Hamlet of Kimmirut
Master Drainage Plan



PRESENTED TO

Department of Community and Government Services (CGS)
Government of Nunavut

FEBRUARY 21, 2020
ISSUED FOR USE
FILE: 704-TRN.WTRM03118-02

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
DEM	Digital Elevation Model
GIS	Geographic Information System
GPS	Global Positioning System
SWMM	Stormwater Management Model
AES	Atmospheric Environmental Service
GN	Government of Nunavut

LIMITATIONS OF REPORT

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1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by the Department of Community and Government Services (CGS), Government of Nunavut to develop a Master Drainage Plan (MDP) for the Hamlet of Kimmirut (Kimmirut). CGS and Kimmirut require that an MDP be conducted in Kimmirut, for both the existing town site and planned future subdivisions identified in the Community Plan.

The Terms of Reference (ToR) developed by CGS confirmed the fact that Kimmirut has in-force a Community Plan (By-law No. 127) and a Zoning By-law (By-law No. 128). These by-laws are due for a statutory five-year review sometime in 2019 or 2020. To make sure the community plans are developed in harmony with the local site drainage limitations, it was recommended that a complete review of the local drainage system be completed. In addition to a detailed review of the community plans and its impacts on the exiting stormwater system, CGS identified the need to review and evaluate the conditions of the existing drainage system. Based on anecdotal information and details provided by CGS, a number of pre-existing drainage issues are present within the existing townsite.

The 2016 census revealed the population of Kimmirut to be 389 persons (which is a decline from 455 persons in the 2011 census), distributed in 139 dwellings. Development of the community of Kimmirut is restricted by the topography of the land; as a result, any of the proposed subdivisions need to be constructed away from the core area of the community. In order to ensure that the Hamlet of Kimmirut has sufficient and suitable developable land to accommodate population growth forecast in the Community Plan, it is necessary that a qualified team of professionals complete a detailed drainage review of the potential development sites.

The drainage study has been staged in two phases. Tetra Tech's previous memo dated March 21, 2019 concluded the first phase which encompassed a review of all available background material, development of inputs to a hydrologic model, and development of the preliminary drainage recommendations.

The second phase of this project included the following tasks:

- Complete a site visit to Kimmirut by a team of water resource engineers to identify, assess, and document all drainage infrastructure and known drainage issues;
- Develop an inventory of existing drainage issues;
- Update the stormwater model to assess the drainage system for existing and proposed development conditions; and
- Complete the Kimmirut Master Drainage Plan.

2.0 REVIEW OF BACKGROUND INFORMATION

Tetra Tech collected, compiled and processed all information related to the drainage system of the Hamlet of Kimmirut, made available by officials from the Government of Nunavut and the Hamlet, and from publicly available reports and data.

The initial background review process provided Tetra Tech with an understanding the terrain, climate, long-term land-use plans, and known drainage issues in Kimmirut.

Reviewed background data has included the following:

- 2017 Satellite Imagery (.tif);
- 2017 Digital Elevation Models (Bare earth and surface models available in .tif and .asc formats);
- 2017 Building footprint, infrastructure, and transportation vector datasets (AutoCAD .dwg and ESRI File Geodatabase or Shapefile formats);
- 2017 Hydrology (water bodies and watercourses) vector datasets (AutoCAD .dwg and ESRI File Geodatabase and Shapefile formats);
- 2017 Contours vector datasets (AutoCAD .dwg and ESRI File Geodatabase and Shapefile formats);
- 2014 Community Plan and Community Plan By-law;
- 3vGeomatics 2016 ground movement report entitled: *Nunavut Terrain Analysis Final Report 2015-16*;
- Tetra Tech EBA 2015 geotechnical memo entitled: Desktop Geotechnical Evaluation for Duplex, Kimmirut, NU;
- National Topographic Survey (NTS) 1:50,000 Topography Map of Kimmirut;
- Google Earth 2016 Satellite Imagery;
- Historical climate data for Kimmirut, Cape Dorset, and Iqaluit Airports, monitored and made available by Environment Canada; and
- Online data sources (CBC news).

Additional anecdotal background information was collected through informal discussions with Hamlet staff and local residents during the 2019 field visit.

2.1 Community Plan, Population and Expansion Plans (Land Use)

The Government of Nunavut CGS division maintain and regularly update community plan maps for each community within the Territory. The purpose of these community plans are to outline Council's policies for managing the physical development of each Hamlet for the next 20 years. The community plan for the Hamlet of Kimmirut was updated in 2014 (included as Appendix B).

The community plan includes existing land parcels as well as proposed parcels of land allocated for future community growth. This combination of existing and proposed development forms the scope of our Master Drainage Plan, which aims to provide feedback not only on how to improve the existing drainage system, but also prescribe how the drainage features of the future area should be designed.

Based on discussions with CGS staff we understand that multiple changes have been made to the plan since its 2014 publication. These changes primarily relate to the location of lots for future development and are reflected in the 2019 update of the community plan. The results of this community drainage study should be incorporated within the same 2019 community plan update.

Through the development of this report, Tetra Tech has identified sections of the community plan which should not be developed. Instead, Tetra Tech is recommending that CGS consider revising the community plan so to develop a plan which is less prone to drainage issues. For consideration, Appendix B includes a revised community plan.

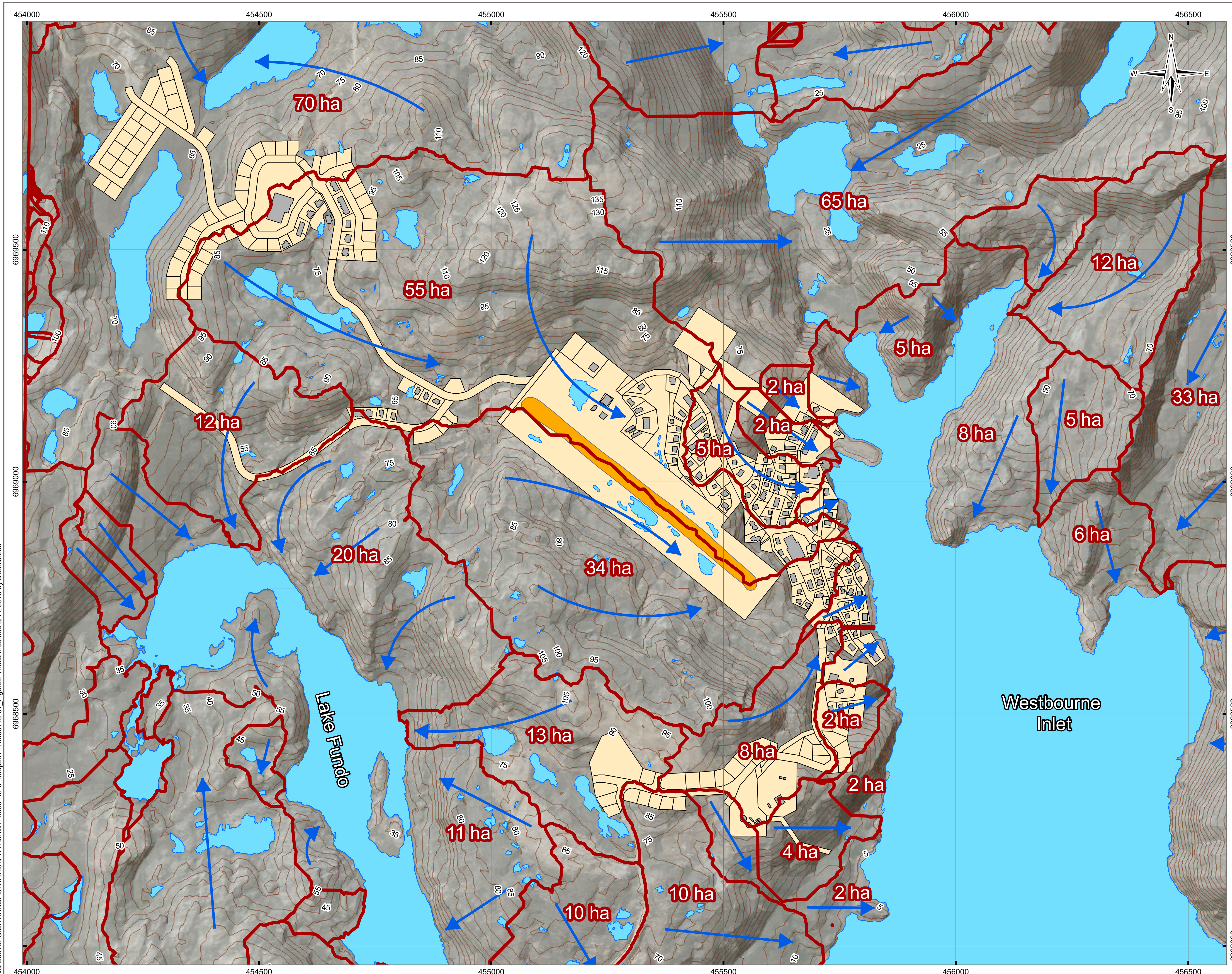
2.2 Terrain

The Hamlet of Kimmirut is founded upon undulating bedrock on the southern coast of Baffin Island. The community itself is situated on the shores of Glasgow Inlet, set in a valley created by bedrock ridges rising over 100 metres in elevation to the northwest and southwest.

2.2.1 Topography and Watershed Delineation

A Digital Elevation Model (DEM) of the Kimmirut area was developed to represent the topography of the project area. The DEM was derived from aerial photographs used to extract elevation information through a technique called photogrammetry. The use of measurements from photographs is of sufficient accuracy for use within a drainage planning exercise.

Tetra Tech has reviewed this DEM in conjunction with NTS 1:50,000 topography maps of the area and has performed a watershed delineation analysis to identify drainage patterns in the Kimmirut area. The existing drainage patterns are presented in Figure 2-1, and were confirmed during the 2019 freshet field visit. Note that several paths are impacted by the presence of other surficial obstructions such as buildings and conveyance systems such as culverts and ditches.



LEGEND

- Flow Direction
- Watershed (Area labeled in ha)
- Water Body
- Building Footprint
- Runway
- Parcel
- Contour (5m)

NOTES
Base data source:
Imagery from ESRI Basemap Gallery, 2017

STATUS
ISSUED FOR USE

KIMMIRUT DRAINAGE PLAN

Watershed Delineation

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:8,000
100 50 0 100
Meters

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Figure 2-1

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2.2.2 Surficial and Subsurface Geology

Based on investigation conducted by Tetra Tech, bedrock is exposed throughout the Kimmirut region. The surficial vegetation in the area is sparse and treeless. The region's terrain is characterized as tundra, and the soil is locked in permafrost apart from a thin surficial layer that thaws during the summer months (Kikkert, 2019). The area is assumed to have very low permeability, producing low infiltration rates and high runoff rates.

2.2.3 Land Stability

3VGeomatics completed a terrain analysis of the Kimmirut area in 2015 using Synthetic Aperture Radar to determine landmasses prone to movement. The project was undertaken in order to identify areas in the Kimmirut area suitable for development.

The results of their analysis concluded that displacement is expected to occur predominantly on steep sided slopes and scattered small pockets located in flatter areas. Almost all existing buildings are located on suitable terrain with little expected ground movement; however, we note that the proposed expansion of Kimmirut, as outlined in the 2014 Community Plan, does overlap portions of terrain which 3VGeomatics has flagged as being unsuitable or only marginally suitable for development. Further site inspection of these lots will need to be conducted to determine if they will be developed. Tetra Tech recommends that the 2019/2020 update of the Kimmirut Community Plan will include a revised layout to account for the recommendations proposed by 3VGeomatics.

2.3 Climate

The climate in Kimmirut is typical of the sub-arctic region, characterized by low precipitation and winter temperatures predominating for eight months of the year (Beckstead, G. & L.B. Smith 1985). Using data from Atlas Canada (The Prairie Climate Centre, 2019), Figure 2-2 shows the climate normals for the period between 1976 and 2005. The average daily maximum, mean, and minimum temperatures in February are -21.5°C, -25.1°C, and -28.8°C respectively. The same temperatures in July are 10.6°C, 6.9°C, and 3.2°C respectively. The annual mean daily temperature is -8.8°C. Extreme maximum and minimum temperatures are 25.5°C and -43.0°C respectively. The annual average warmest maximum temperature is 17.4°C and the annual average coolest minimum temperature is -39.0°C. Total annual precipitation is 422 mm (The Prairie Climate Centre, 2019). The maximum daily rainfall on record is 35 mm, which occurred on August 16, 2004.

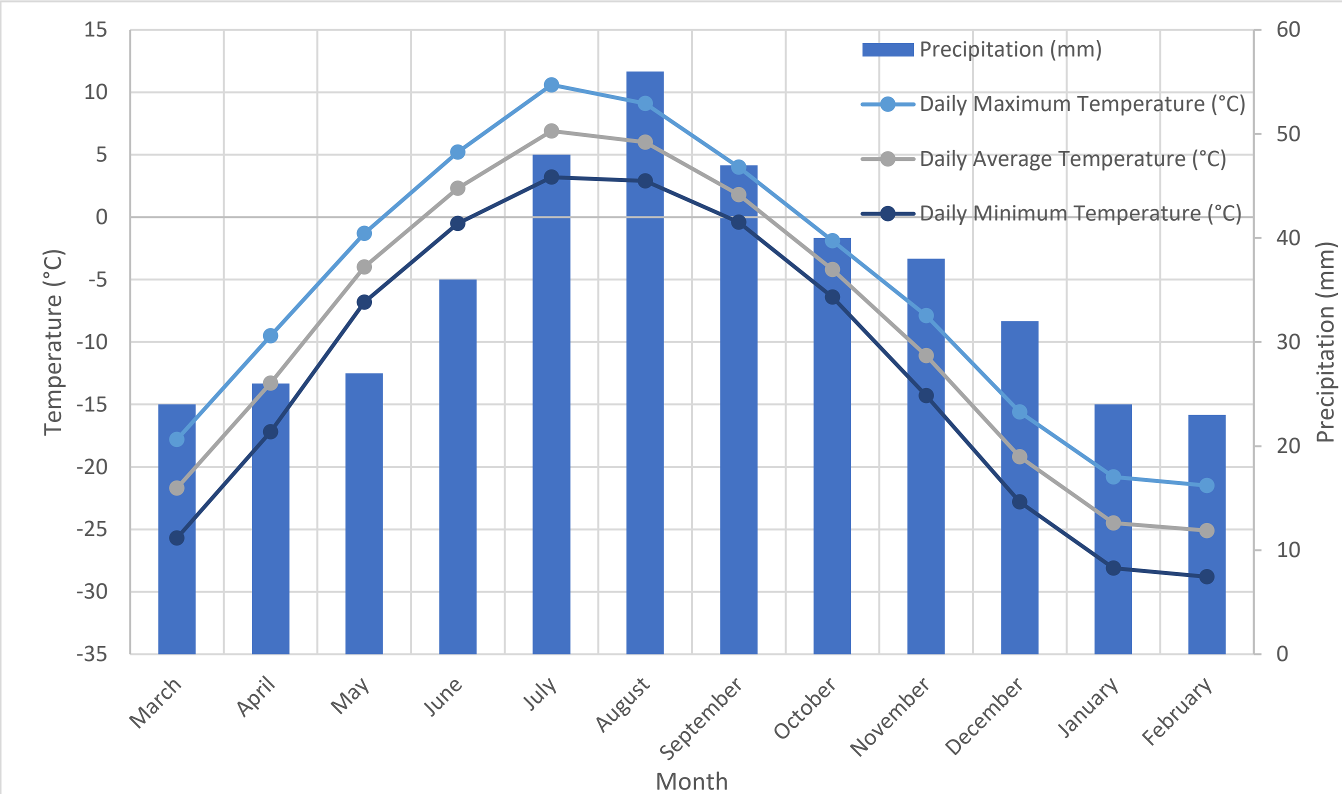


Figure 2-2: Average Temperature and Precipitation (1976-2005). Kimmirut

2.3.1 Climate Change

Due to limited climate change research available for the region covering the Hamlet of Kimmirut, relevant findings from Lewis and Miller's "*Climate Change Adaptation Action Plan for Iqaluit"* (2010) was utilized for this section of the report. Lewis and Miller (2010) presented a summary of perceived sensitivities to climate change in Iqaluit, including the following:

Infrastructure

1. *Damage to infrastructure is expected to increase due to increases in climate variability and extreme events.*
2. *A decrease in the permafrost layer was identified as the most significant climate-related concern for infrastructure.*
3. *The following may be particularly at risk: buildings with shallow foundations; buildings, roads and buried pipes along steep south facing slopes and/or in areas of high snow accumulation; any building or road in areas of poor drainage where water may pool.*
4. *The following infrastructure may be vulnerable to other climate change impacts: buildings or piping in poor condition due to age, absence of regular maintenance, outdated design or over-extended use; infrastructure located along the coast which may be susceptible to damage from flooding or storm surges; the drainage system which may be impacted by changes in precipitation; and the City's water supply.*

5. *All new municipal infrastructure shall be designed and constructed to specifications that withstand projected changes in climate over their expected design life and meet sustainable development standards.*

6. *City outfalls should be designed to fall outside the range in tidal variability.*

Buildings

1. *With an increase of the active layer of permafrost, many existing building foundations could experience structural damage.*

2. *With a change in weather patterns such as extreme storm events, more extreme temperature variations, increased humidity in snow and more rain, buildings will be more susceptible to weathering and moisture damage.*

3. *Some waterfront buildings are vulnerable to flooding at extreme high tides or under storm surge conditions and minimum foundation levels may need to be established.*

Water Supply System

1. *Changes in permafrost will have implications for both existing and new underground piping.*

2. *Warmer air temperatures could cause surface evaporation of the City's water supply and could eventually reach temperatures that allow algae and other micro-organisms to grow, thereby compromising water quality.*

3. *Increased rainfall could potentially put the municipal water supply at risk by washing contaminants and soil into the reservoir.*

Wastewater Treatment System

1. *Increased precipitation, in the form of heavy rainfall, could overwhelm the system and cause failure or overflow, which could contaminate adjacent water bodies.*

Waste Disposal System

1. *Increase in the active layer of permafrost could lead to changes the freeze-thaw cycle, drainage and water flow around the landfill. Design and operation of the landfill needs to take this into consideration.*

2.3.1.1 Short Duration Rainfall Events

Regarding climate change effects on short duration rainfall events, IDF_CC Online Tool v3.5 developed by Western University (Simonovic, Schardong, Gaur, & Sandink, 2018) provides projected rainfall intensity-duration-frequency (IDF) data under climate change. The IDF curves are calculated using historical data combined with data from Global Circulation Models (GCM) projected from 2050 to 2100. The tabular data is listed in Table 2-1. Detailed hydrological modelling of Kimmirut was conducted based on these climate change adjusted rainfall volumes.

Table 2-1: Projected IDF at Kimmirut (Ungauged Location, Total mm)

T (years)	2	5	10	25	50	100
5 min	1.31	1.89	2.42	3.36	4.24	5.16
10 min	1.92	2.95	4.02	6.20	8.53	11.38
15 min	2.62	4.07	5.52	8.32	11.17	14.36
30 min	4.68	6.73	8.32	10.81	12.75	14.36
1 h	7.21	9.90	12.32	16.65	20.60	24.64
2 h	11.12	14.53	17.48	22.60	27.05	31.31
6 h	21.50	28.46	32.89	38.76	42.28	43.89
12 h	30.91	40.46	45.76	52.11	55.29	39.79
24 h	37.50	49.75	56.42	64.42	68.54	69.44

2.3.1.2 Kimmirut Regional Climate Projections

Atlas Canada (The Prairie Climate Centre, 2019) climate change projections were analysed for the region surrounding the Hamlet of Kimmirut. Atlas Canada projects changes over the 30-year time periods of 1976-2005 and 2021-2050 for the RCP8.5 climate change scenario. Between these two time periods, the annual mean temperature is expected to increase by 2.8 °C from -8.8 °C to -6.0 °C. Annual precipitation is expected to increase by 12 percent from 422 mm to 472 mm. The maximum 1-day precipitation is expected to increase by 14 percent from 18 mm to 20 mm between the same time periods. Seasonal mean temperature and precipitation projections are shown in Table 2-2 below.

Table 2-2: Atlas Canada RCP8.5 Climate Change Projections

Metric	Projected Increase	1976-2005 Mean Value	2021-2050 Mean Value	Unit
Spring Mean Temperature	2.2 °C	-13	-10.7	°C
Summer Mean Temperature	1.6 °C	5.1	6.7	°C
Fall Mean Temperature	2.3 °C	-4.5	-2.1	°C
Winter Mean Temperature	4.7 °C	-22.9	-18.2	°C
Spring Precipitation	9 %	77	84	mm
Summer Precipitation	9 %	141	153	mm
Fall Precipitation	11 %	125	139	mm
Winter Precipitation	21 %	79	96	mm
Maximum 1-Day Precipitation	14 %	18	20	mm

As a result of the projected increase in spring temperatures for the 2021-2050 time period, the timing of the spring snowmelt event is expected to occur approximately 6 days earlier in the spring season. The timing of the start of snowfall in the fall season is expected to be delayed by approximately 10 days compared to the 1976-2005 time period due to the projected increase in fall temperatures.

As a result of the projected change in spring melt and fall freeze dates, the duration of winter is expected to decrease for the 2021-2050 time period by approximately 16 days. Due to the expected shorter winter duration, an approximate 8% reduction in precipitation as snowfall is estimated; conversely, as a result of the projected monthly precipitation increases, snowfall in the Kimmirut area is expected to increase by approximately 11%. The combined net effect of a shorter winter and the increase in precipitation is estimated to result in a 3% increase in annual snowfall for the 2021-2050 time period.

In the spring, despite the timing of the freshet being expected earlier, the 2021-2050 warming rate is projected to be very similar to the average warming rate on record in the 1976-2005 time period. A projected precipitation increase of approximately 0.1 mm per day during the spring snowmelt period results in an estimated increase of approximately 1 to 3 mm of rainfall during the spring snowmelt period. Therefore Tetra Tech estimates the springtime snowmelt runoff rates for the 2021-2050 time period to increase by a marginal amount.

During the part of the year when temperatures in Kimmirut are above-freezing, an increase of approximately 10% rainfall, from 195 mm to 214 mm is projected for the 2021-2050 time period. Due to the projected increased rainfall, larger and more severe summer precipitation events are expected for the Kimmirut region in the 2021-2050 time period. Figures 2-3 and 2-4 below show the Atlas Canada temperature and precipitation projections discussed in this section.

