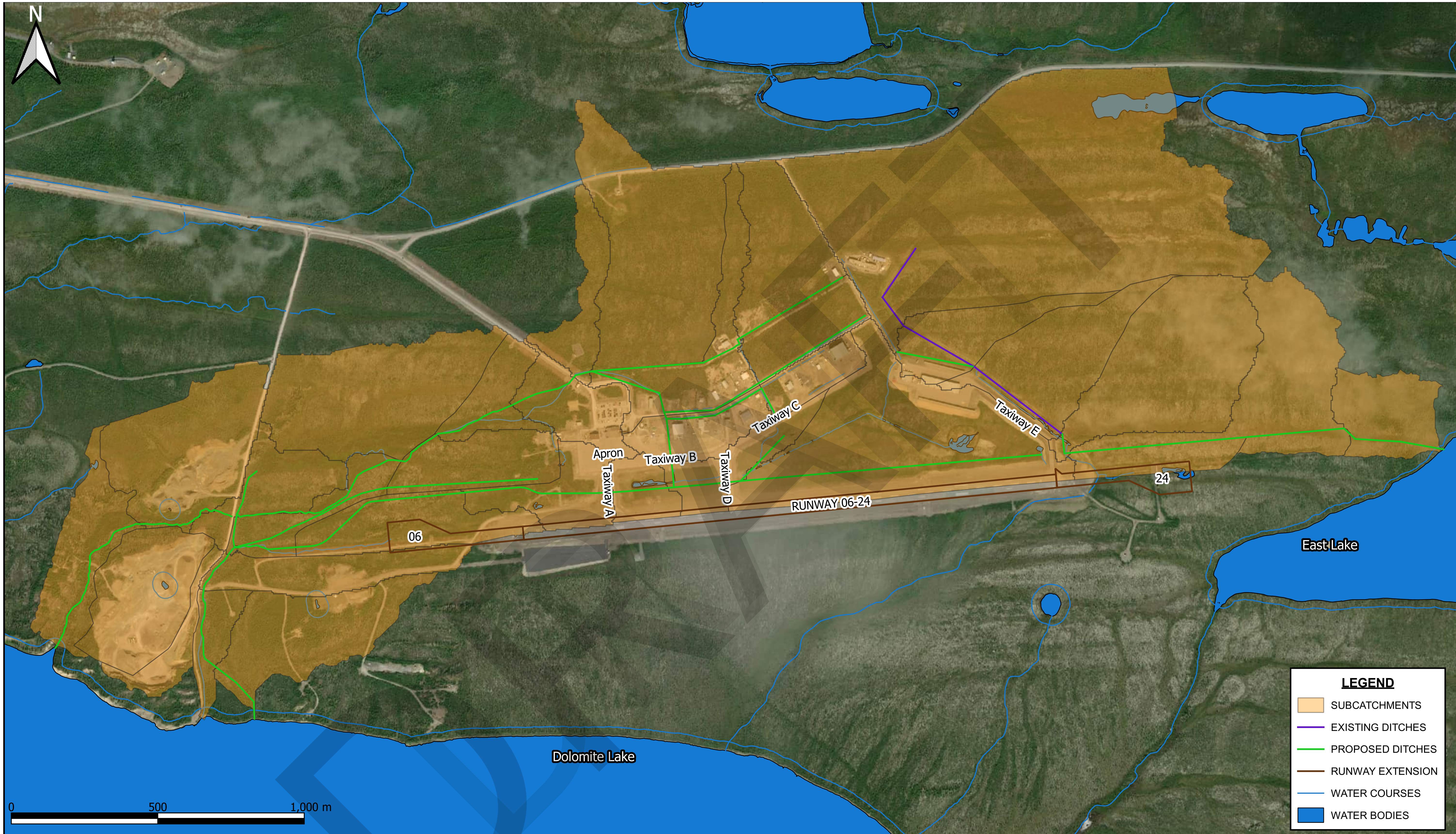

NO.	DATE	ENG	BY	SUBJECT

REVISIONS

Data Sources
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Associated Engineering

Government of Northwest Territories

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Date:	2023/01/24

INUVIK AIRPORT - CIVIL INFRASTRUCTURE IMPROVEMENTS & INUVIK MIKE ZUBKO AIRPORT RUNWAY 06-24 EXTENSION

SUB-CATCHMENTS

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REVISIONS

Data Sources
1. Orthographic imagery courtesy of ESRI Satellite.
2. Existing, watercourse, waterbodies, and infrastructure shapefiles provided by the Government of Northwest Territories ATLAS.

Associated Engineering

Government of Northwest Territories

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Scale:	1:12500
Drawn:	N. VAN DER MARK
Approved:	M. MACLATCHY
Projection:	UTM ZONE 8N
Date:	2023/01/24

INUVIK AIRPORT - CIVIL INFRASTRUCTURE IMPROVEMENTS & INUVIK MIKE ZUBKO AIRPORT RUNWAY 06-24 EXTENSION

MODELLED INFRASTRUCTURE

DRAWING	REV NO.	SHEET
MAP 4-2	B	

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