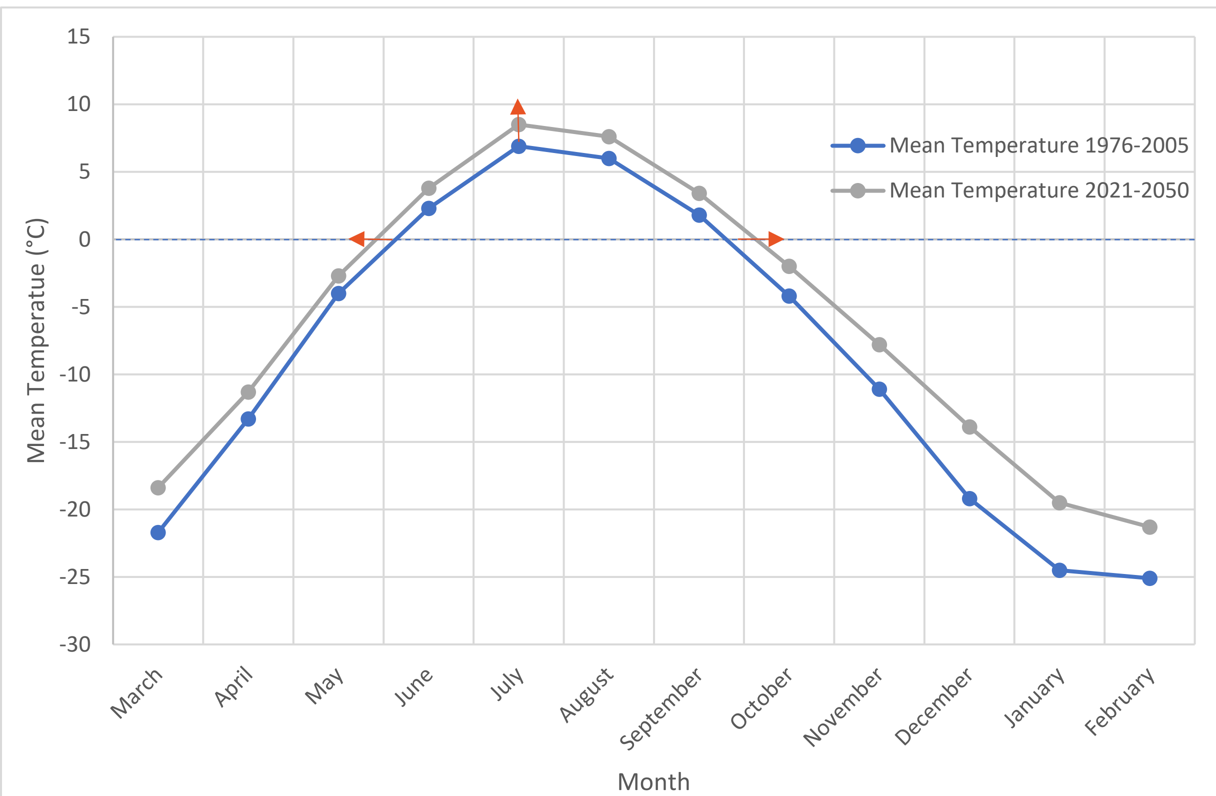


Figure 2-1: Atlas Canada Projected Monthly Mean Temperature

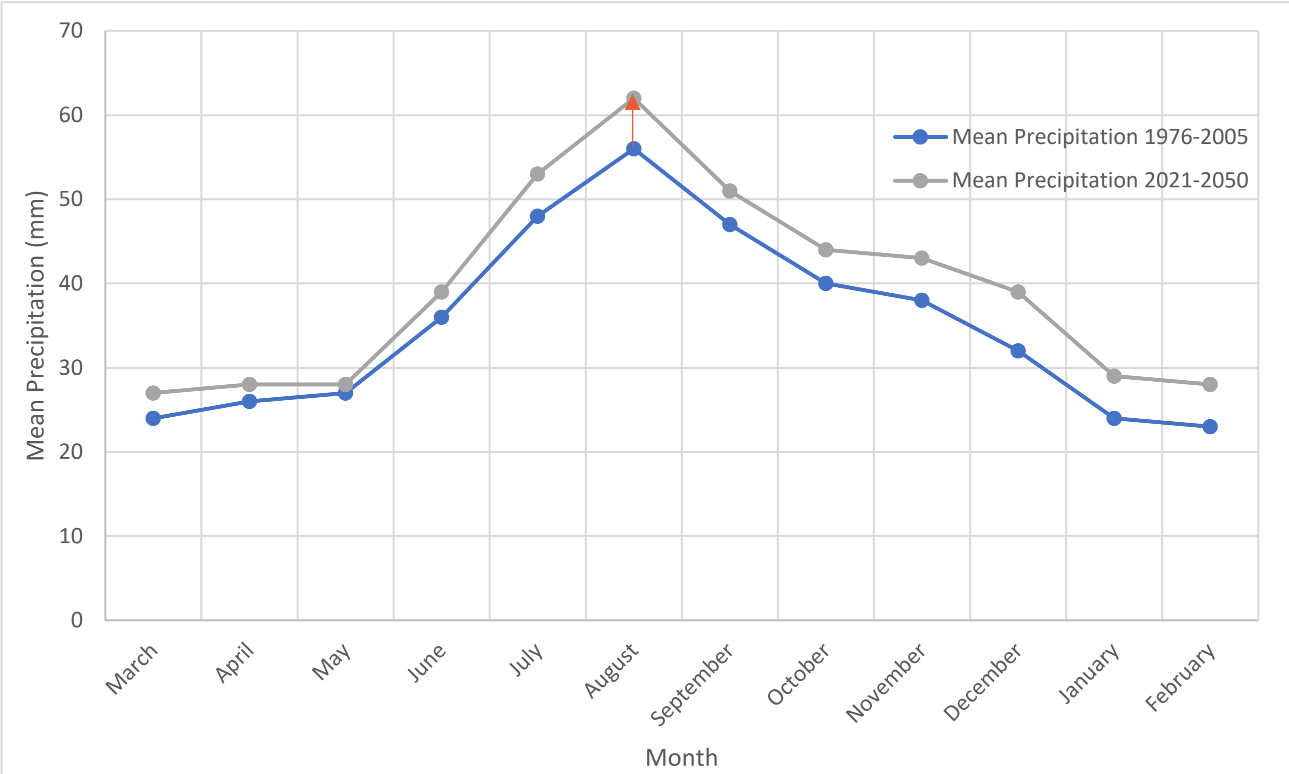


Figure 2-2: Atlas Canada Projected Monthly Mean Precipitation

3.0 INVENTORY OF EXISTING DRAINAGE SYSTEM AND ISSUES

A critical task in the development of a Drainage Master Plan is to identify, assess, and log all critical drainage infrastructure and known deficiencies. This process included the location and description of the physical assets that compose the drainage system, including key geometric characteristics and conditions. Using field and desktop data, this information was used to build a georeferenced map of the drainage system. The inventory also includes the location and description of existing issues such as ponding and damaged culverts. The following sections describe the activities conducted during the site visit, and the development of the georeferenced map of the drainage system.

3.1 Site Visit

A site visit was conducted from May 29-30, 2019 by two Tetra Tech staff, Mark Aylward-Nally and David Moschini. The purpose of the site visit was to:

- Discuss ongoing drainage issues and maintenance practices with the Kimmirut foreman, Miki Lyta;
- Conduct a walkthrough inspection of the drainage system of the Hamlet; and
- Conduct informal interviews with local residents regarding known drainage issues.

3.1.1 Walkthrough Inspection

A walkthrough of Kimmirut was conducted from May 29 to May 30, 2019. The objective of the site visit was to:

- Develop an understanding of the drainage patterns through the town;
- Identify main drainage routes and key infrastructure assets;
- Get GPS points of key infrastructure locations, for instance upstream and downstream culvert ends;
- Measure culvert dimensions and document culvert conditions;
- Identify areas of ponding;
- Record a photo inventory of key elements of the drainage system;
- Identify drainage outlet locations; and
- Conduct Informal Interviews with Hamlet residents.

Based on the walkthrough inspection, Tetra Tech has observed the following:

1. Aside from the main drainage corridor within Kimmirut (which runs from the arena, past the airport, and through town) the remainder of the Hamlet is lacking a formal drainage system.
2. This remaining area is plagued by nuisance ponding, roadway rutting, and has the potential for roadway washouts during heavy rainfall events or snowpack years.

Photographs of the existing system components and their condition are included in Appendix E.

3.1.2 Development of the Georeferenced Map

Using the GPS points, field notes and photographs obtained during the site visit, the topology of the drainage network was put together in a GIS shapefile. The shapefile includes locations of open channels (ditch or swale) or culverts. A naming convention was developed and every asset was named in the shapefile. Connectivity of the drainage system was developed using data from the site visit, and supplemented by mapping data provided by the government. A separate shapefile was created to mark areas with drainage issues identified during the site visit. The drainage issues identified included ponding areas, damaged culverts, uncontrolled overland flow and erosion issues. Figures 3-2 to 3-5 in Section 3.4 highlight the documented drainage issues.

3.2 Drainage

The drainage patterns of the Hamlet of Kimmirut follow the natural relief, however the construction of fill pads for buildings and road embankments have modified the natural drainage trends, leading to an increase in surface runoff volume and peak flows. The majority of runoff passing through the community is confined to a single watercourse, with its headwaters located within the ridges which flank the community. Runoff from these ridges collects in a channel alongside the airstrip before flowing east through the community and into Glasgow Inlet. It is this watercourse which endured a flash flood during the 2012 freshet, flooding a home just east of the airstrip. We estimate this watercourse to have a watershed area of approximately 89 hectares at its confluence with the inlet.

Tetra Tech have completed a delineation of the existing drainage patterns within Kimmirut using the 2015 Aerial Photograph derived DEM as well as from observations and photographs collected during the site visit. Drainage areas and flow paths are presented on Figure 2-1 in Section 2.2.1.

Land allocated for future expansion of the community is located up the valley to the northwest based on the 2014 Community Plan. These lots are located at a local high point and are anticipated to drain in a variety of directions, including into Lake Fundo and Soper Lake. Developing drainage paths and proposed drainage infrastructure for these future development areas is included within the scope of the Master Drainage Plan.

3.3 Drainage Infrastructure

During the 2019 freshet site visit, existing ditches, swales, and natural streams were observed. Additionally, 32 culverts were assessed. The diameter of the culverts ranged from 300 mm to 1200 mm, with the majority having a diameter of 500 mm or 600 mm. Most of the culverts were damaged or partially or fully buried, and some were more functional than others. An Inventory of Existing Culverts is included in Appendix E. Naturally formed swales and streams were observed throughout the community including few formal ditches.

3.4 Drainage Issues

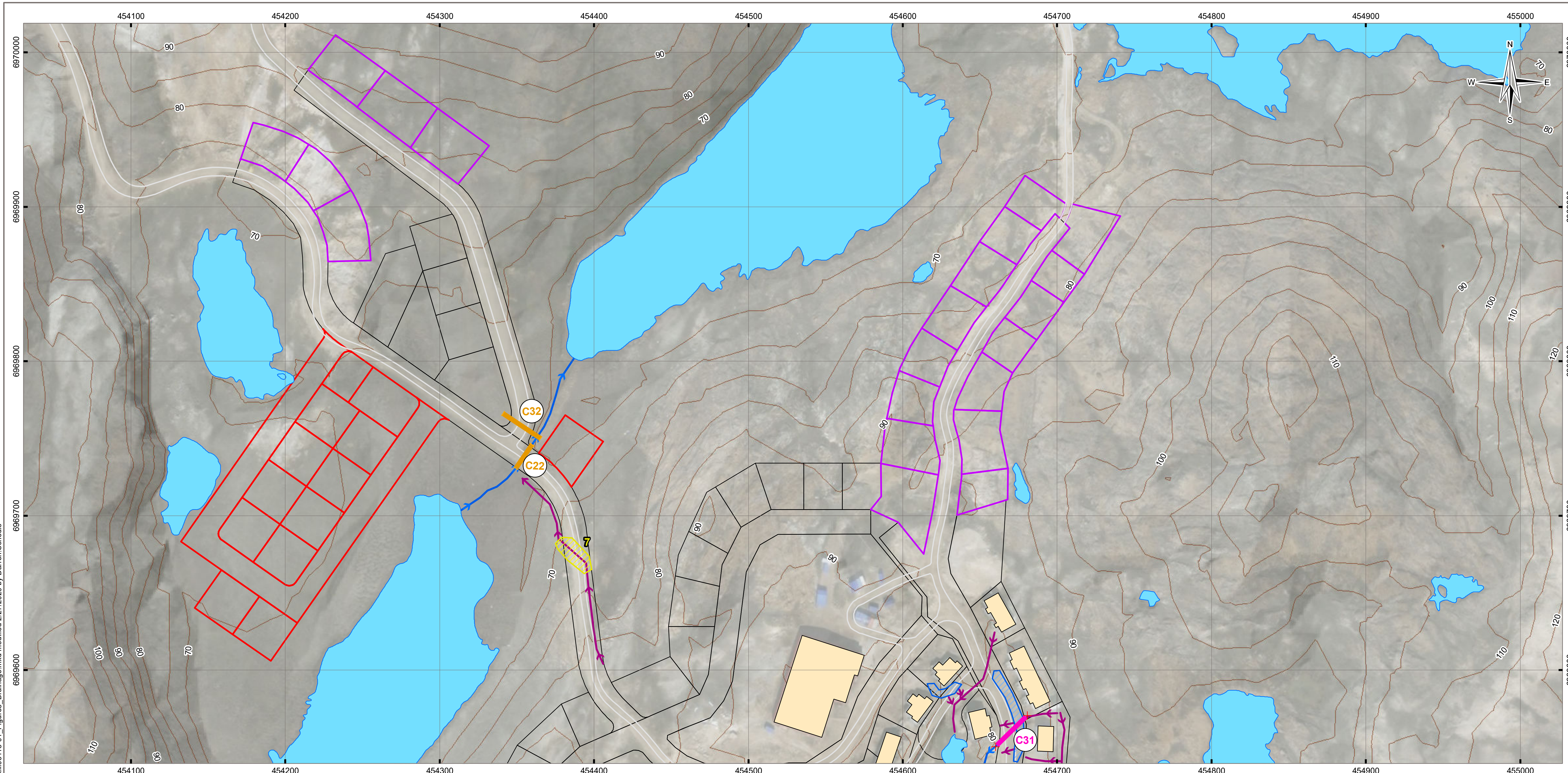
Developing and maintaining a well-functioning drainage system is an ongoing concern within most northern communities. From Tetra Tech's 2019 freshet site visit, several types of drainage issues in Kimmirut were identified. Many of the existing culverts were damaged, buried, and/or blocked with sediment, rocks, and debris. Ice blockages were also noted. A lack of formalized ditches was an issue which resulted in ponding and flow paths across roadways which can cause washouts and rutting during a larger rainstorm or snowmelt event.

Typical drainage issues identified within the community of Kimmirut are detailed in Table 3-1.

Table 3-1: Kimmirut Drainage Issues

Issue	Cause
Spring flooding	Culvert blocked by ice/snow
Damaged culvert inlet/outlet	Damage caused by excavator cleaning snow and/or ice during spring
Buried or blocked culvert inlet/outlet	Culvert inlet and/or outlet blocked due to sediment, rock, and debris deposition, and/or ice blockage.
Ponding	Blocked culverts, poor grading, vegetation overgrowth, lack of an outlet.
Erosion	Velocity threshold for erosion is exceeded

Figures 3-1 to 3-5 below depict the drainage issues and existing infrastructure identified in Kimmirut and include the anecdotal flooding event that occurred downstream of the airport on May 6, 2012, which damaged a public housing duplex (CBC News, 2012). Figures 3-6 to 3-12 show examples of the typical drainage issues identified during Tetra Tech's site visit. Appendix E includes a summary of the existing culverts and erosion sites identified within the community.

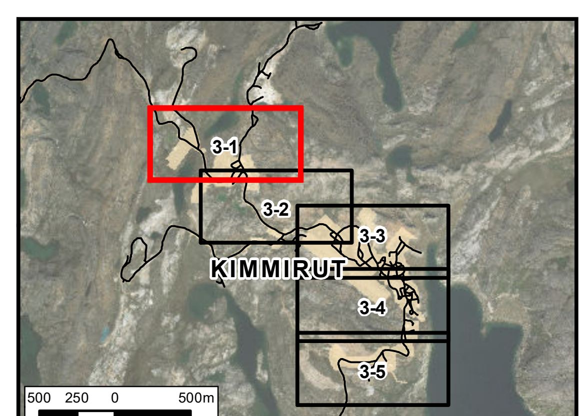


LEGEND

- Anectodal Flooding
- Erosion
- Ponding
- Blocked Culvert
- Partially Blocked Culvert
- Damaged Culvert
- Existing Culvert
- Culvert Not Assessed
- Overland Flow
- Well Defined Flow
- C## Culvert Number
- 3 Erosion Site Number

Base Data

- Parcel Requiring Site Improvements
- Proposed Parcel
- Current Parcel
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Drainage Issues
Site Visit May 29-30, 2019

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

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Figure 3-1

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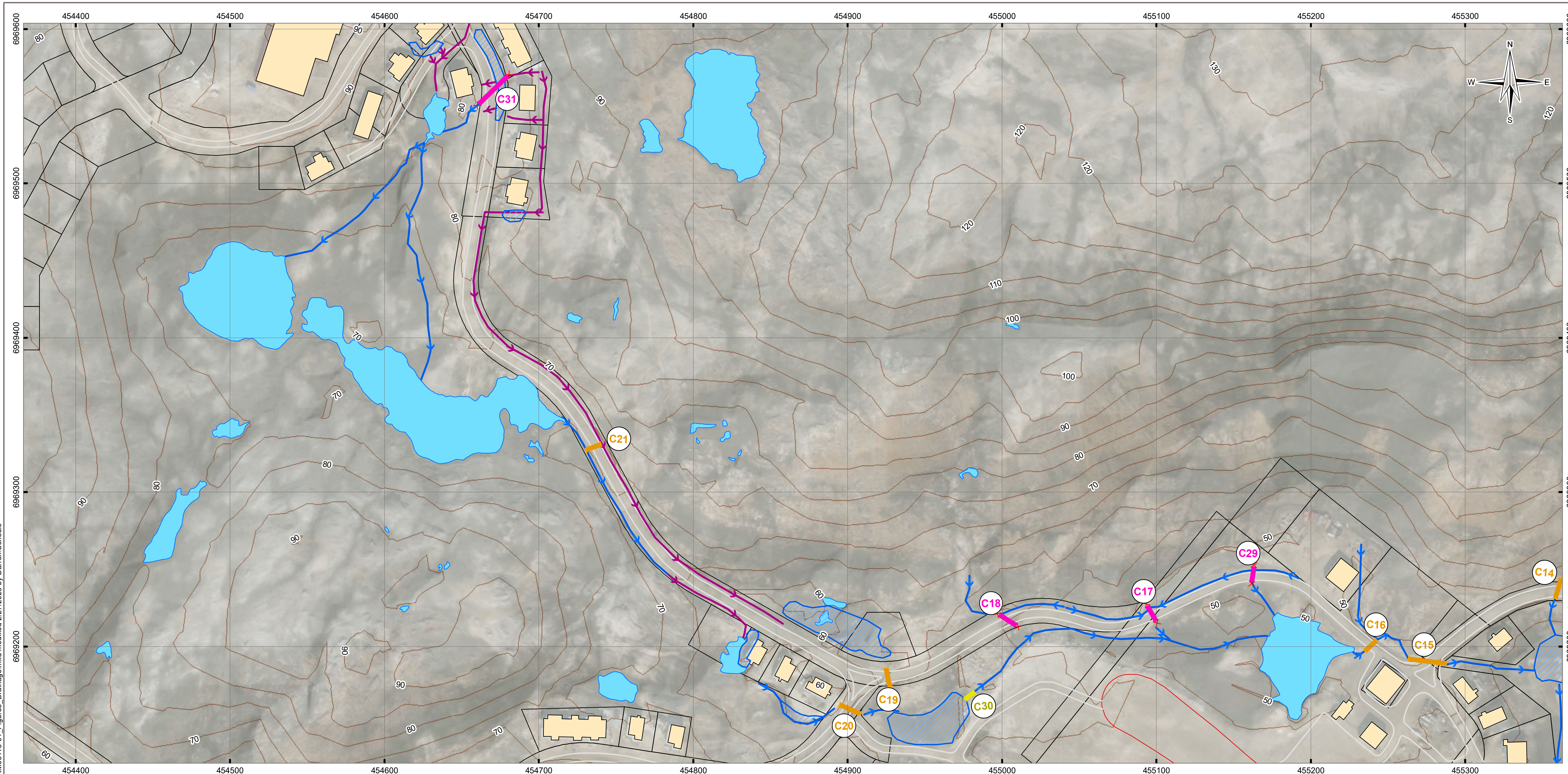

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- Runway
- Building Footprint
- Gravel Road
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- Waterbody

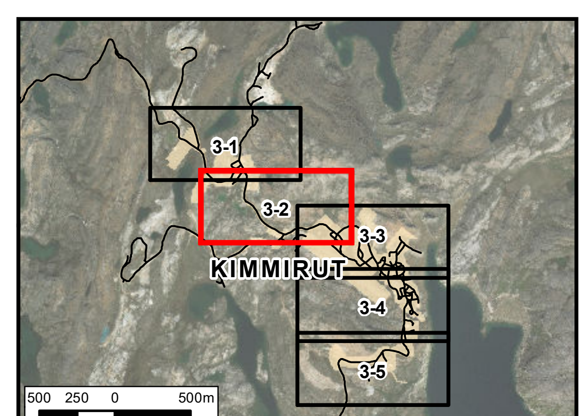

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Figure 3-2

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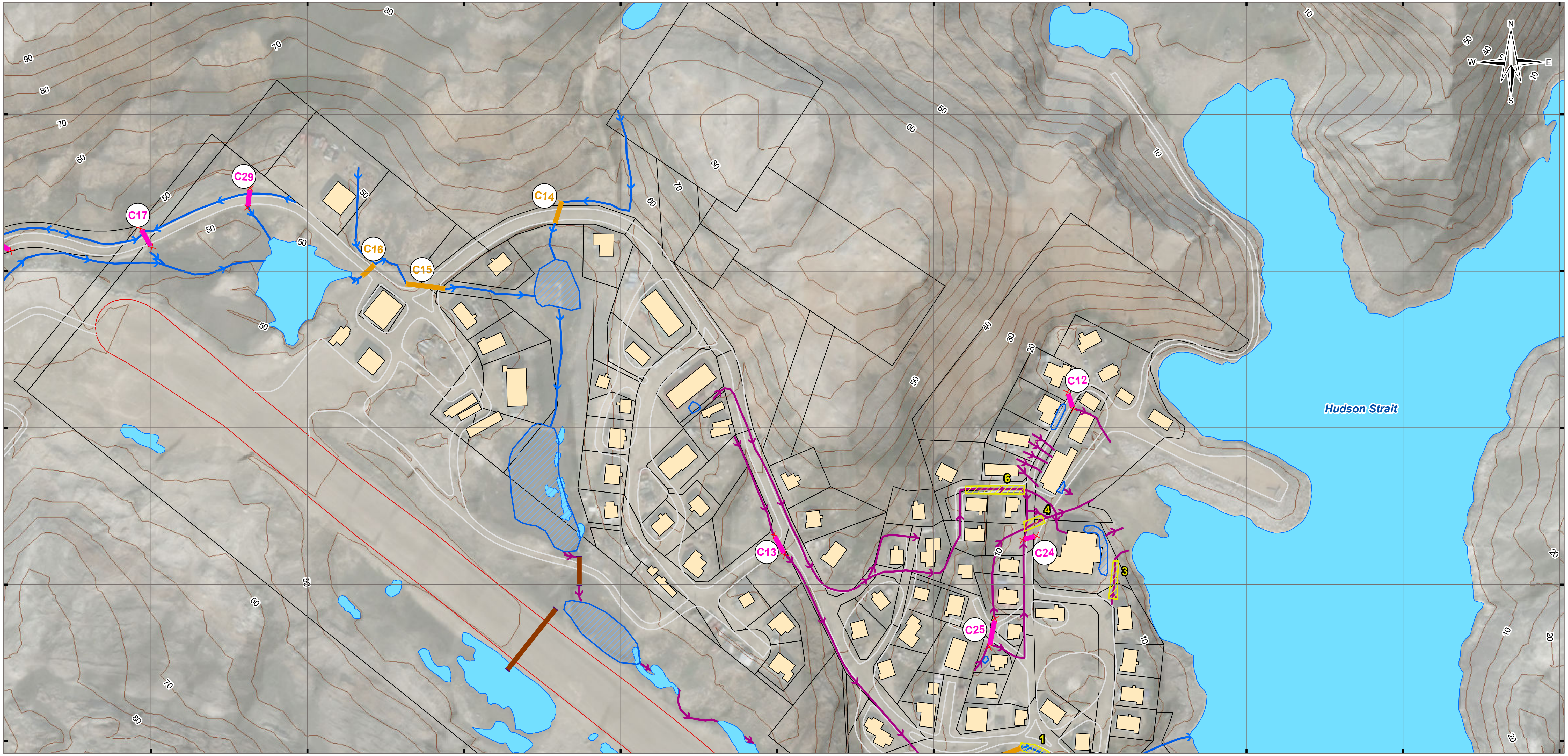

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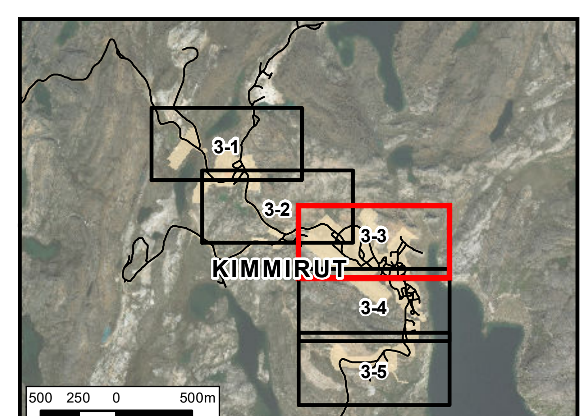
Base Data

- Current Parcel
- Runway
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Drainage Issues
Site Visit May 29-30, 2019

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03118-01_Figure3_Drainage.mxd

TETRA TECH

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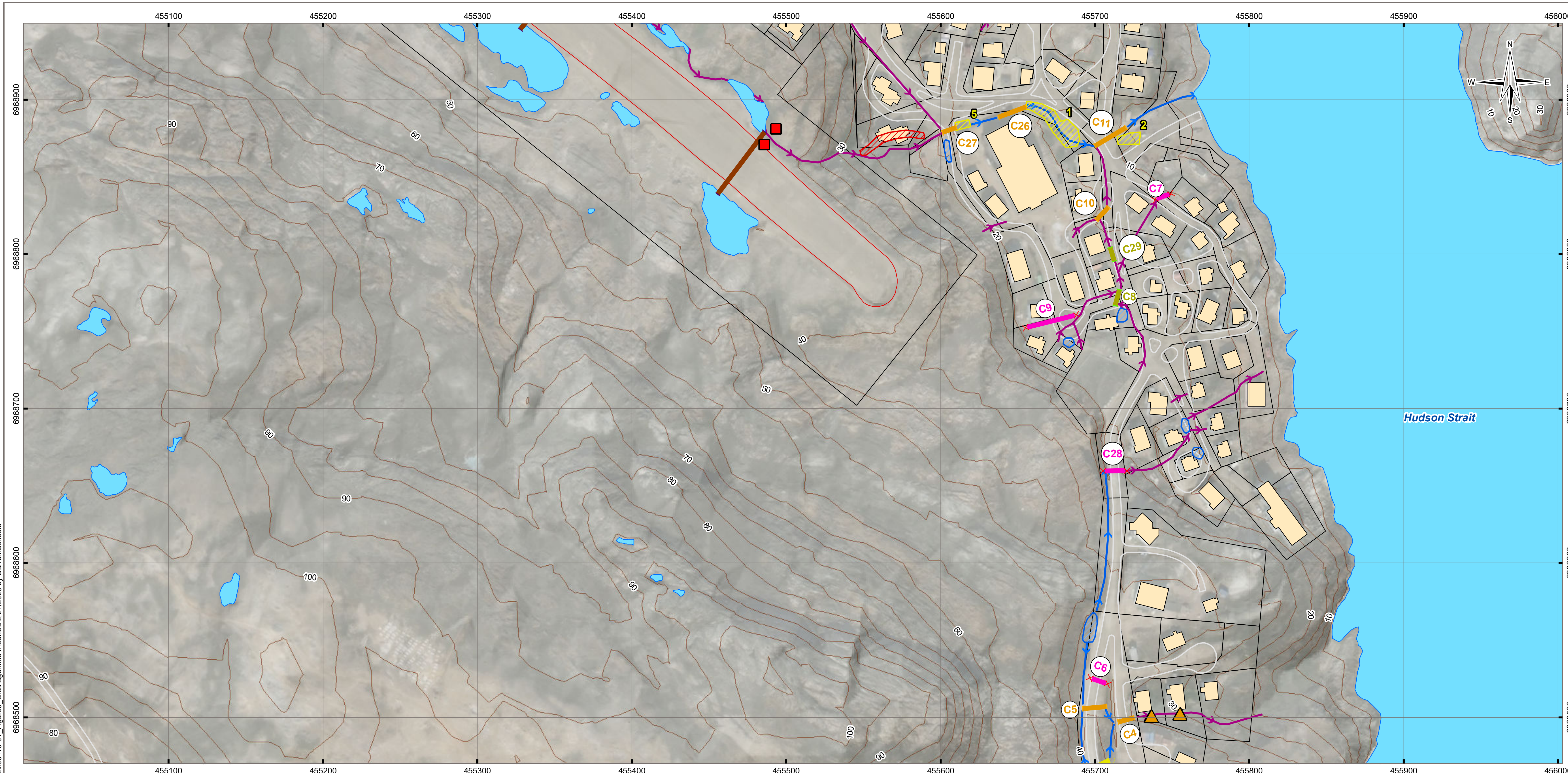
DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 3-3



LEGEND

- Anectodal Flooding
- Erosion
- Ponding
- Blocked Culvert
- Partially Blocked Culvert
- Damaged Culvert
- Existing Culvert
- Culvert Not Assessed
- Overland Flow
- Well Defined Flow

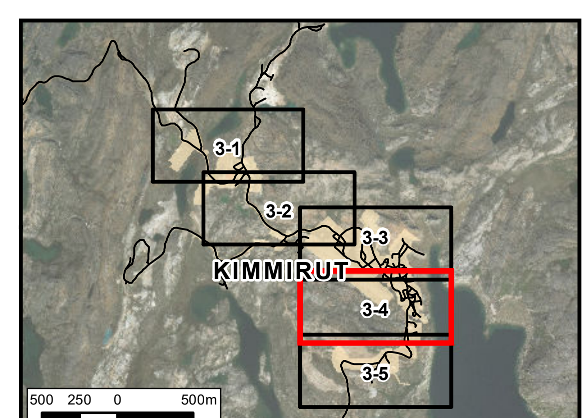
- C## Culvert Number
- 3 Erosion Site Number

Base Data

- Current Parcel
- Runway
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody

Problem Area

- Ditch Under Building
- Blockage (Dam)



NOTES
Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Drainage Issues
Site Visit May 29-30, 2019

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure3_Drainage.mxd

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DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 3-4

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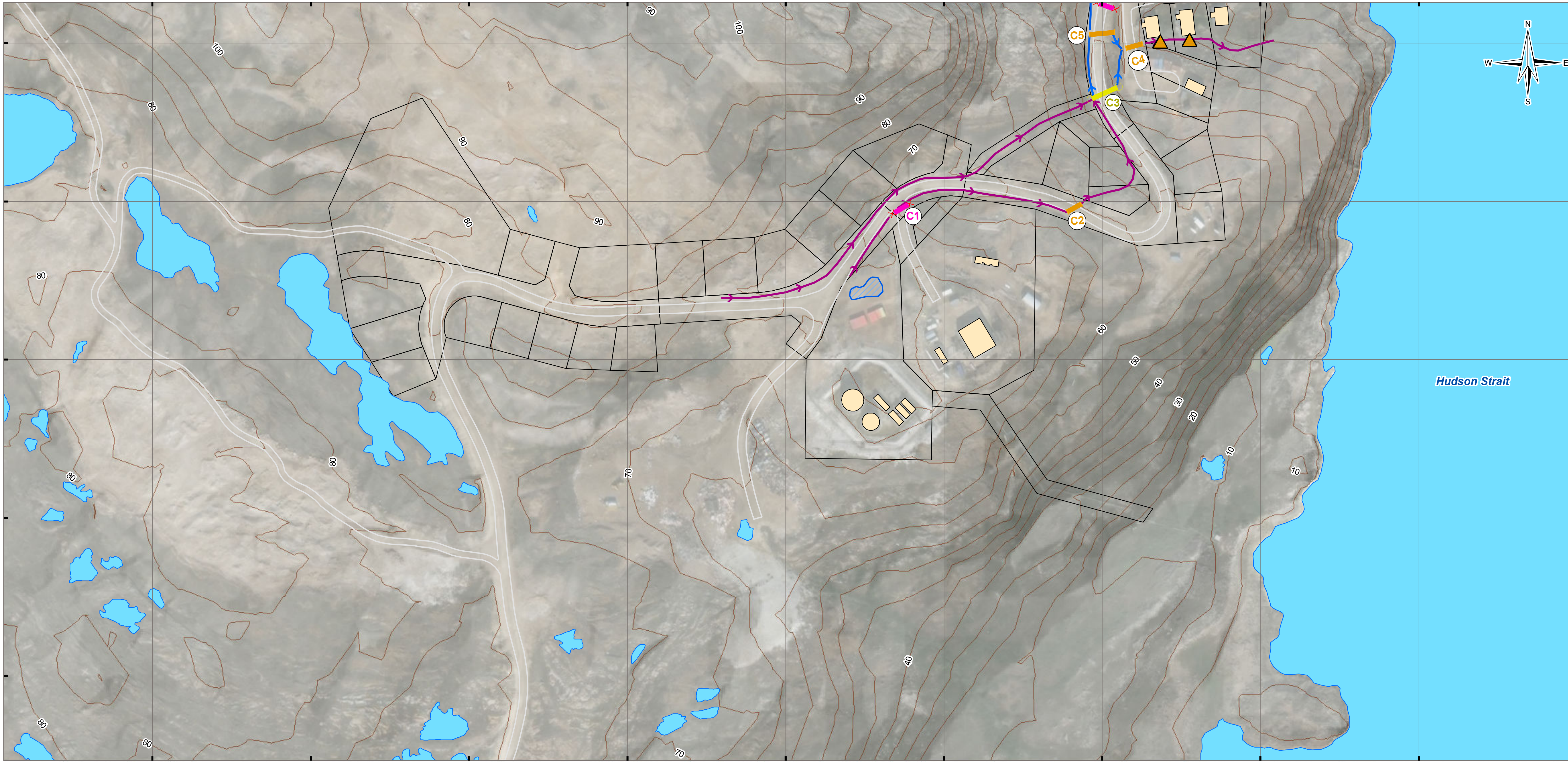


LEGEND

- Anectodal Flooding
- Erosion
- Ponding
- Blocked Culvert
- Partially Blocked Culvert
- Damaged Culvert
- Existing Culvert
- Culvert Not Assessed
- Overland Flow
- Well Defined Flow

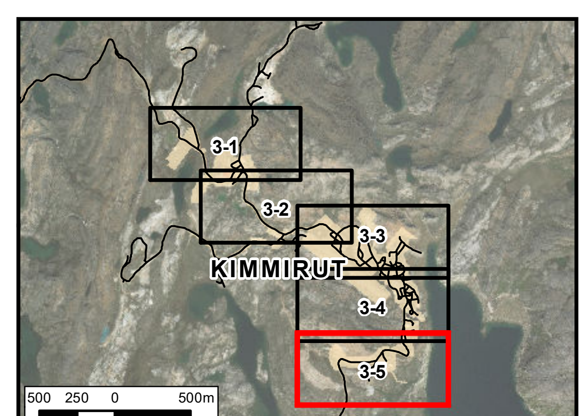
- C## Culvert Number
- 3 Erosion Site Number

Base Data

- Current Parcel
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody

Problem Area

- Ditch Under Building



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Drainage Issues
Site Visit May 29-30, 2019

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure3_Drainage.mxd

TETRA TECH

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DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 3-5

Figure No.	Description	Image
3-6	Typical damaged culvert inlet. Culvert 20	
3-7	Ponding water near building	
3-8	Overland flow	

Figure No.	Description	Image
3-9	Typical damaged culvert outlet. Culvert 10	
3-10	Main watercourse through Kimmirut. Site of May 6, 2012 flooding event.	
3-11	Overland flow around house	

Figure No.	Description	Image
3-12	Ponding water around house	

Figures 3-6 to 3-12: Kimmirut Drainage Issues – Site Visit May 29-30, 2019

3.5 Site Equipment

During the site visit, an inventory of the available equipment within the community of Kimmirut was developed. The following non-exhaustive list of equipment was noted in Kimmirut:

- Excavator: CAT 320E
- Bulldozer: CAT D6T
- Backhoe: CAT 420D
- Front-loader: Deere 624K
- Rock Crusher: Lokotrack LT96
- Grader: Volvo grader
- Dump Trucks

4.0 ANALYSIS OF DRAINAGE SYSTEM

Drainage principles, design criteria, and design scenarios used to develop the proposed drainage system for the Hamlet of Kimmirut are detailed in this section of the report, as well as modelling results and recommendations.

4.1 Drainage Principles

According to the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), drainage systems should be designed in accordance with the level of risk that is established during the planning process. The CSA Group also noted that:

- "It is recognized that the capacity of any drainage system might be exceeded at some point;
- The design will be impacted by physical constraints present within communities;
- The desired acceptable level of risk might not be achievable in any given community due to physical (spatial) limitations, resources, subsurface conditions, and topography, among other factors;
- The acceptable level of risk established might be impacted by the changing climate, for example, due to the changing climate, what was previously considered to be a 1-in-10 year event might occur on average every five years in the future."

In addition to the CSA Group's design principles, the development of the proposed upgrades was based on Tetra Tech's practical principles as follows:

1. Effectively capture and route water around populated areas to protect buildings and communities;
    a. Where possible, minimize the imposition of waterways through populated areas by restricting use of large ditches to areas outside of the populated areas;
2. Utilize shallow swales for driveway crossings and roadside drainage;
3. Minimize complexity for drainage system construction, maintenance, and management by:
    a. Minimizing the number of different culvert diameters specified;
    b. Minimizing the number of new culverts, which would not only need to be barged to Kimmirut for installation, but also need to be maintained once installed;
    c. Minimizing the number of different ditch and swale dimensions specified;
    d. Keeping the design simple such that the Hamlet foreman and crew can not only construct but also maintain the new drainage systems with ease;
4. Capture and immediately convey water towards the nearest major watercourse/waterbody (i.e. ocean, lake, river, or stream);
5. Use multiple outlets to add redundancy at critical locations throughout the system;
6. Design using projected precipitation trends to account for future climate change;
7. Select culvert sizes based on available roadway embankment cover;
8. Design drainage swales through driveways to comfortably accommodate the tires and undercarriage of vehicles; and
9. Develop plans recognizing the land use limitations, for example remove nuisance ponding from the front of the Northern Store and from the foot of exterior staircases leading to residences.

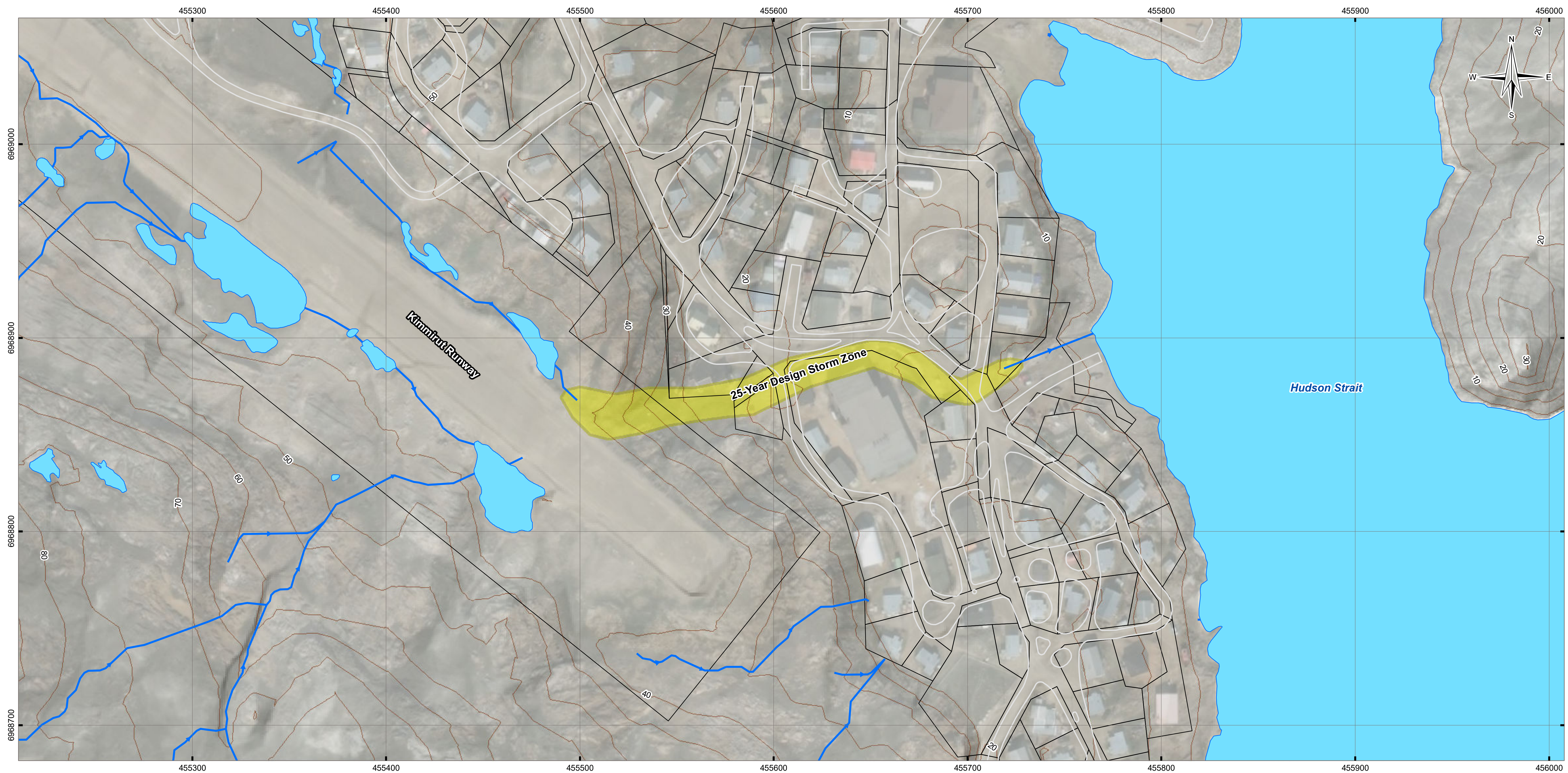
4.2 Design Criteria

As per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), the culvert design capacity prescribed by the CSA Group is:

- Size culverts to accept design flow at 80% capacity under free flow condition (1:10 year event).
- Size culverts to accept 1:100 design flow at 80% of available head at entrance.

In addition to the above requirements the proposed drainage system was developed to meet the following general criteria:

1. Ditches and swales were sized to convey the 10-year 1-hour storm event. The duration of the 1-hour storm was selected as the critical event following a review of a number of storm durations ranging from 1 hour to 24 hours. The goal was to provide sufficient capacity to handle the critical event. Tetra Tech has further upsized the culverts to add additional capacity to compensate for debris deposition blocking the culverts and limiting their capacity. Buried culverts and significant deposition was noted in the majority of culverts noted in the field visit described in Section 3.1.
2. Along the main stream draining the airport through the main part of town (see Figure 4-1), culverts were sized to convey the 25-year 1-hr event. Selection of the more severe storm event was based on the critical nature of this portion of the drainage system and proximity to the school.
3. Ditches were sized to maintain at least 100 mm of freeboard during the 10-year 1-hour storm event.
4. Swales were sized to maintain at least 50 mm of freeboard during the 10-year 1-hour storm event.

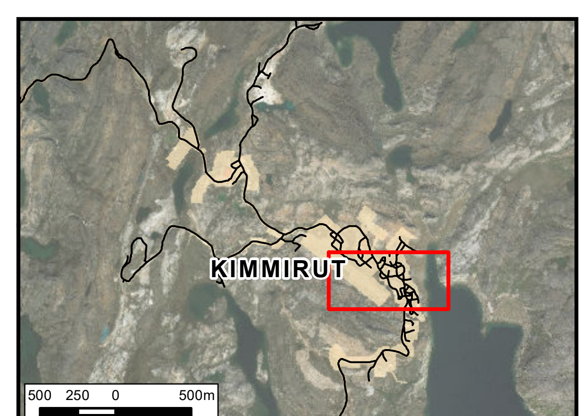


LEGEND

- 25-Year Design Storm Zone
- Stream

Base Data

- Current Parcel
- Gravel Road
- Topographic Contour (5m)
- Waterbody



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
25-Year Design Storm Zone

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,000
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure4_25YearStorm.mxd

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DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-02

Figure 4-1

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4.3 Design Scenarios

Kimmirut's geology promotes low rates of infiltration and in turn yields high runoff volumes, even during small rainfall or snowmelt events. The shallow surficial bedrock covered by a shallow overburden common to the area limits the amount of infiltration and groundwater recharge.

Based on the limited anecdotal information we have, we understand that historical flooding has occurred due to snowmelt events. However, we believe that the critical event likely to have the greatest impact on Kimmirut's drainage system is a severe rainfall event. Historical flooding noticed within the community is caused by the non-existent drainage system and poor snow management.

The model was run with six design storm scenarios: the 10-year 1-hr, 10-year 24-hr, 25-year 1-hr, 25-year 24-hr, 100-year 1hr, and 100-year 24hr event. Using historical data extracted from the Inuvik weather station, a synthetic distribution was developed to represent the rainfall pattern likely to develop over the course of a 24 hour event.

The 1-hr storm distributions were developed using the AES distribution for Northern Quebec. Climate change adjusted precipitation volumes for each of the scenarios were obtained using the IDF_CC Tool 3.5 developed by Western University as described in Section 2.1 of this report, and the volumes are summarized in Table 4-1.

As the IDF_CC tool is reporting data for the Kimmirut community as ungauged, Tetra Tech has verified the quality of the rainfall estimates using data extracted from both the Kimmirut weather station (1994 to 2004) and nearby weather stations (Cape Dorset, 1971 to 2019).

Table 4-1: Kimmirut Design Storm Scenarios

Design Storm Scenarios	Volume (mm)
10-year 1-hr	12.3
10-year 24-hr	56.4
25-year 1-hr	16.7
25-year 24-hr	64.4
100-year 1-hr	24.6
100-year 24-hr	69.4

4.4 Modelling of System

A systems analysis approach was adopted to design the proposed drainage system for the Hamlet of Kimmirut. PCSWMM, a state-of-the-art stormwater program was used to develop the model of the drainage system. The model uses a node-link arrangement where links represent conduits, such as ditches and culverts; and junctions represent a point where two or more links are joined, according to how the drainage network operates.

In addition, the drainage area is split into subareas or subcatchments, which are the hydrological units used to calculate flows. Flows calculated from a subcatchment are assigned to a junction, and then hydraulically routed through the drainage network. Through this approach, flows are aggregated through the system until discharged to an outfall point. Figure 4-2 shows the sub-catchments, junctions and conduits represented in the model. Input parameters for the subcatchments, junctions and conduits are presented in Appendix G.

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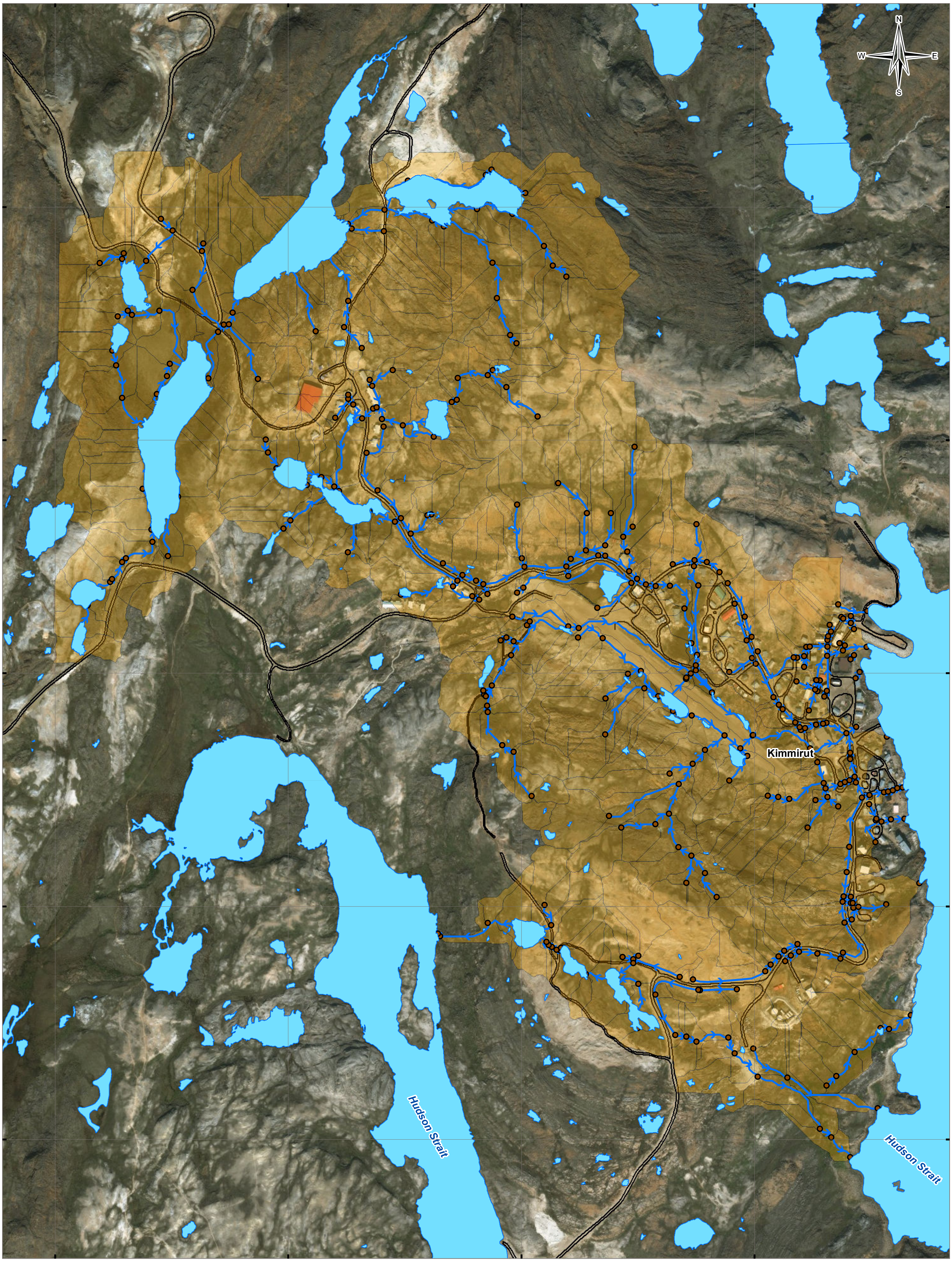
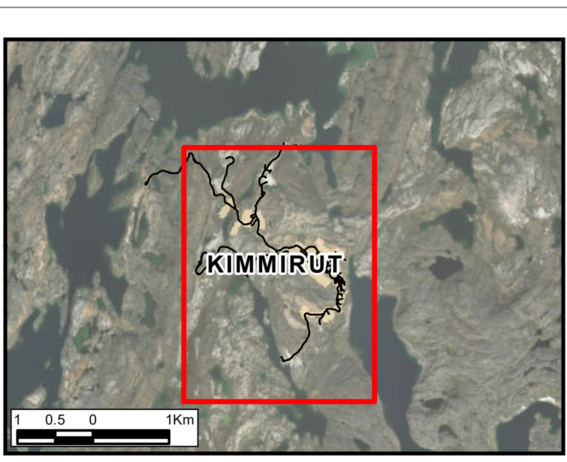


LEGEND

- Junction
- Conduit
- Subcatchment

Base Data

- Gravel Road
- Waterbody



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

PCSWMM Model of Kimmirut

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:8,000

150 75 0 150

Metres

FILE NO.
WTRM03118-01_Figure4-2_Subcatchments.mxd

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DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-01

Figure 4-2

4.5 Modelling Results

Although the typical process followed in developing a stormwater management plan includes development of a hydrologic/hydraulic model of the existing system, the absence of a proper drainage system within the community has forced Tetra Tech to shortcut directly towards modelling of the proposed system and then use the modelling results to size and identify the type of infrastructure required to convey the estimated flows.

After modelling the scenarios described in Section 4.3, Tetra Tech proposes that 27 of the existing culverts be upgraded and that 18 new culverts be added to the system. In addition, Tetra Tech is also recommending that a formal system of swales and ditches be integrated into the community allowing for the safe conveyance of runoff. Table 1 in Appendix F shows the specifications and modelled performance of the 45 proposed culverts for the 10-year 1-hour design storm scenario. As detailed, Tetra Tech is recommending that the proposed culverts range in size between 450 mm to 1400 m.

As the CSA recommends that culverts be sized to a minimum of 450 mm in diameter, Tetra Tech has opted to maintain this minimum size requirement. It should be noted that in certain cases the swale profiles and site limitations will force the embedment of some culverts so to meet the minimum depth of cover requirements set by the supplier of the selected culvert. The minimum cover requirements are needed to structurally support the integrity of the culverts. Figure 4-3 provides a schematic representation of the typical installation details where the integration of the minimum depth of cover requires culvert embedment.

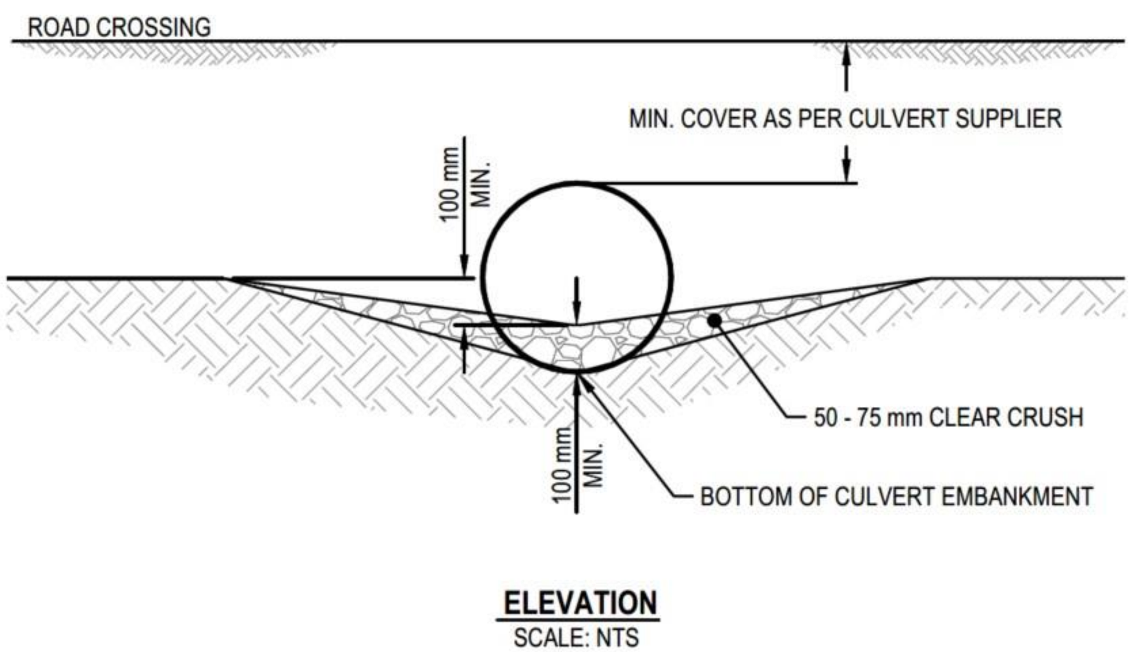


Figure 4-3: Typical Embedded Culvert Details

As noted in the proposed plans, a number of swales are being proposed in recognition of the narrow roadways in Kimmirut. Throughout numerous areas within the community, the buildings are very close to the edge of the road network. The alternative to swales of adding deep/wide ditches will inevitably impact the ability of the hamlet residents to access their properties and will likely impact traffic movement. Figure 4-4 below provides an overview of the typical challenges a deep drainage system would have to contend against.

Figure 4-4: Typical Narrow Laneway in Kimmirut

4.6 Drainage Recommendations

This section presents a summary of recommended actions needed to upgrade the Level of Service of the drainage system of the Hamlet of Kimmirut. Currently, there are a number of deficiencies as identified in Section 3.0. Tetra Tech has developed the following series of recommendations which, when implemented will remedy the issues identified throughout the community.

The proposed upgrades for the community include the upgrading of culverts, ditches and swales.

4.6.1 Culverts

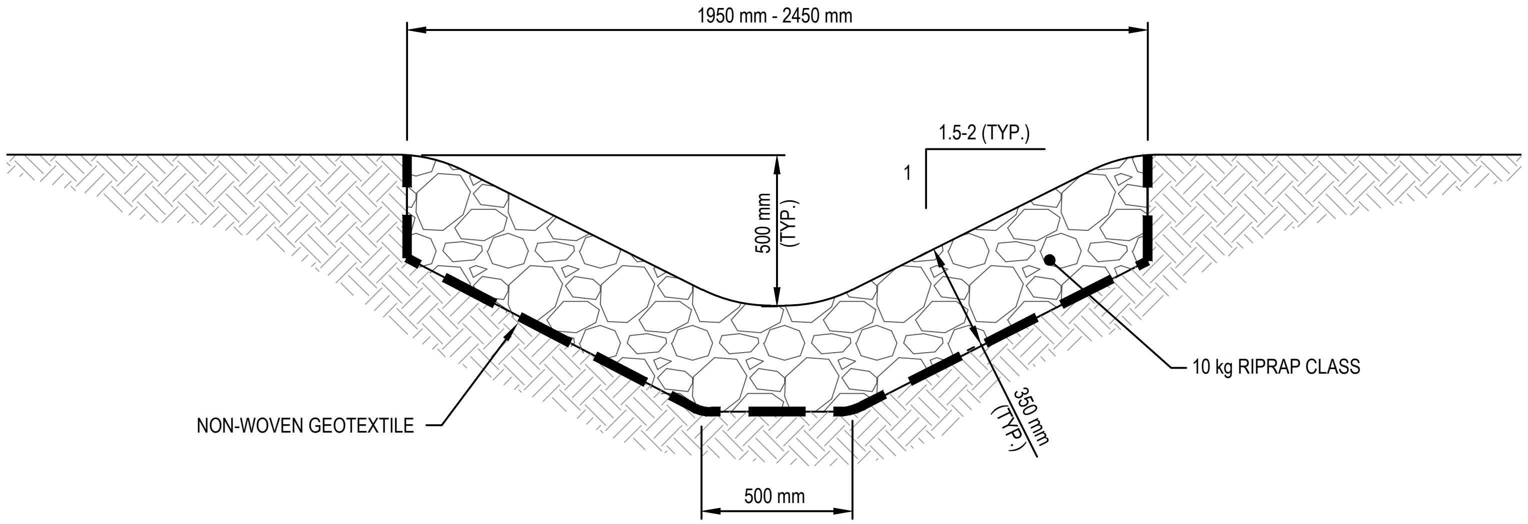
1. The minimum culvert size should be 450 mm. The minimum culvert size recommendation from CSA Group (2015) is 450 mm for de-icing purposes.
2. Cover over culverts shall meet the structural requirement set by the supplier of the selected pipe type. A recommended minimum of 300 mm should be included where vehicular traffic is likely to be present.
3. For long-term durability, the proposed culvert material should be Smooth Wall Steel Pipe (SWSP). The use of SWSP including a wall thickness of 10 to 12 mm will afford the community a very long service life. As detailed in Appendix E, most if not all corrugated steel pipes in Kimmirut have failed to retain their structural integrity and have likely been damaged by maintenance equipment or road traffic. If however CSP culverts are preferred, Tetra Tech recommends the use of culvert end stiffeners or sleeves to better support the structural integrity of the ends of the culverts. A sample photo of a culvert end stiffener is included in Appendix H. Note that Tetra Tech recommends a wider stiffener covering 2 times the culvert diameter. Details of a culvert end stiffener and sleeve are included in Figure 5-11 in Section 5.4.1.
4. Inlet grates are recommended for the three proposed 1400 mm diameter culverts.
5. Culverts should be provided with high visibility markers to prevent damage during spring cleaning activities.
6. An annual maintenance program should be implemented to prepare the system for the spring freshet. This may include the steaming of specific culverts and/or the removal debris limiting the capacity of the culvert crossings.
7. Table 1 in Appendix F includes the proposed culvert upgrades throughout the hamlet.
8. Based on the areas of erosion noted during our site visit and on water velocities modelled using PCSWMM, Tetra Tech recommends the use of riprap aprons for culvert inlets and outlets. Appendix E includes riprap recommendation for all culvert aprons.
9. Culverts are to extend a minimum of one culvert diameter past the embankment as shown in Figure 5-17 in Section 5.4.3.
10. Headwall and endwall side slopes are to be 1.5H:1V to 2H:1V. Side slopes of 2H:1V are preferred where space allows.
11. Where space does not allow for a riprap protected side slope culvert inlets and outlets should include a concrete headwall as a recommended alternative option.

4.6.2 Ditches and Swales

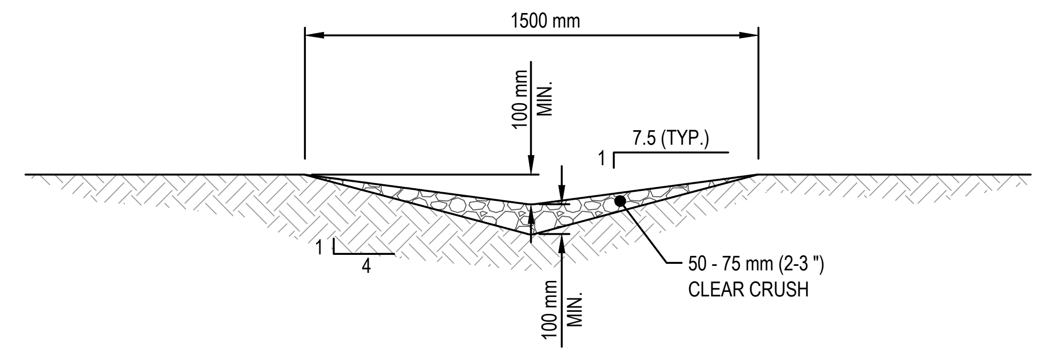
1. Open channels must include a revetment system for erosion protection, particularly in areas where permafrost can be impacted. Failure to do so may lead to hydraulic erosion, which in turn may lead to thermal degradation of the permafrost layer.
2. Ditches and swales should be as flat as possible, but not flatter than 0.5%.
3. Ditches to have a minimum bottom width of 500 mm, a minimum depth of 500 mm and side slopes ranging between 1.5H:1V to 2H:1V.
4. Ditches in the 25-Year Design Storm Zone as shown in Figure 4-1 to have a minimum bottom width of 500 mm, a minimum depth of 750 mm, and side slopes ranging between 1.5H:1V to 2H:1V. Side slopes of 2H:1V are preferred where space allows. Flatter side slopes should be considered near schools and

children's playgrounds. Figure 4-5 includes typical cross section details for the proposed ditches and swales.

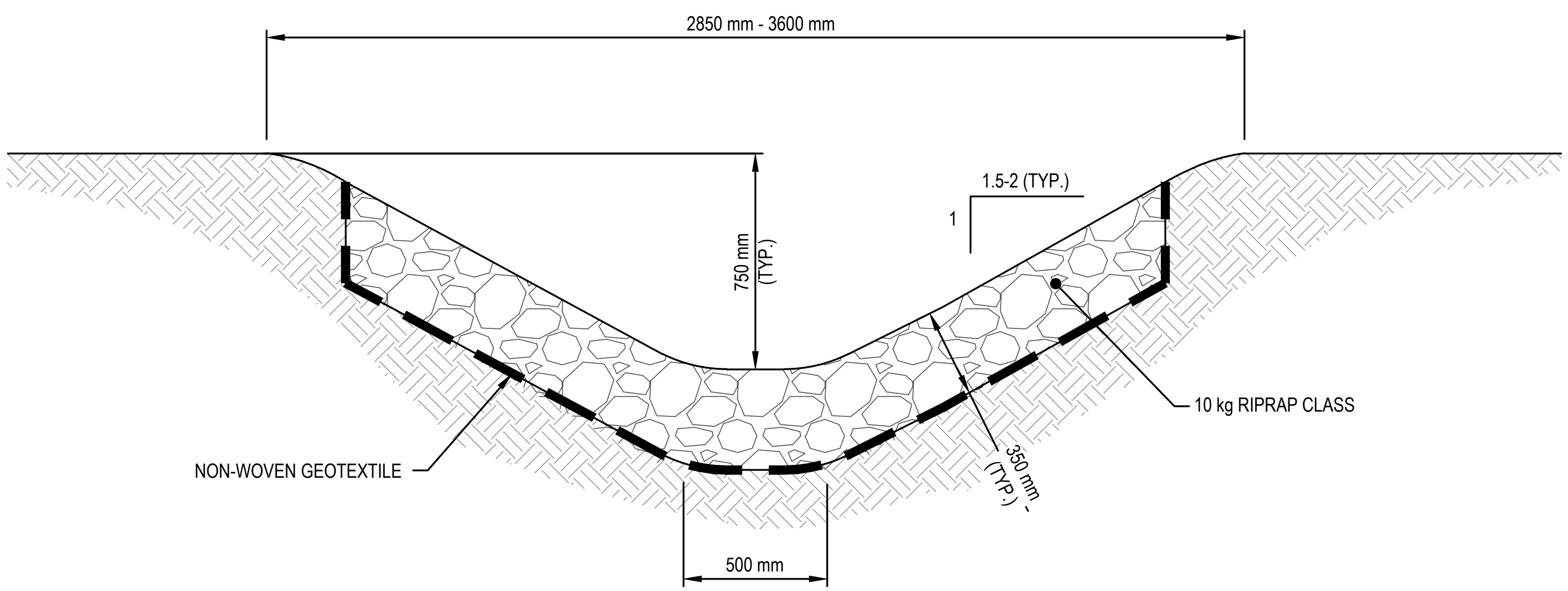
5. Ditches to be lined with a non-woven geotextile between the existing soil and the specified riprap layer.
6. Ditches are to be lined with a 10 kg class riprap layer having a minimum thickness of 350 mm.
7. Swales are to include a minimum depth of 100 mm. Swale side slopes are to be 7.5H:1V minimum to allow for vehicular traffic to safely cross without damage. Swales are to be lined with a 50-75 mm (2-3") clear crush layer having a minimum thickness of 100 mm in the centre of the swale. Figure 4-5 includes typical cross section details for the proposed swales.
8. The community of Kimmirut may wish to increase the active depth of the existing swales throughout the community by raising the road profiles. This may be necessary to formalize the proposed swale sections detailed in Figure 4-5.
9. To the extent possible, ponding water nearby and underneath of buildings should not be promoted. Grading practices underneath building should promote the movement of water away from the footprints of buildings.



1 FIG.1 **TYPICAL DITCH**
SCALE: 1:25



2 FIG.1 **TYPICAL SWALE**
SCALE: 1:25



3 FIG.1 **TYPICAL LARGE DITCH**
SCALE: 1:25

10 kg RIPRAP CLASS			
ROCK GRADATION PERCENTAGE (kg)			
15 %	50 %	85 %	
1	10	30	
APPROXIMATE AVERAGE DIMENSIONS (mm)			
15 %	50 %	85 %	100 %
90	195	280	330

TYPICAL 50-75 mm (2-3") CLEAR CRUSH GRADATION

LEGEND

NOTES

NUM	DATE	DWN	CKD	APR	DESCRIPTION
A	12/9/19	MJK	ER	DNM	ISSUED FOR REVIEW

REVISIONS

PROFESSIONAL SEAL

CLIENT

Nunavut

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KIMMIRUT DRAINAGE PLAN

TYPICAL DITCHES AND SWALE DIAGRAMS

PROJECT NO.	OFFICE	DES	CKD	REV	DRAWING
WTRM03118-02	VANC	ER	ER	A	FIG.4-5
DATE	SHEET No.	DWN	APP	STATUS	
December 9, 2019	- of -	MJK	DNM	IFU	

5.0 MASTER DRAINAGE PLAN

Based on the issues identified in the field, and on the modeling results, a number of upgrades are proposed for the existing drainage system, as well as for the proposed community expansion areas. The system being proposed is composed of ditches, swales and culverts, with outlet locations as shown in Figures 5-1 to 5-5. With the proposed upgrades combined with a proper maintenance program including removal of debris/sediments and de-icing, the proposed system will handle the design flows identified in Section 4.3 of this report.

5.1 Community Plan (Proposed Development Areas)

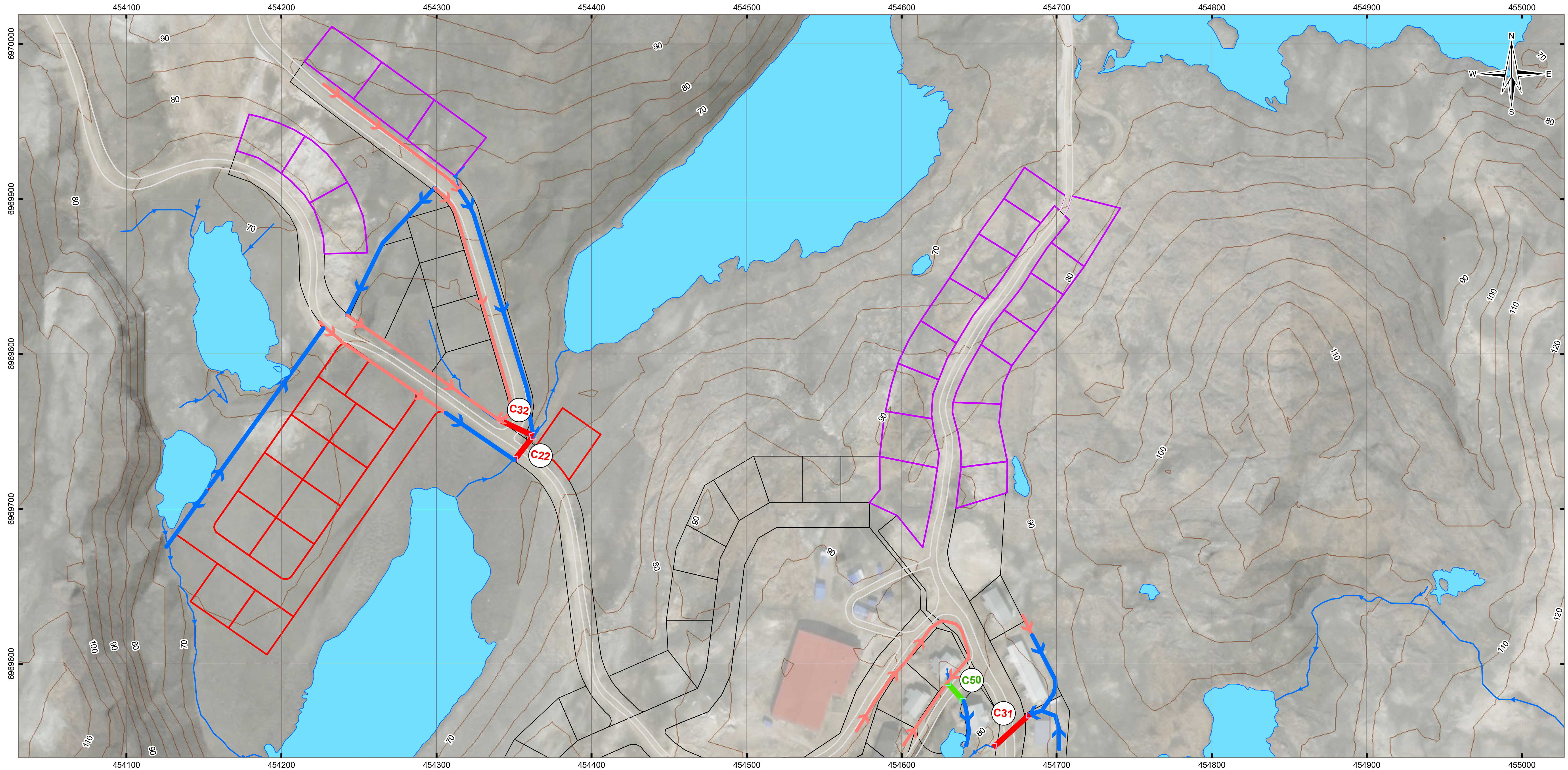
The 2014 Kimmirut Community Plan included in Appendix B outlines proposed developments which will allow for future community growth. Existing topography and drainage conditions were reviewed and a preliminary design of drainage infrastructure for the proposed development areas was developed.

Appendix B also includes a revised development plan for CGS to consider. Parcels outlined in red are recommended to be relocated due to observed poor drainage conditions. Tetra Tech recommends relocating the following proposed development areas:

- The 12 lots outlined in red in the northwest region due to the poor drainage conditions observed in the field. The proposed lots are downstream of a ridge and are within the natural drainage path draining into a lake downstream of the proposed development footprint. However, should CGS wish to develop this area, Tetra Tech recommends raising the building pad elevations above existing grade with suitable fill material as well as implementing the proposed perimeter ditch and swale system shown in Figure 5-1 to mitigate against drainage issues. The site would have to be raised to an elevation which is topographically higher than the crown of the road. That way, if the culvert is plugged, water will be able to overtake the road without impacting the proposed lots.

- The lot outlined in red beside Culvert 22 due to its proximity to the culvert crossing which imposes a risk of flooding. Should CGS wish to develop this lot, Tetra Tech similarly recommends raising the building pad elevation above existing grade with suitable fill material as well shifting the lot up the road further away from the flood plain area. The toe of the proposed embankment will need to be protected from erosion. The use of appropriately sized riprap will provide the necessary protection.

Parcels outlined in purple are proposed relocation lots for the lots outlined in red and are strategically located in areas which appear to be well-drained, as well as suitable for construction. The proposed revisions are intended to protect future development from potential drainage issues. The community expansion lots on the ridges surrounding the ice rink appeared to be in suitable locations with respect to drainage considerations. Grading of these lots should promote movement of surface water away from the buildings and access roads. It should be noted that this report did not review the geology or permafrost conditions within the community.

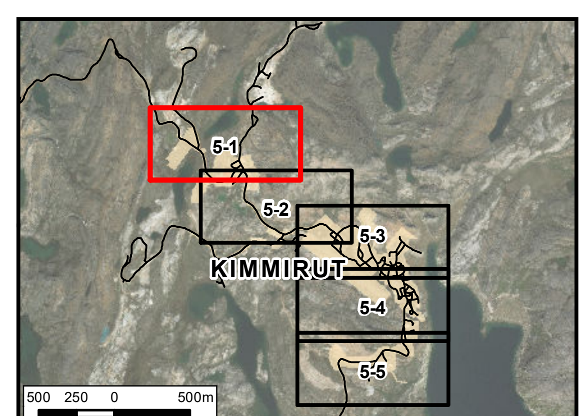


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Parcel Requiring Site Improvements
- Proposed Parcel
- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

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DATE	PROJECT NO.
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Figure 5-1

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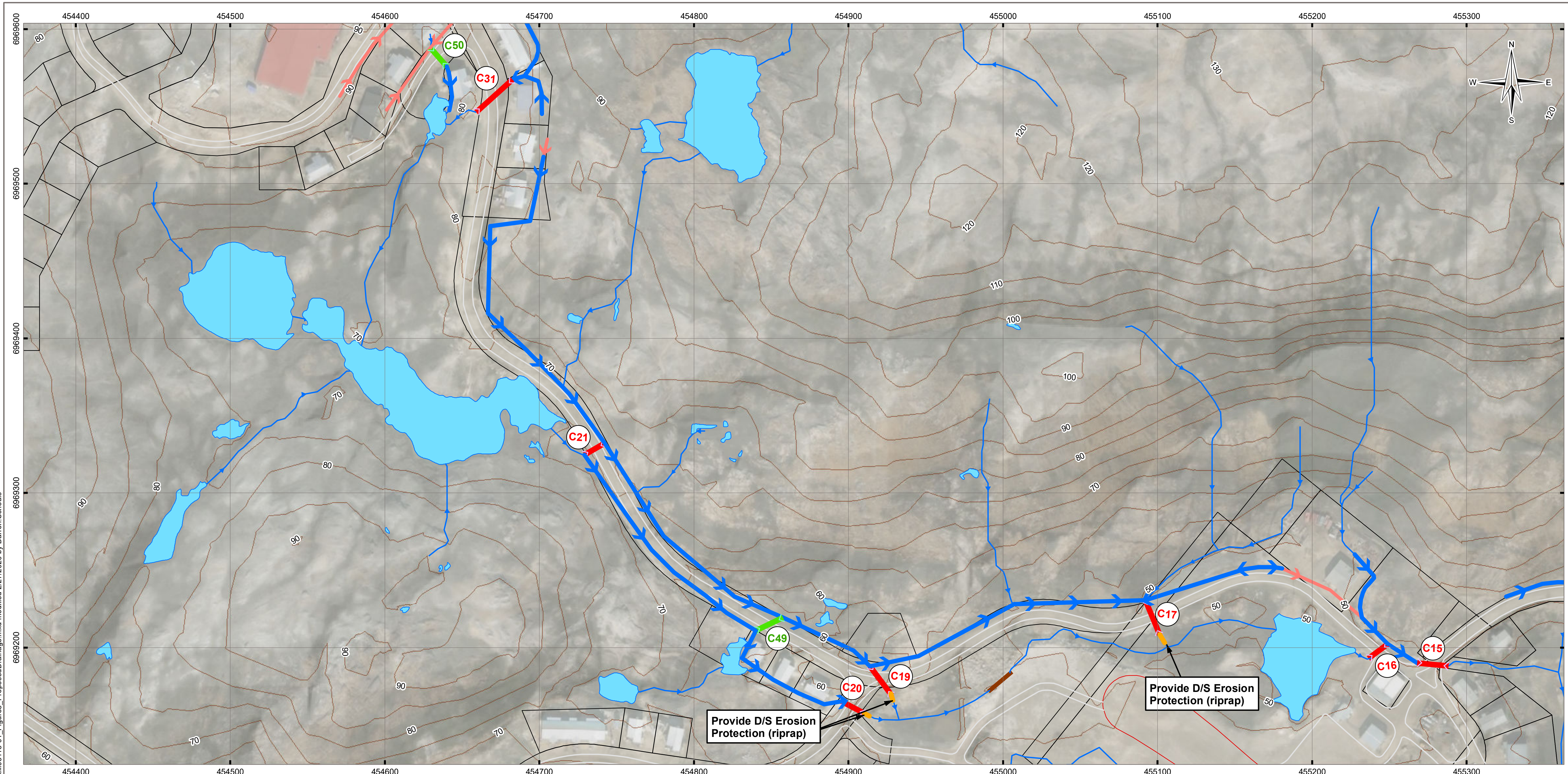


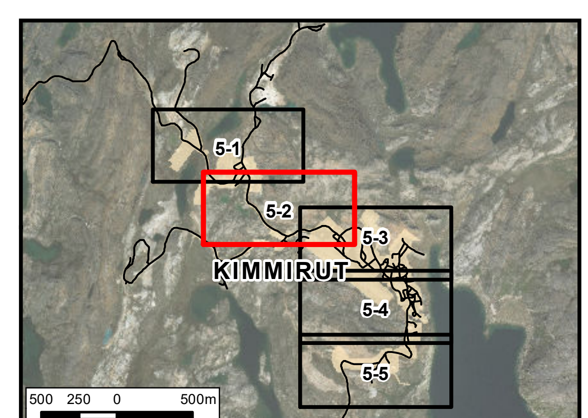
Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5_ProposedDrainage.mxd modified 2/27/2020 by Darren.Schouls

LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

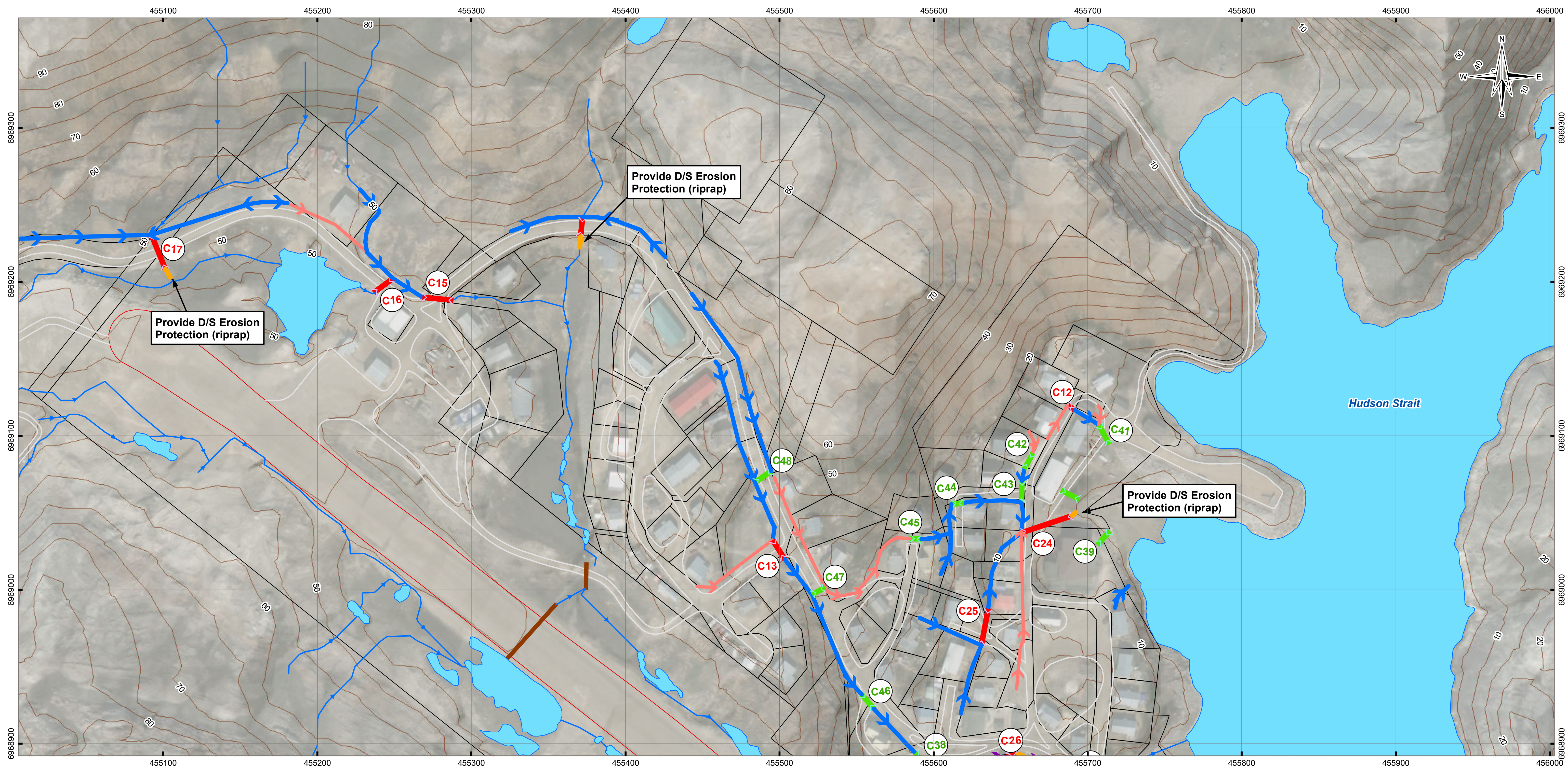
FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-2

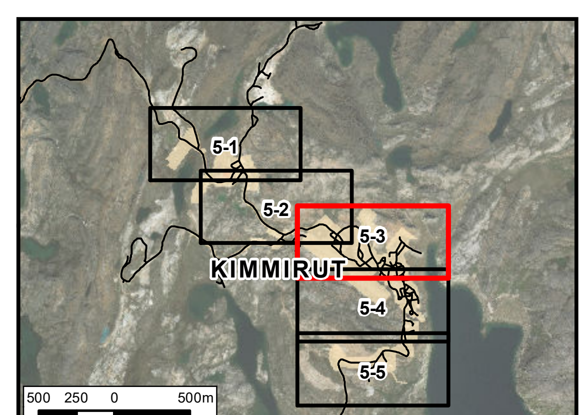


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
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STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-3

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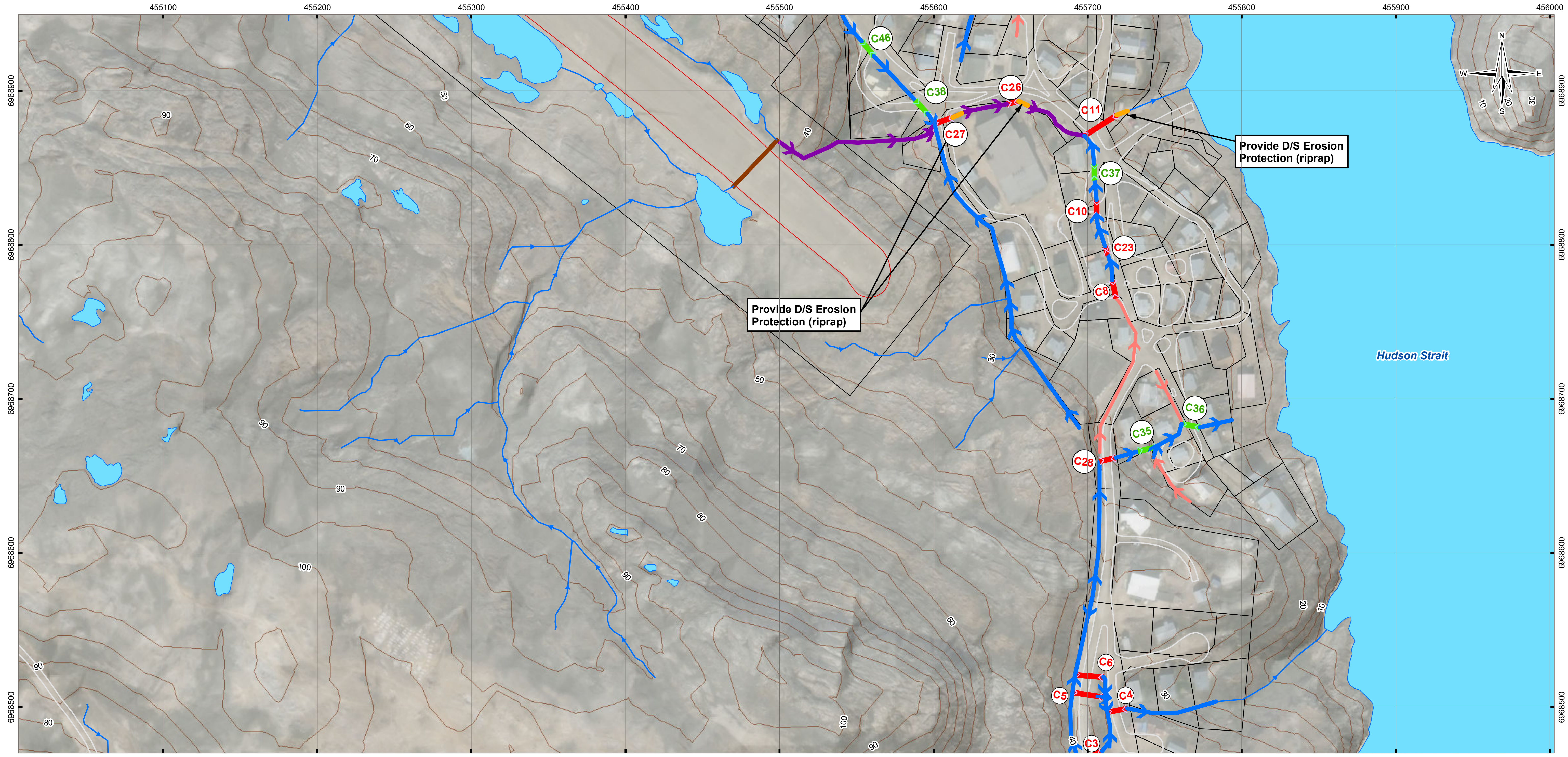
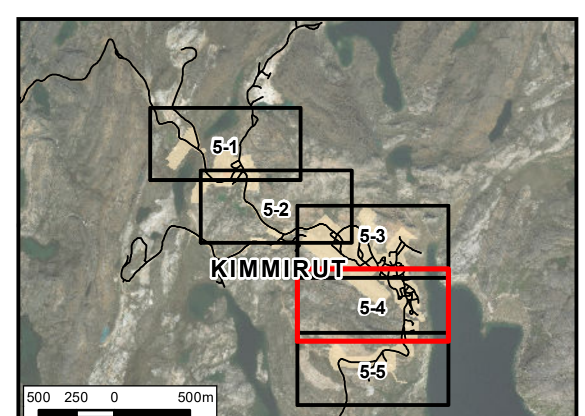


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

Base data source:
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STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

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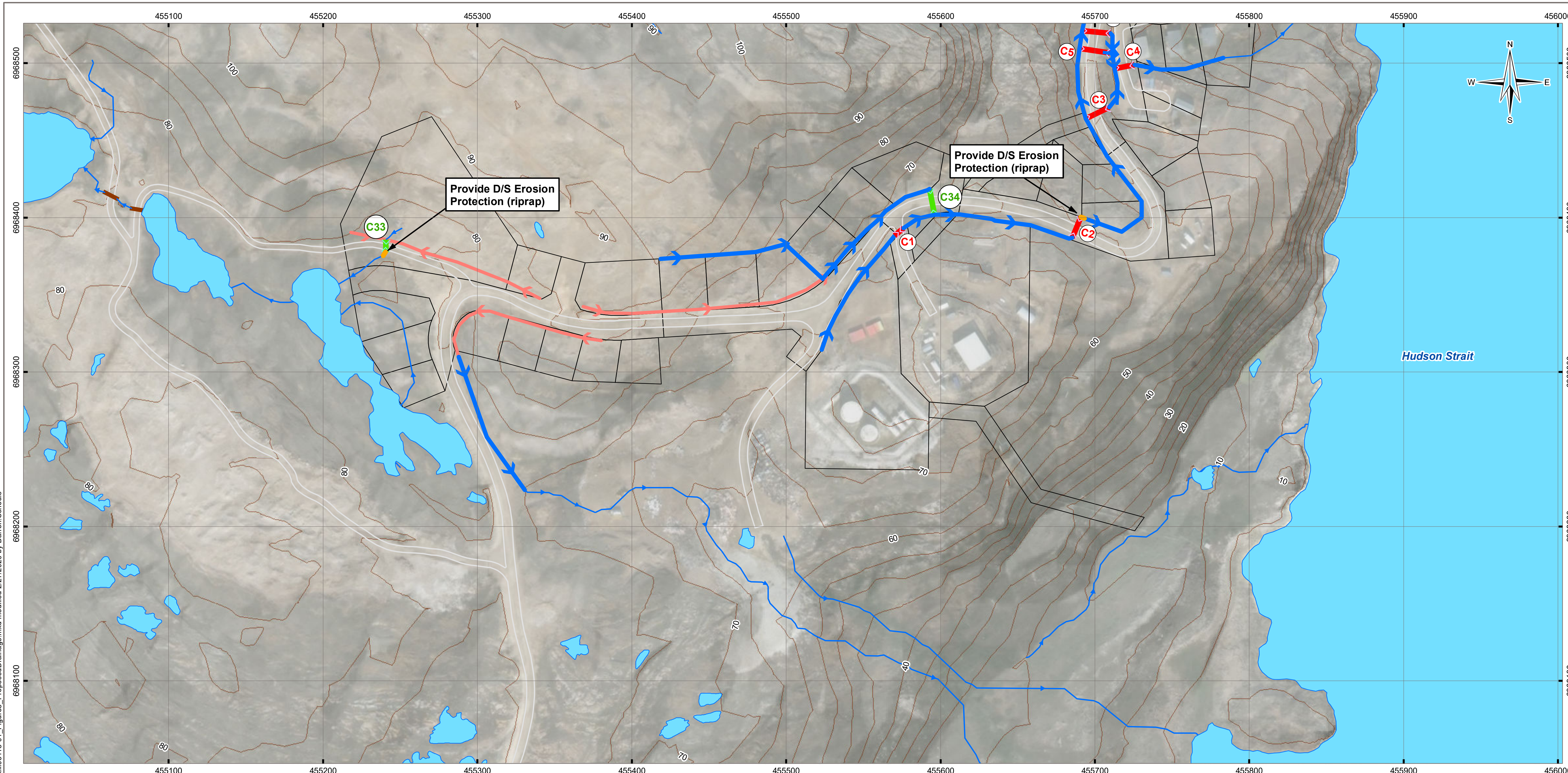
Figure 5-4

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5_ProposedDrainage.mxd modified 2/27/2020 by Darren.Schouls

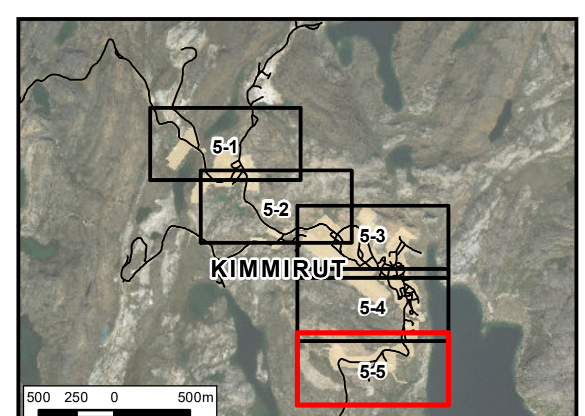


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

Base data source:
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STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

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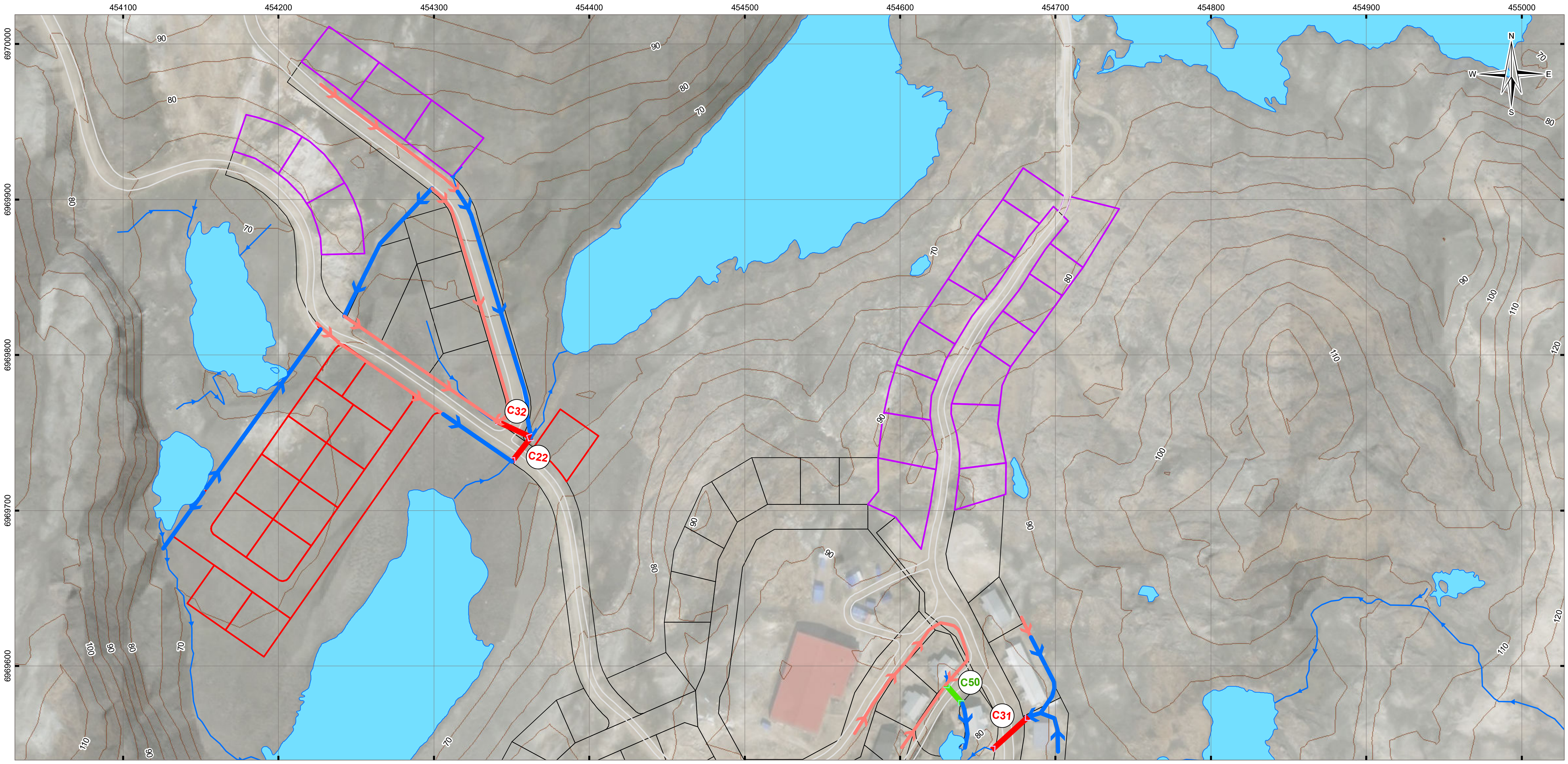
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

TETRA TECH

Figure 5-5

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5_ProposedDrainage.mxd modified 2/27/2020 by Darren.Schouls

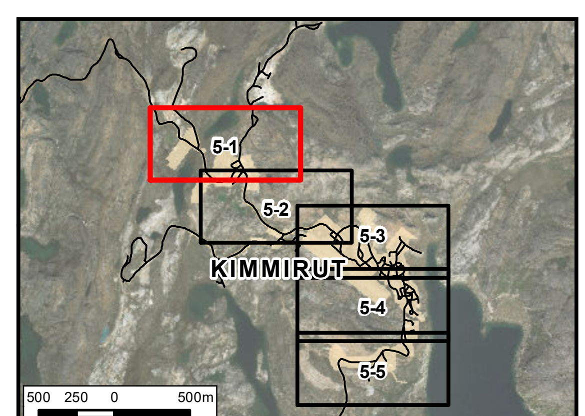


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Relocate Parcel
- Proposed Parcel
- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
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2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

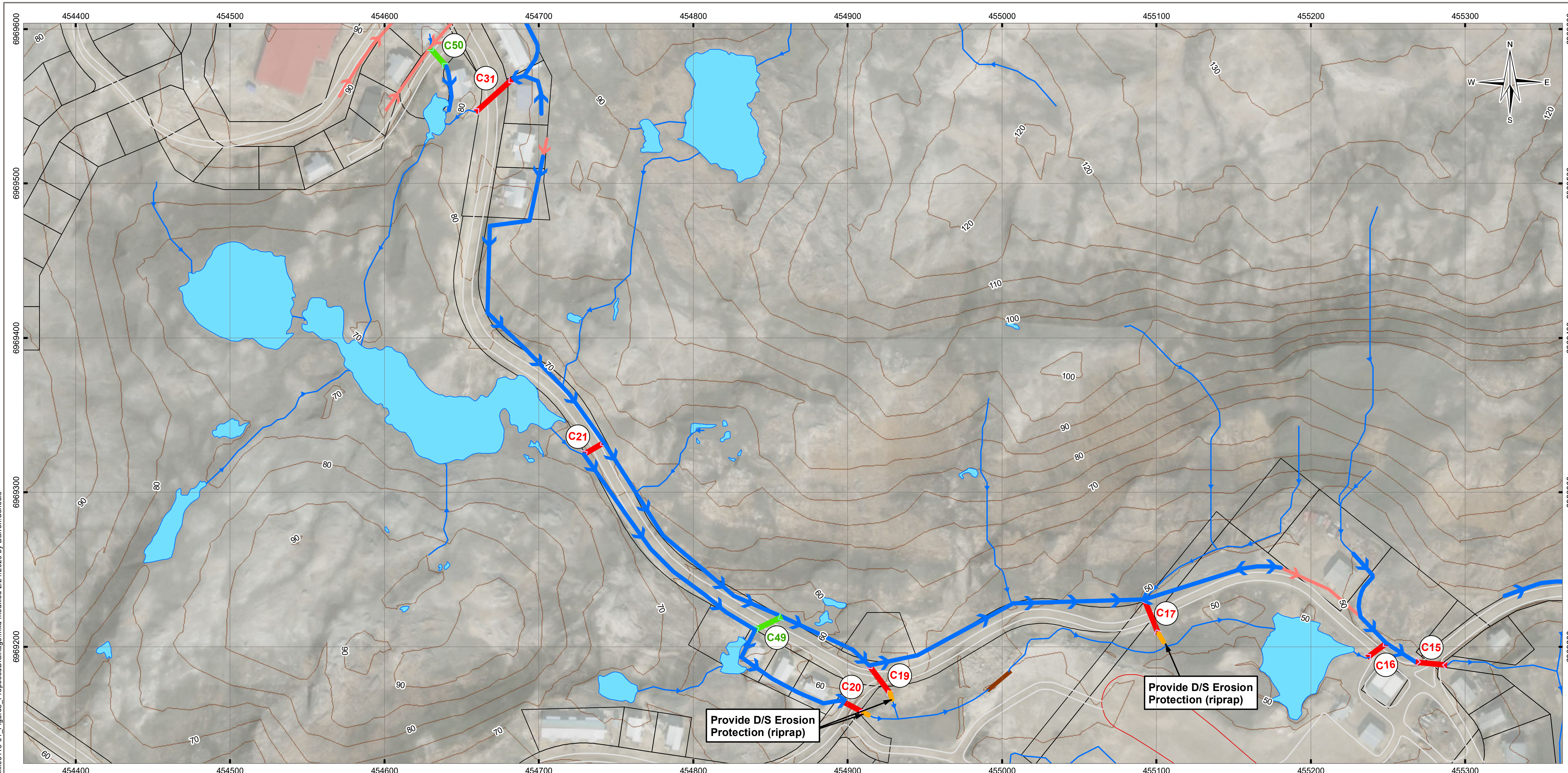
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-02

Figure 5-1

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5_ProposedDrainage.mxd modified 2/21/2020 by Darren.Schouls

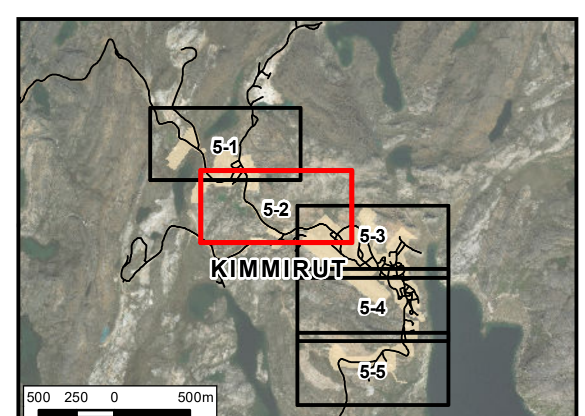


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
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STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

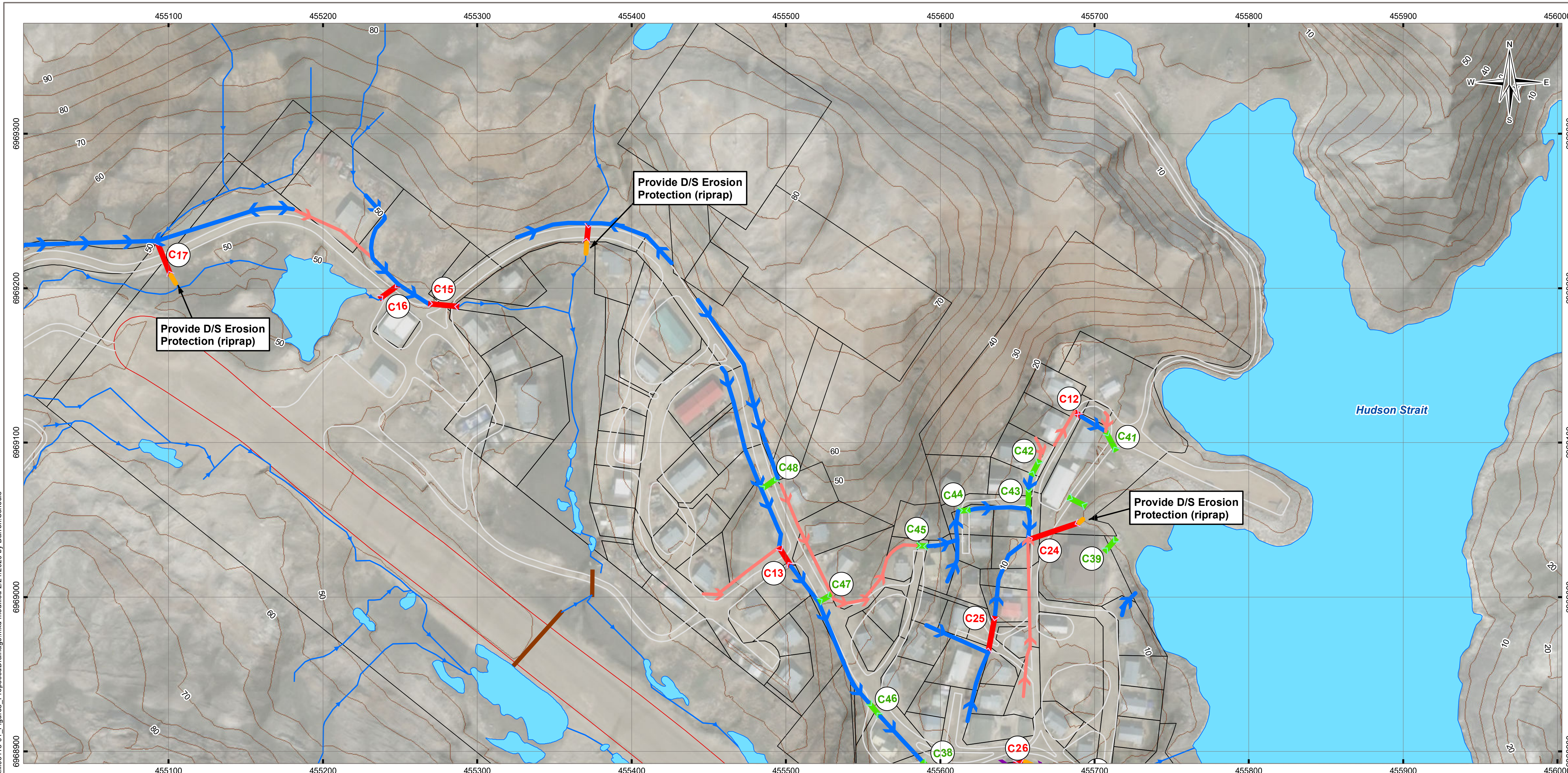
FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-02

Figure 5-2



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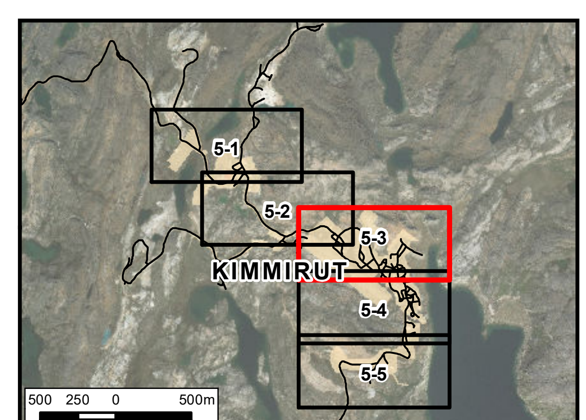
LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

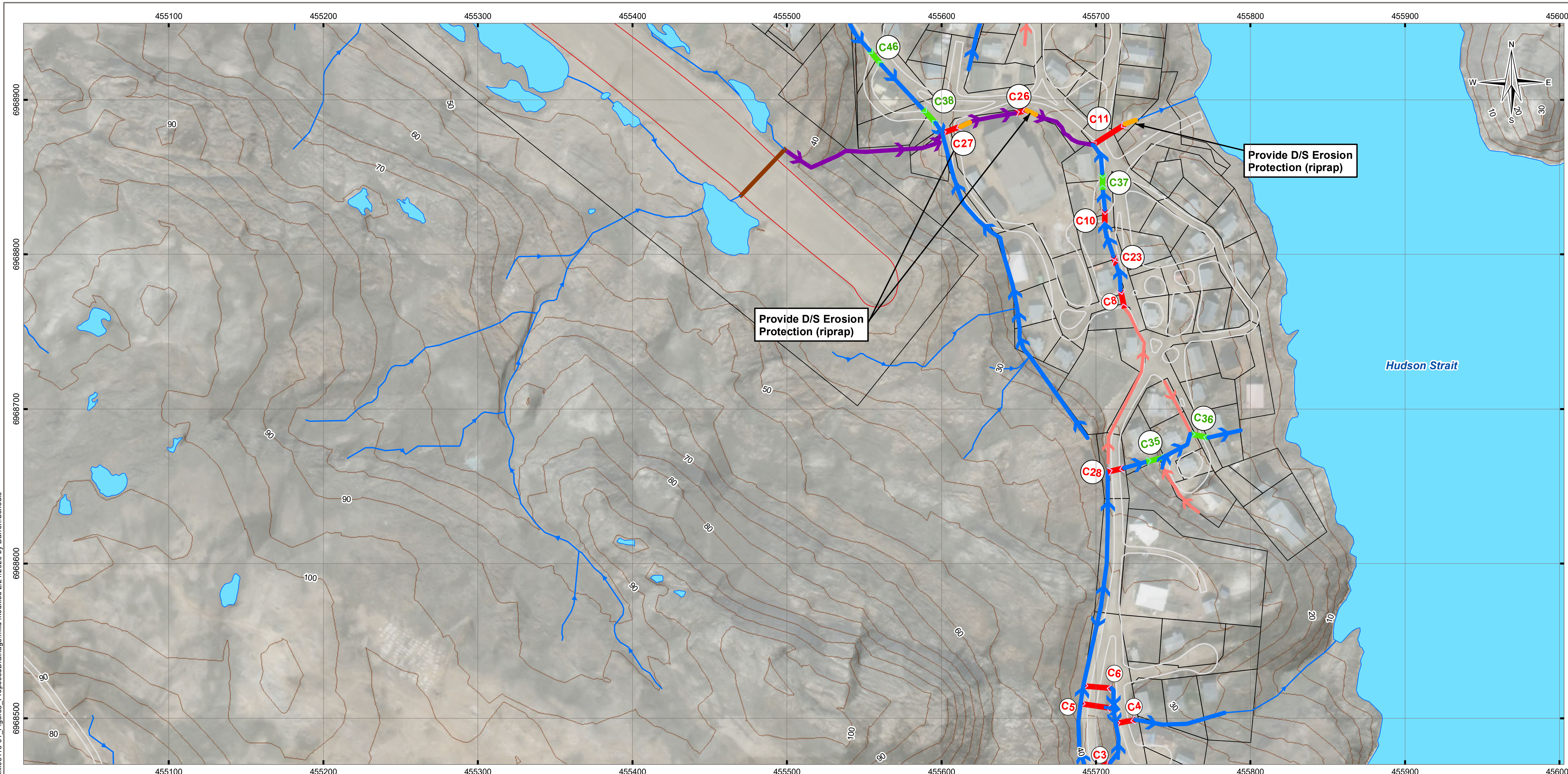
FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-02

Figure 5-3

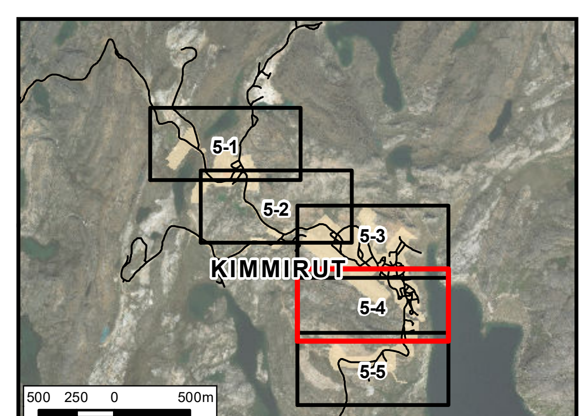


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE
February 21, 2020

PROJECT NO.
ENG.WTRM03118-02

Figure 5-4

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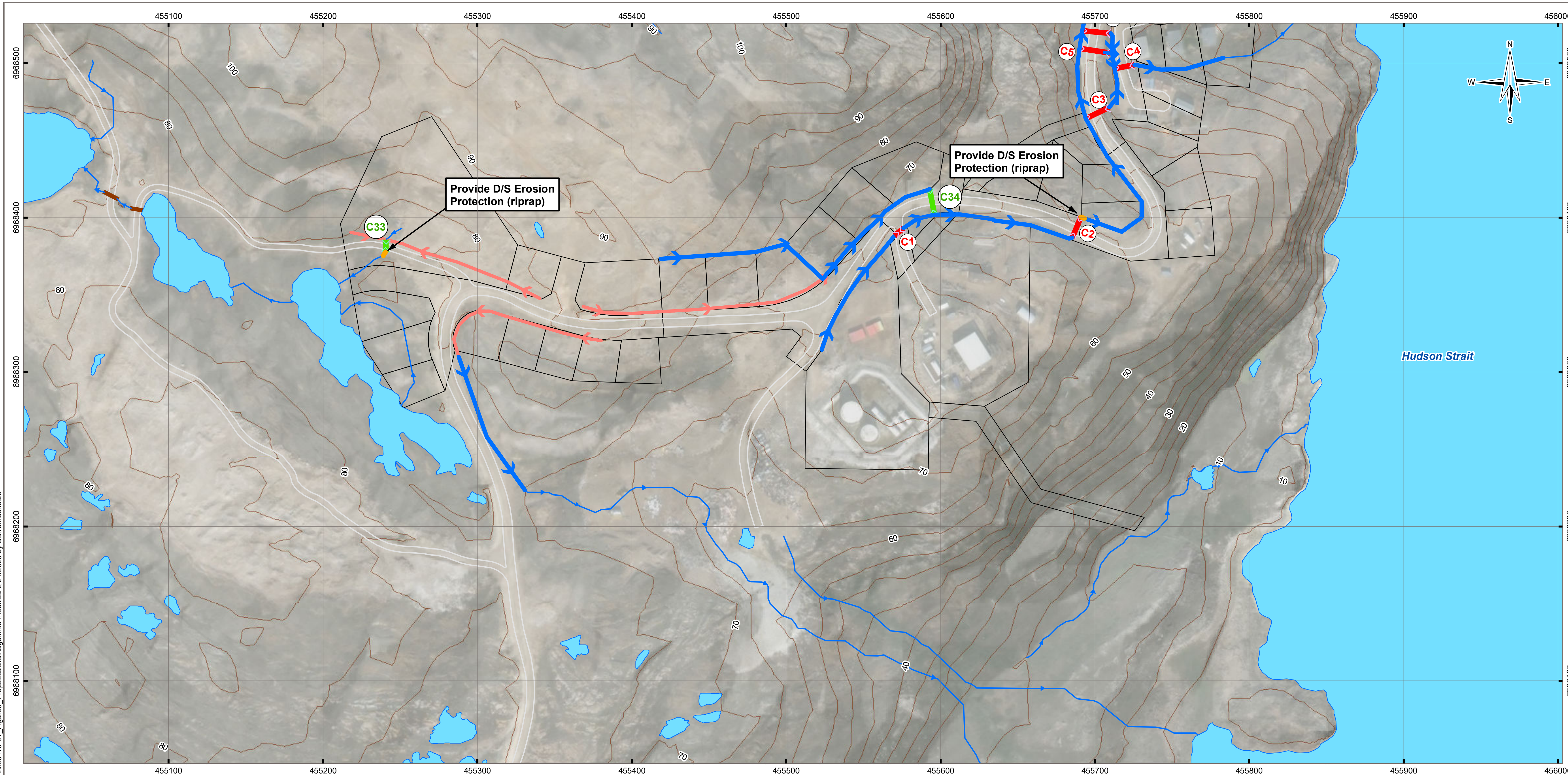
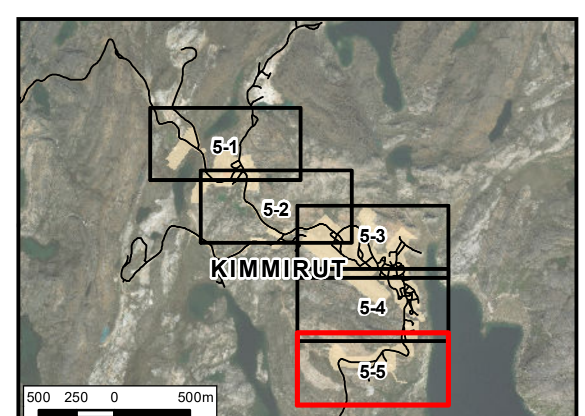


LEGEND

- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream
- C## Culvert Number

Base Data

- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Conceptual Drainage Design

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5_ProposedDrainage.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 21, 2020	ENG.WTRM03118-02

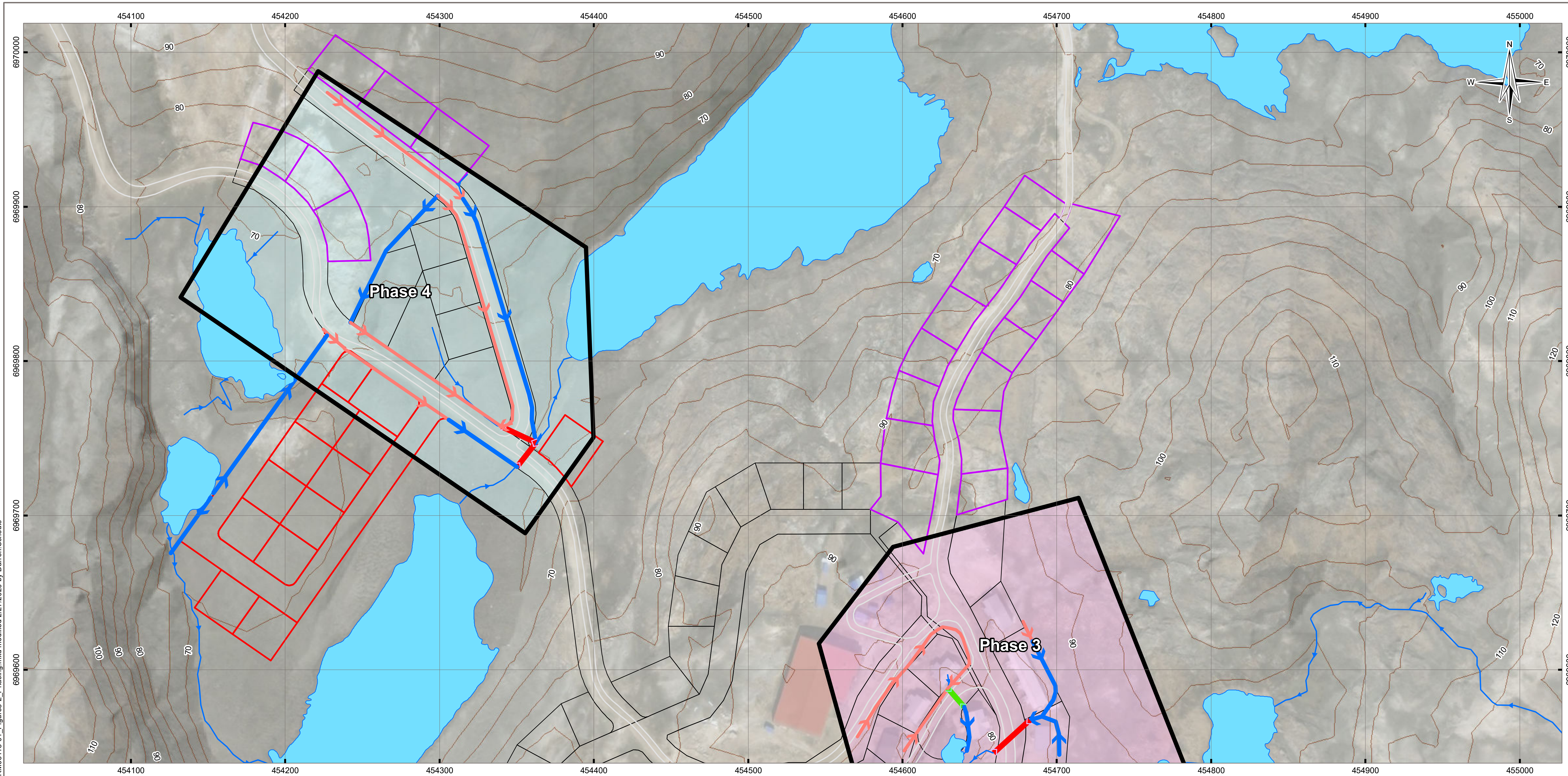
TETRA TECH

Figure 5-5

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5_ProposedDrainage.mxd modified 2/21/2020 by Darren.Schouls

5.2 Project Phasing

Tetra Tech has developed a staging plan allowing CGS and the Hamlet to first focus on the most important elements of our drainage plan and consider postponing some of the less critical aspects to future construction seasons. For each stage shown below in Figures 5-6 to 5-10, we have developed a Class “D” cost estimate to assist in future budgeting (see Section 5.3 below).



LEGEND

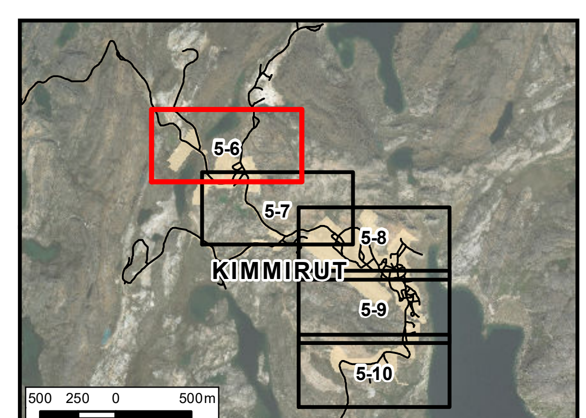
- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream

Project Phasing

- Phase 3
- Phase 4

Base Data

- Parcel Requiring Site Improvements
- Proposed Parcel
- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
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STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Project Phasing

PROJECTION: UTM Zone 19
DATUM: NAD83
CLIENT: Nunavut

Scale: 1:2,500
40 20 0 40
Metres

TETRA TECH

FILE NO.: WTRM03118-01_Figure5-2_Phasing.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE: February 27, 2020
PROJECT NO.: ENG.WTRM03118-02

Figure 5-6

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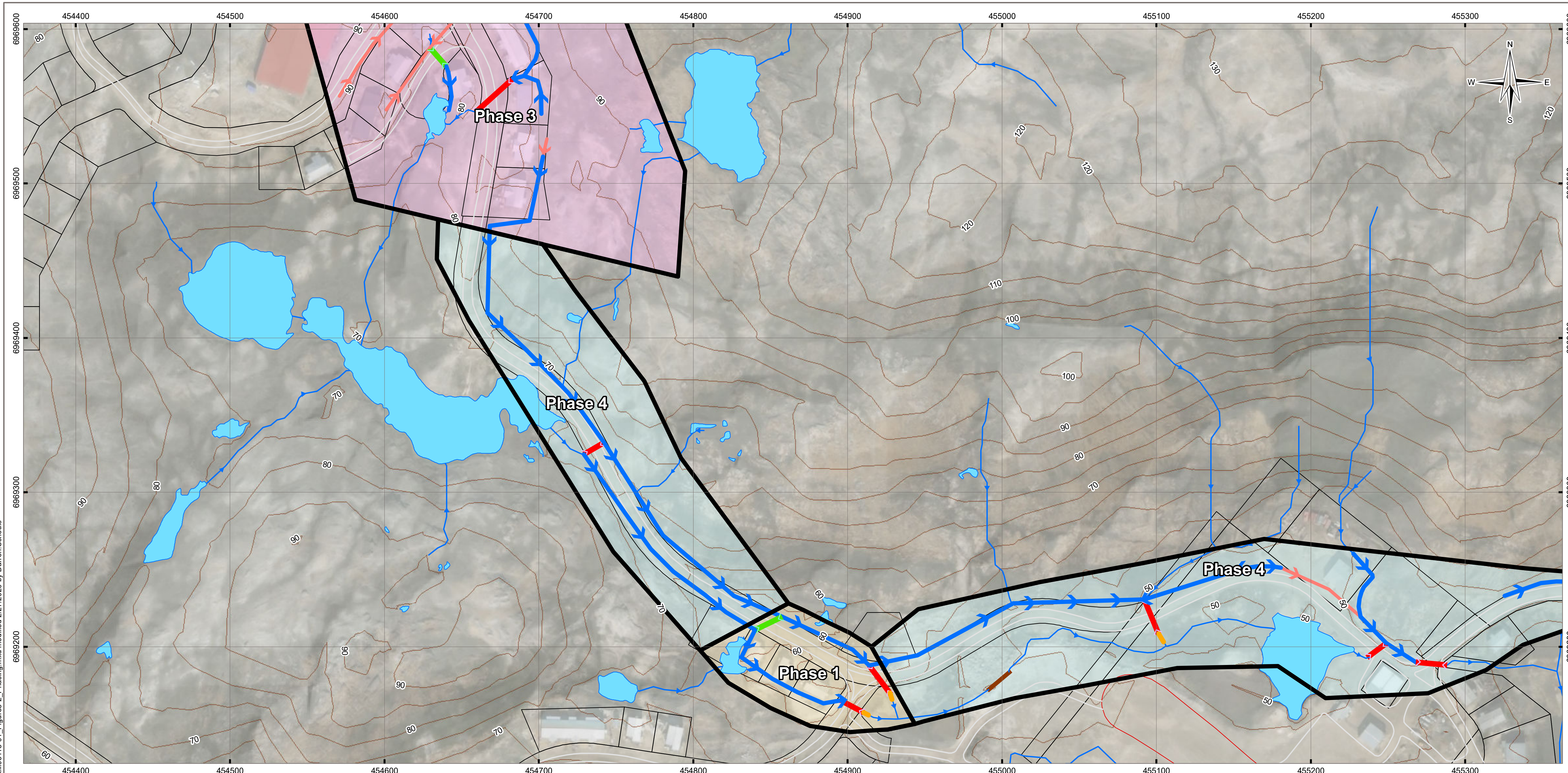


LEGEND

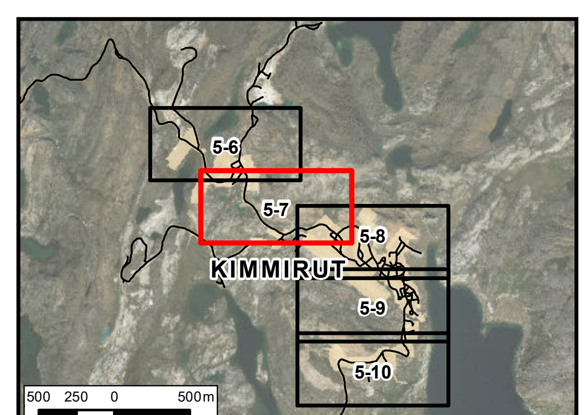
- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream

Project Phasing

- Phase 1
- Phase 3
- Phase 4

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

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STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Project Phasing

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

TETRA TECH

FILE NO.				
WTRM03118-01_Figure5-2_Phasing.mxd				
OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0
DATE	PROJECT NO.			
February 27, 2020	ENG.WTRM03118-02			

Figure 5-7

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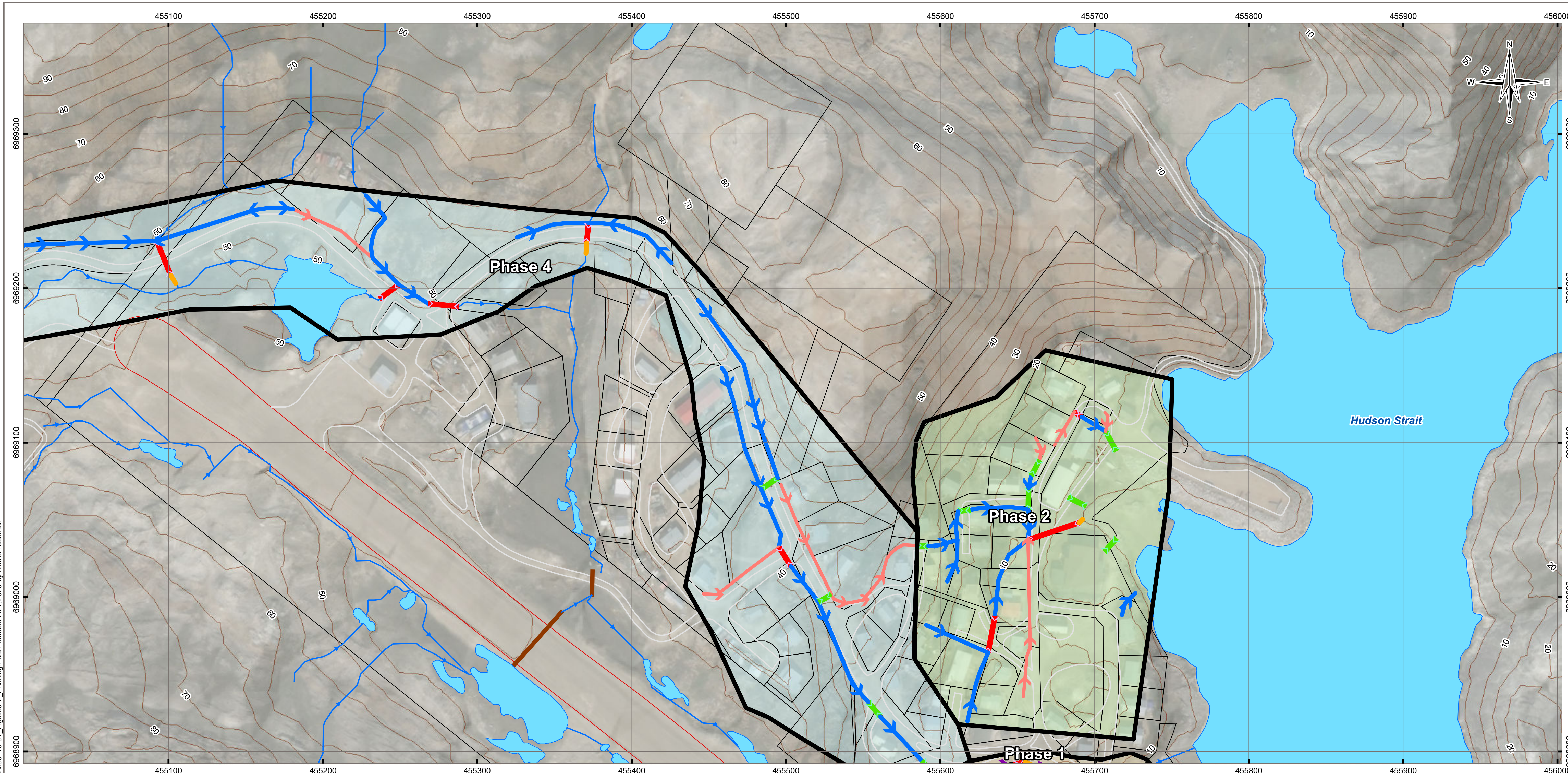

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LEGEND

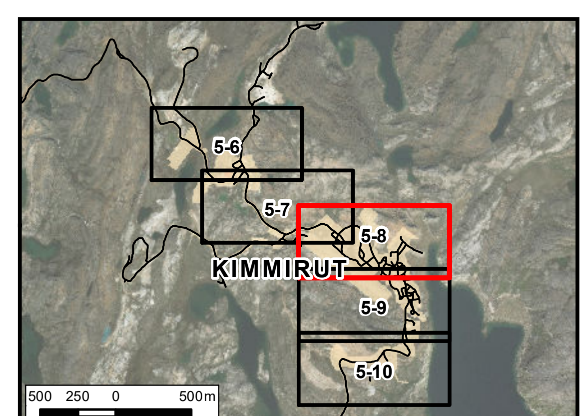
- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream

Project Phasing

- Phase 1
- Phase 2
- Phase 4

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
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STATUS
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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Project Phasing

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

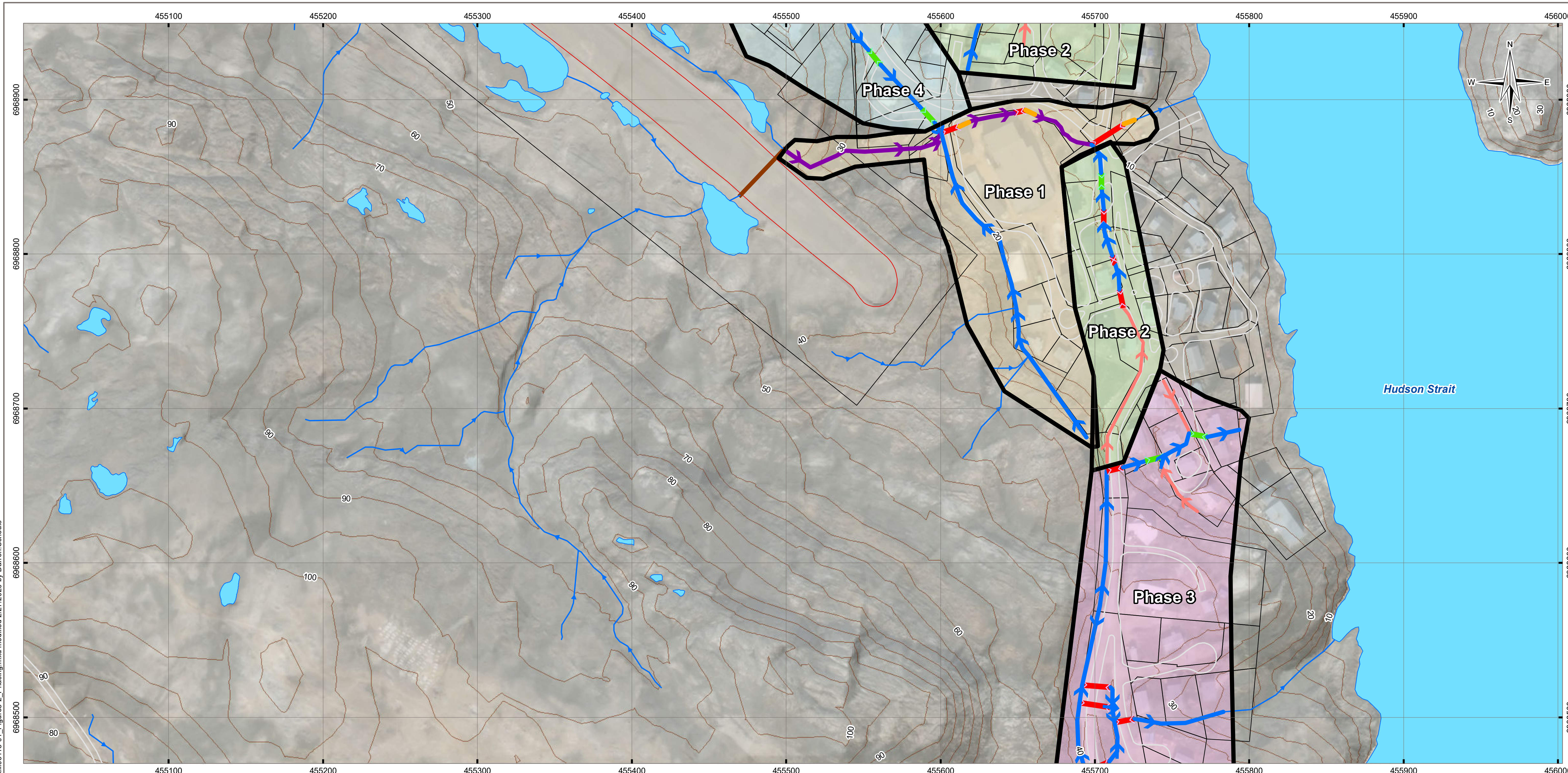
FILE NO.
WTRM03118-01_Figure5-2_Phasing.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

TETRA TECH

Figure 5-8



LEGEND

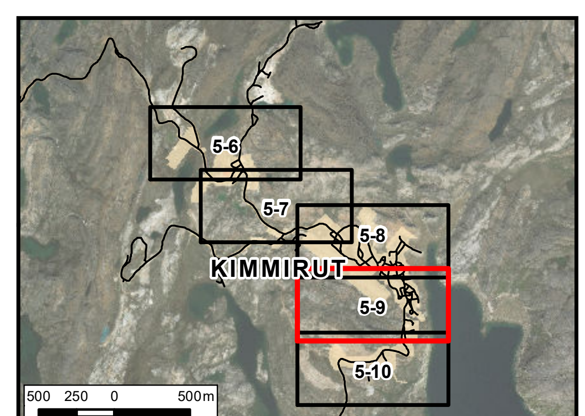
- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream

Project Phasing

- Phase 1
- Phase 2
- Phase 3
- Phase 4

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES

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2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

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KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Project Phasing

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03118-01_Figure5-2_Phasing.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-9

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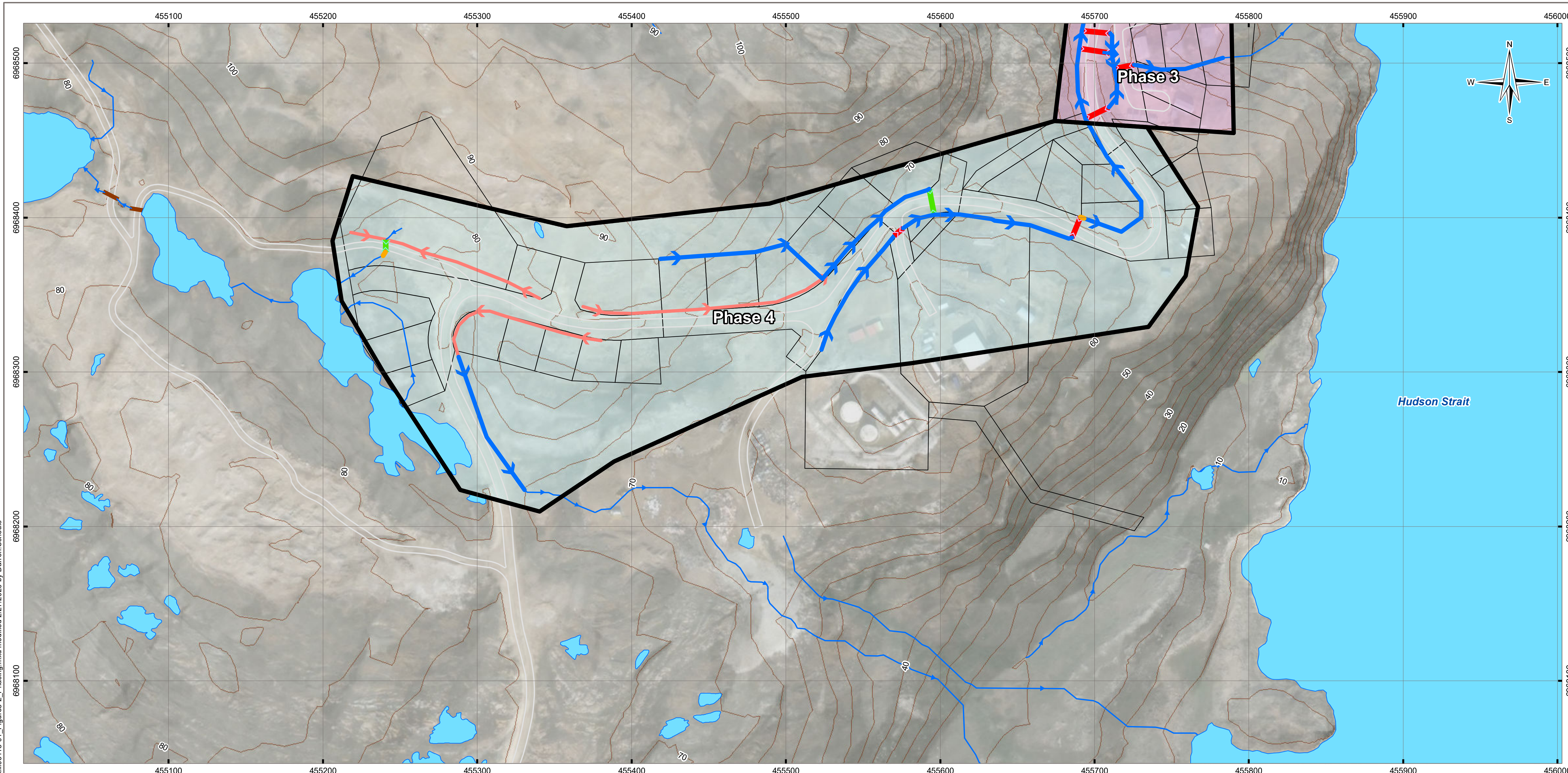


LEGEND

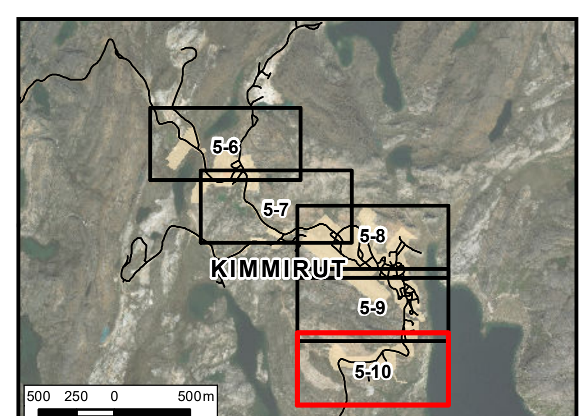
- Culvert Armoured Discharge Area
- New Culvert
- Culvert Not Assessed
- Replace Culvert
- Formalize Typical Ditch
- Formalize Typical Large Ditch
- Formalize Typical Swale
- Stream

Project Phasing

- Phase 3
- Phase 4

Base Data

- Current Parcel
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan Project Phasing

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03118-01_Figure5-2_Phasing.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-10

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5.3 Construction Cost Estimate

Construction of the Kimmirut Master Drainage Plan has been broken into four phases, with Phase 1 having the highest priority, and Phase 4 having the lowest priority.

A Class “D” cost estimate has been made for each phase. The cost estimates are included in Appendix D. A summary of the cost estimates is shown in Table 5-1 below. Additionally, a summary of the drainage materials required for each phase is presented in Table 5-2 below.

Phasing has been broken down to distribute the cost over a longer period of time to accommodate the availability of annual budgets. Combining phases will translate into greater savings as it will allow the GN to take advantage of the economy of scale.

Table 5-1: Summary of Cost Estimate

		Phase				
		1	2	3	4	Total
Preliminaries		$58,252	$47,274	$48,110	$89,335	$242,972
Civil Works		$303,524	$193,736	$202,104	$614,351	$1,313,715
Miscellaneous		$15,000	$15,000	$15,000	$15,000	$60,000
Sub-total		**$376,776**	**$256,010**	**$265,214**	**$718,686**	**$1,616,687**
Project Contingencies	40.0%	$150,711	$106,086	$287,474	$646,675	$712,059
Total Estimated Construction Cost		**$527,487**	**$358,413**	**$371,300**	**$1,006,161**	**$2,263,361**

Table 5-2: Summary of Required Drainage Materials

	Phase 1			Phase 2			Phase 3			Phase 4			Total		
Item	Est Quantity	Unit	Count	Est Quantity	Unit	Count	Est Quantity	Unit	Count	Est Quantity	Unit	Count	Est Quantity	Unit	Count
450 mm Culvert	20	m	1	152	m	13	69	m	5	131	m	9	372	m	28
600 mm Culvert	24	m	1	36	m	1	71	m	3	66	m	5	197	m	10
750 mm Culvert	17	m	1		m		14	m	1	20	m	1	51	m	3
900 mm Culvert		m			m			m		25	m	1	24	m	1
1400 mm Culvert	46	m	3		m			m			m		46	m	3
Total New Culverts	107	m	6	188	m	14	154	m	9	242	m	16	690	m	45
50 kg Class Riprap	238	cu. m		20	cu. m		0	cu. m		52	cu. m		310	cu. m	
10 kg Class Riprap	728	cu. m		403	cu. m		511	cu. m		2,321	cu. m		3963	cu. m	
50 – 75 mm Clear Crush	0	cu. m		31	cu. m		33	cu. m		167	cu. m		231	cu. m	
Non-Woven Geotextile	2733	sq. m		1,364	sq. m		1,730	sq. m		8,368	sq. m		14,195	sq. m	
Culvert Removal	86	m	5	94	m	6	111	m	6	161	m	10	460	m	27

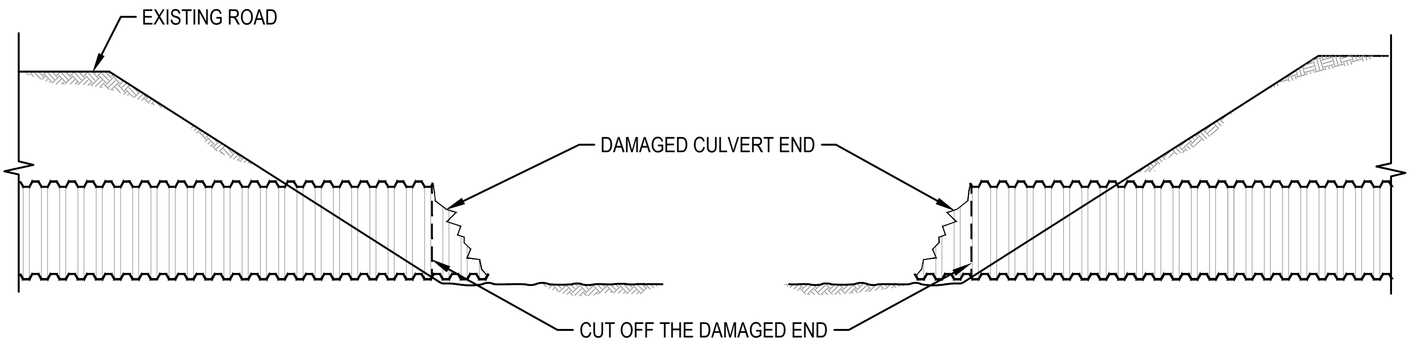
5.4 Ongoing System Maintenance

A properly maintained and monitored community drainage system is an important part of maintaining the safety and well-being of the community. To ensure proper functioning of the drainage system, a program to maintain and monitor the drainage system should be implemented.

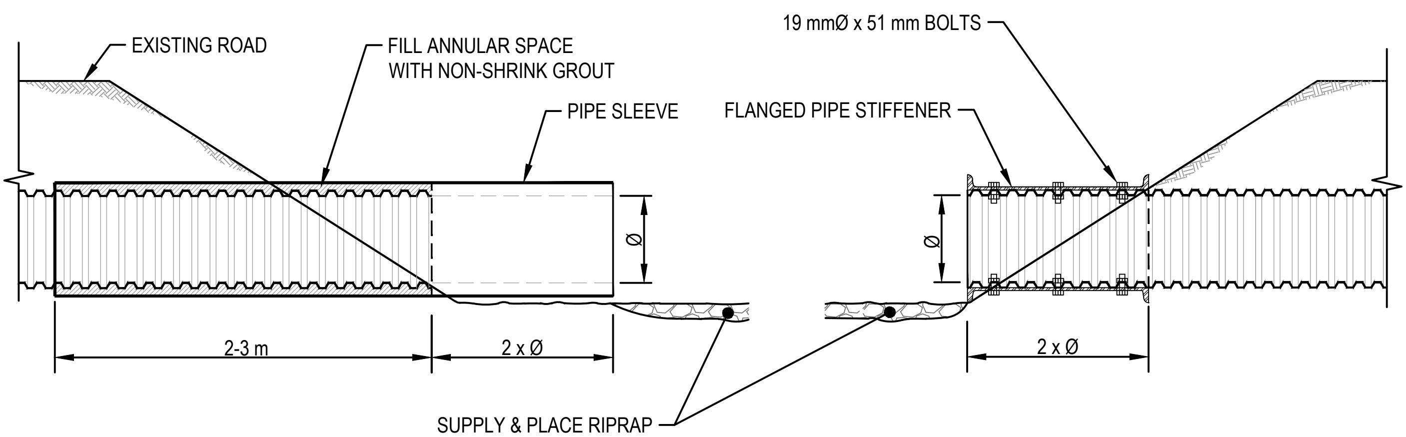
5.4.1 Culvert Maintenance and Repair

As per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), culvert maintenance and repair guidelines are as follows:

- Culverts should be marked with a post painted in a bright colour and installed at the precise location of the culvert end. Culvert marking posts, when lost or damaged, shall be replaced.
- Spare culverts of each size shall be kept on hand to facilitate the repair and replacement of all sizes of culverts.
- Where the culverts are in good shape and only the ends are damaged, a SWSP sleeve should be added to reinstate the original length of the culvert. The annular space between the existing pipe and the SWSP sleeve should be grouted and sealed. Figure 5-11 provides a sketch covering the proposed repairs.



BEFORE REPAIR



AFTER REPAIR

PIPE SLEEVE OPTION
SCALE: NTS

PIPE STIFFENER OPTION
SCALE: NTS

NOTE:

CLIENT

Nunavut

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KIMMIRUT DRAINAGE PLAN

DAMAGED CULVERT END REPAIR DETAILS

PROJECT NO.	DWN	CKD	REV	
WTRM03118-02	MJK	ER	A	**FIG.5-11**
OFFICE	DATE			
VANC	February 20, 2020			

5.4.2 Snow Removal Management Plan

As per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), snowmelt from removed snow should be prevented from re-entering the drainage system. Runoff from stockpiled snow can re-enter and overwhelm the drainage system and causing flooding damage.

To that end, Tetra Tech has identified the following snow removal strategy:

- Removed snow from roadways and driveways can be safely deposited in one of the designated Deposition Zones as shown in Figures 5-12 to 5-16.
- Removed snow from the airport runway can be stored in one of the designated Airport Deposition Zones as shown in Figures 5-12 and 5-16.
- Removed snow from the airport runway shall not be stored along the east side of the runway as shown in Figure 5-14 and Figure 5-15.
- Airport maintenance staff shall continually monitor the snow accumulation to the northeast of the runway where snow damming can occur. Staff are advised to break the snow down with an excavator if damming occurs.

LEGEND

Deposition Zone

Base Data

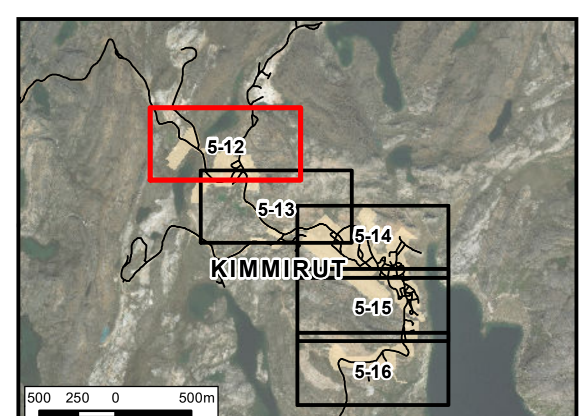
Parcel Requiring Site Improvements

Proposed Parcel

Current Parcel

Gravel Road

Topographic Contour (5 m)



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

TETRA TECH

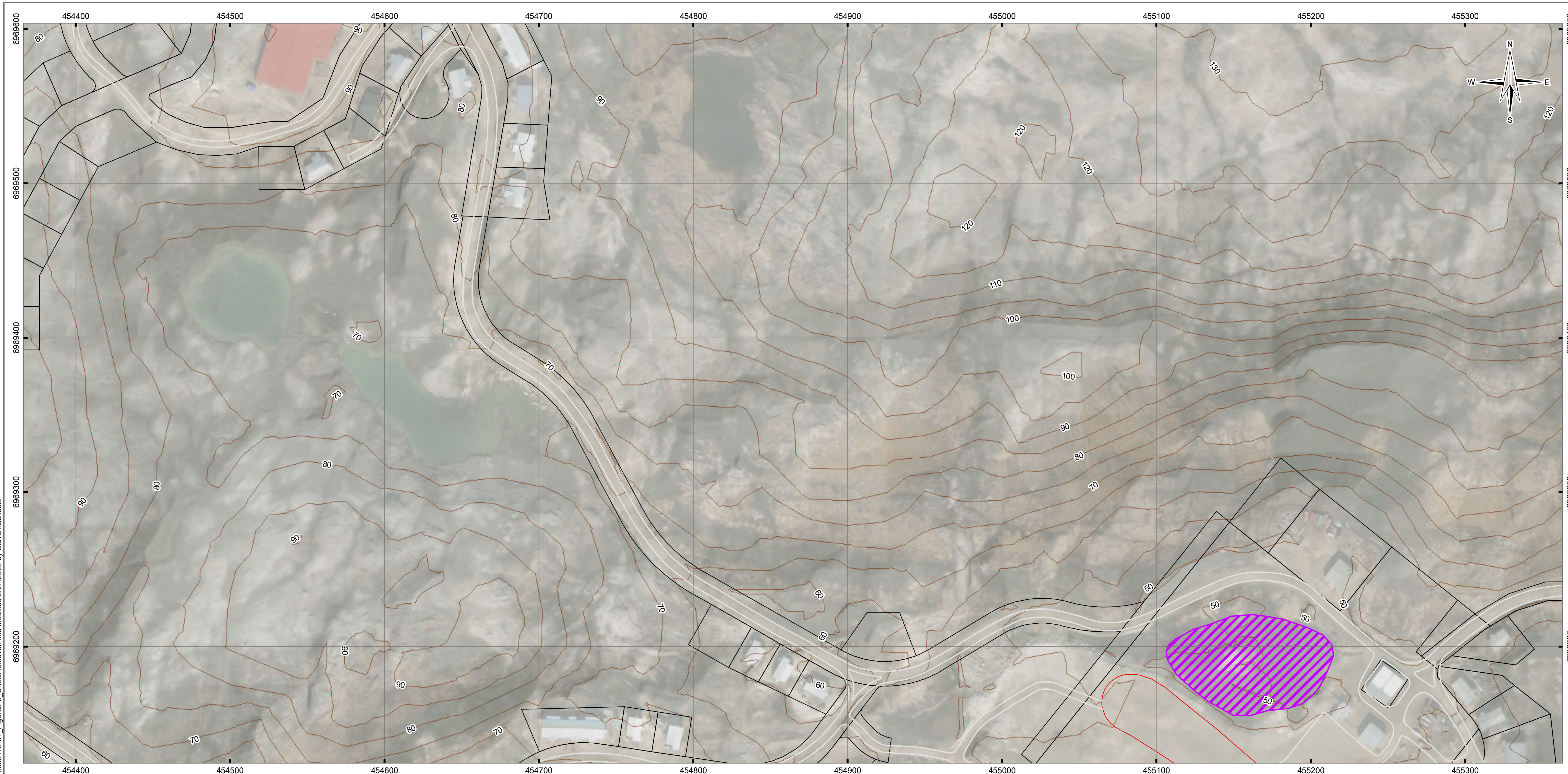
FILE NO.
WTRM03118-01_Figure5-3_SnowRemoval.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-12

Q:\Vancouver\GIS\TRANSPORTATION\WTRM\WTRM03118-01\Maps\WTRM03118-01_Figure5-3_SnowRemoval.mxd modified 2/27/2020 by Darren.Schouls



LEGEND

Airport Deposition Zone

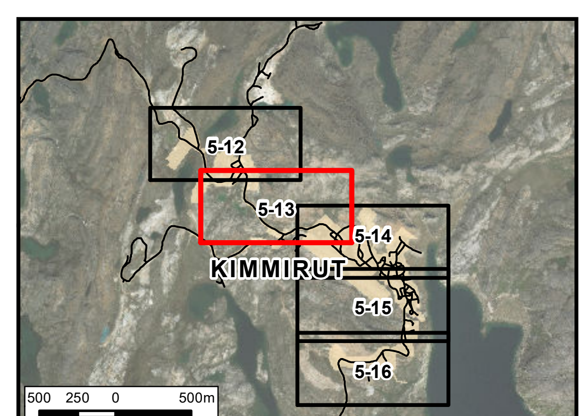
Base Data

Current Parcel

Runway

Gravel Road

Topographic Contour (5 m)



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

TETRA TECH

FILE NO.
WTRM03118-01_Figure5-3_SnowRemoval.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-13

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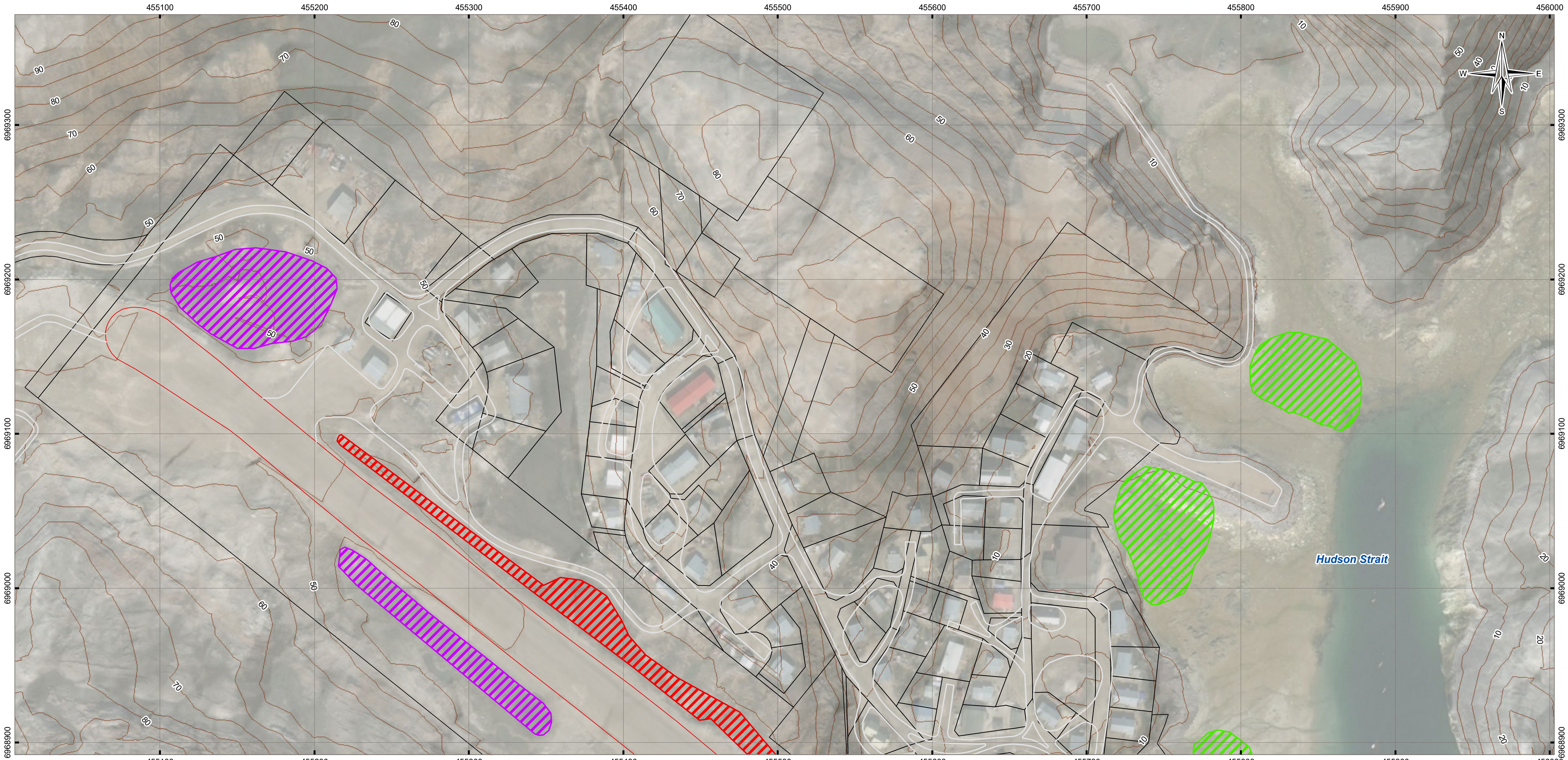
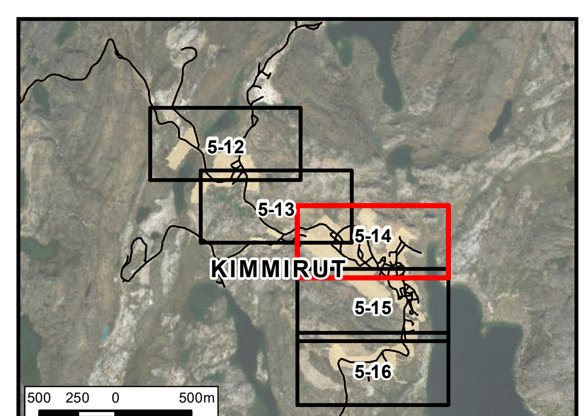


LEGEND

- Airport No Deposition Zone
- Deposition Zone
- Airport Deposition Zone

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)



NOTES
Base data source:
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2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5-3_SnowRemoval.mxd

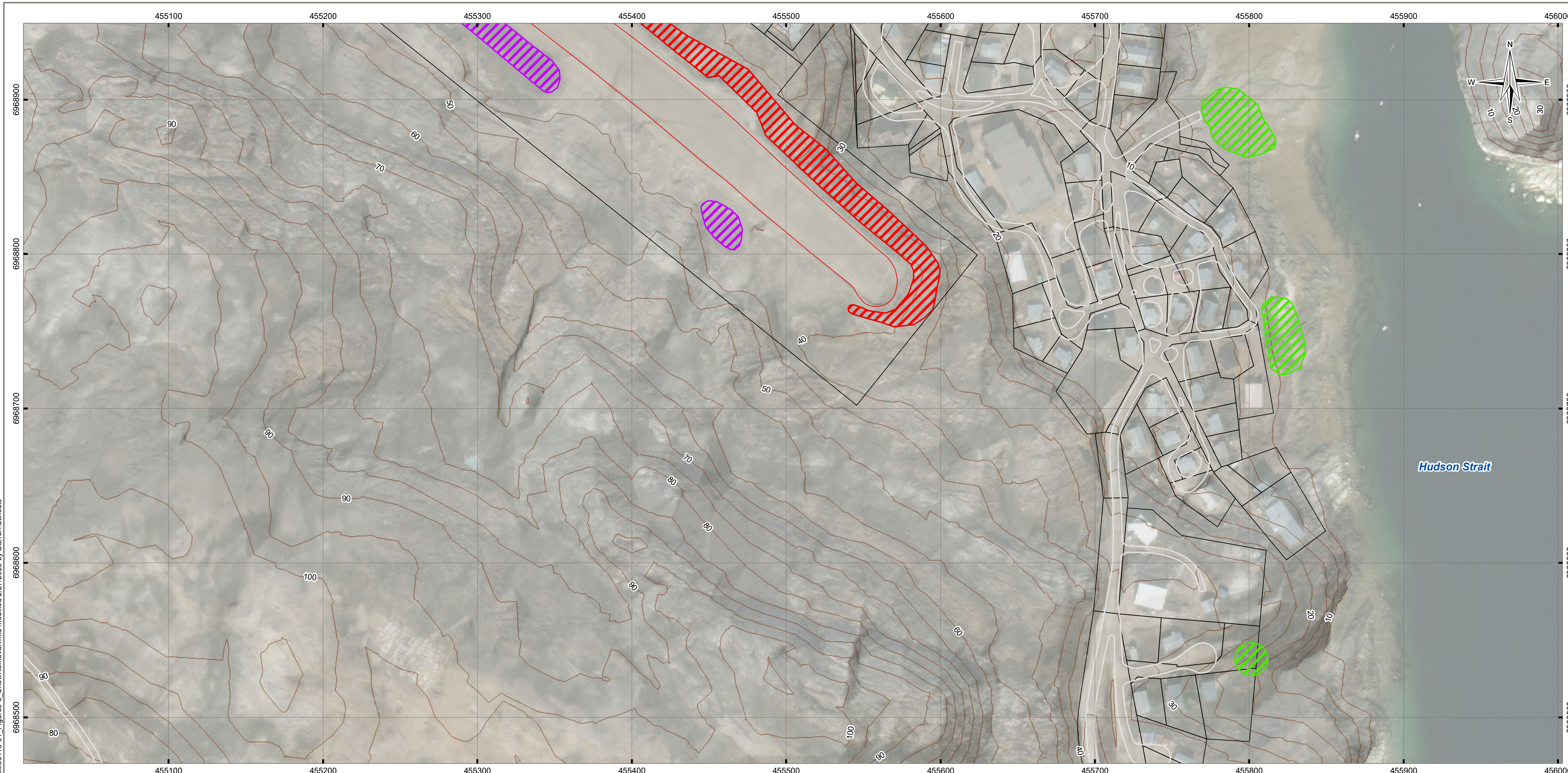
TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE
February 27, 2020

PROJECT NO.
ENG.WTRM03118-02

Figure 5-14

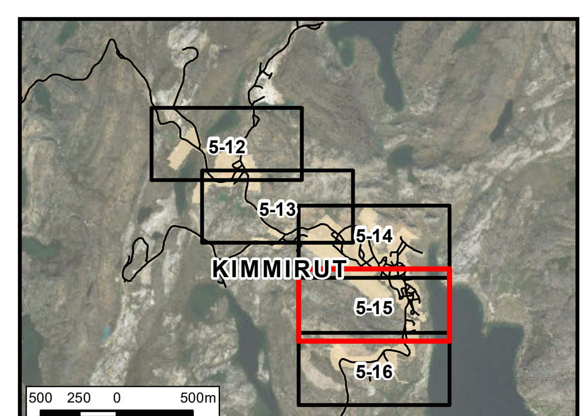


LEGEND

- Airport No Deposition Zone
- Deposition Zone
- Airport Deposition Zone

Base Data

- Current Parcel
- Runway
- Gravel Road
- Topographic Contour (5 m)



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500

40 20 0 40

Metres

FILE NO.
WTRM03118-01_Figure5-3_SnowRemoval.mxd

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

TETRA TECH

Figure 5-15

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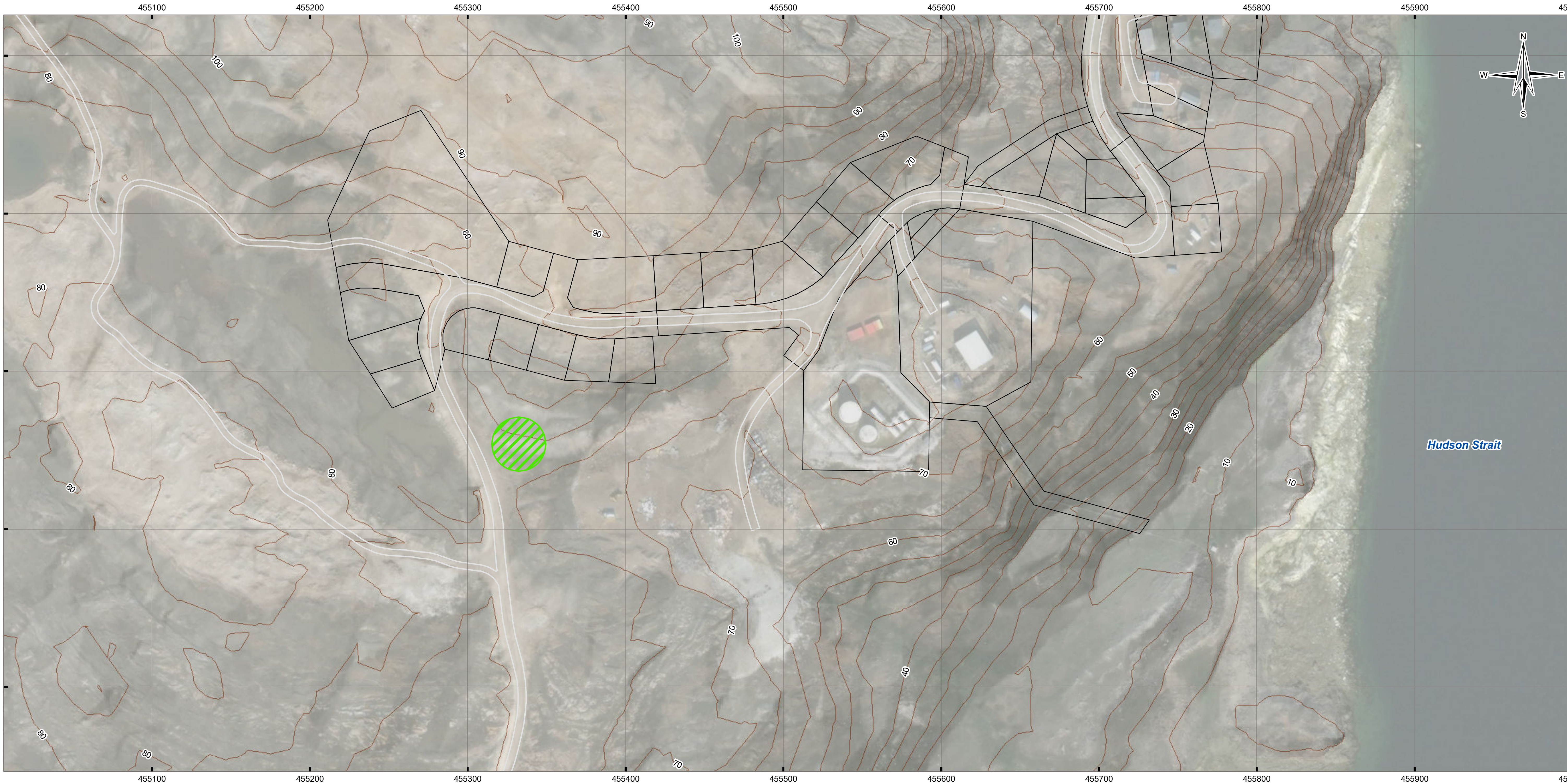


LEGEND

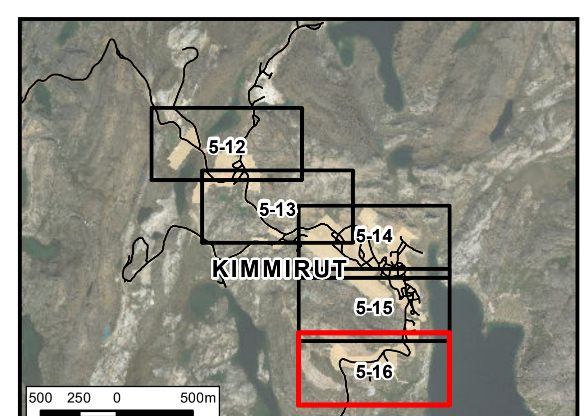
Deposition Zone

Base Data

Current Parcel

Gravel Road

Topographic Contour (5 m)



NOTES

Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT MASTER DRAINAGE PLAN

Community Plan
Snow Removal Management Plan

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:2,500
40 20 0 40
Metres

FILE NO.
WTRM03118-01_Figure5-3_SnowRemoval.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure 5-16

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5.4.3 Culvert Thawing

An annual maintenance program should incorporate a culvert thawing strategy. Some options for thawing culverts are presented in Appendix C for consideration. Figure 5-17 below shows the proposed method for thawing ice inside culverts.

As per the project phasing diagrams shown in Figures 5-6 to 5-10, higher priority culverts should be thawed first. For example, culverts in Phase 1 zones should be thawed before culverts in Phase 2 zones.

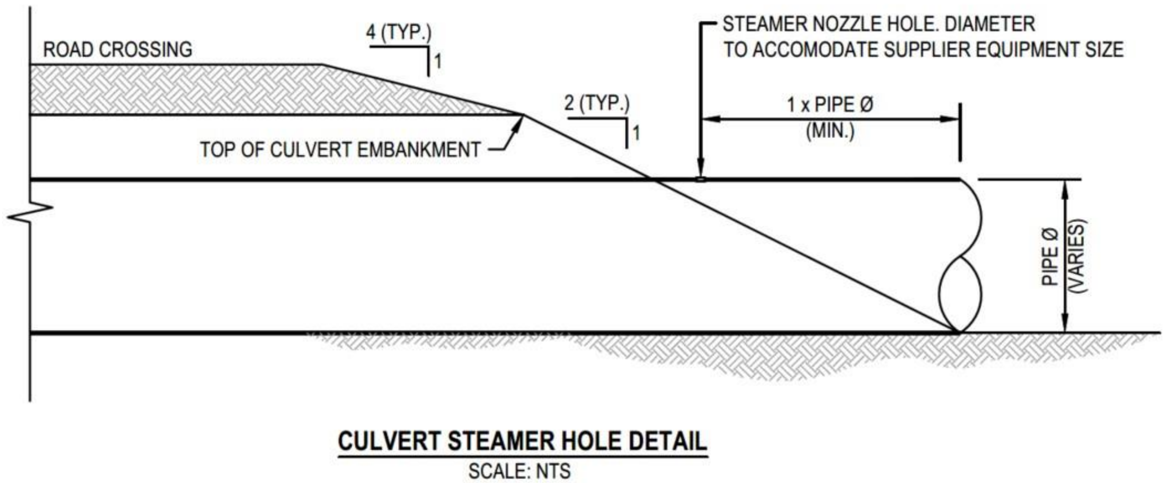

Figure 5-17: Culvert Thawing Detail

5.4.4 Maintenance Schedule

A recommended seasonal maintenance schedule as per the guidelines for community drainage system planning, design, and maintenance in northern communities (CSA Group, 2015), is presented as follows:

Spring:

- Visually inspect and thaw frozen culverts in order of their priority level, as discussed in Section 5.4.3. Note any damages to culverts.
- Remove debris from blocked or partially blocked culverts.
- Collect and dispose of litter if present.
- Following the spring Freshet, inspect the drainage system to identify deficiencies for repair.

Summer:

- Repair washed out ditches, swales and riprap aprons as necessary. Ponding in ditches and swales should be identified and fixed by re-sloping the ditch.
- A water pump can be used to flush blocked culverts free of sediment, rocks, and debris. Discharge of sediments into natural streams should be avoided and appropriate sediment and erosion control measures should be incorporated to protect the receiving water bodies.

- Repair damaged culvert ends. Replace or re-install culverts that have shifted or moved. Repair culverts in order of their priority level and the level of damage observed.

Fall:

- Complete repairs to the drainage system.
- Replace missing or damaged culvert marking posts.
- Create an inventory of materials required for the next year's maintenance program.

Winter:

- Monitor culverts and culvert marking posts.
- Implement the snow removal management plan as detailed in Section 5.4.2.
- Monitor snow buildup beside the airport runway and remove snow as necessary to prevent snow damming.

6.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

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7.0 REFERENCES

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APPENDIX A

TETRA TECH'S LIMITATIONS ON THE USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

HYDROTECHNICAL

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

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1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

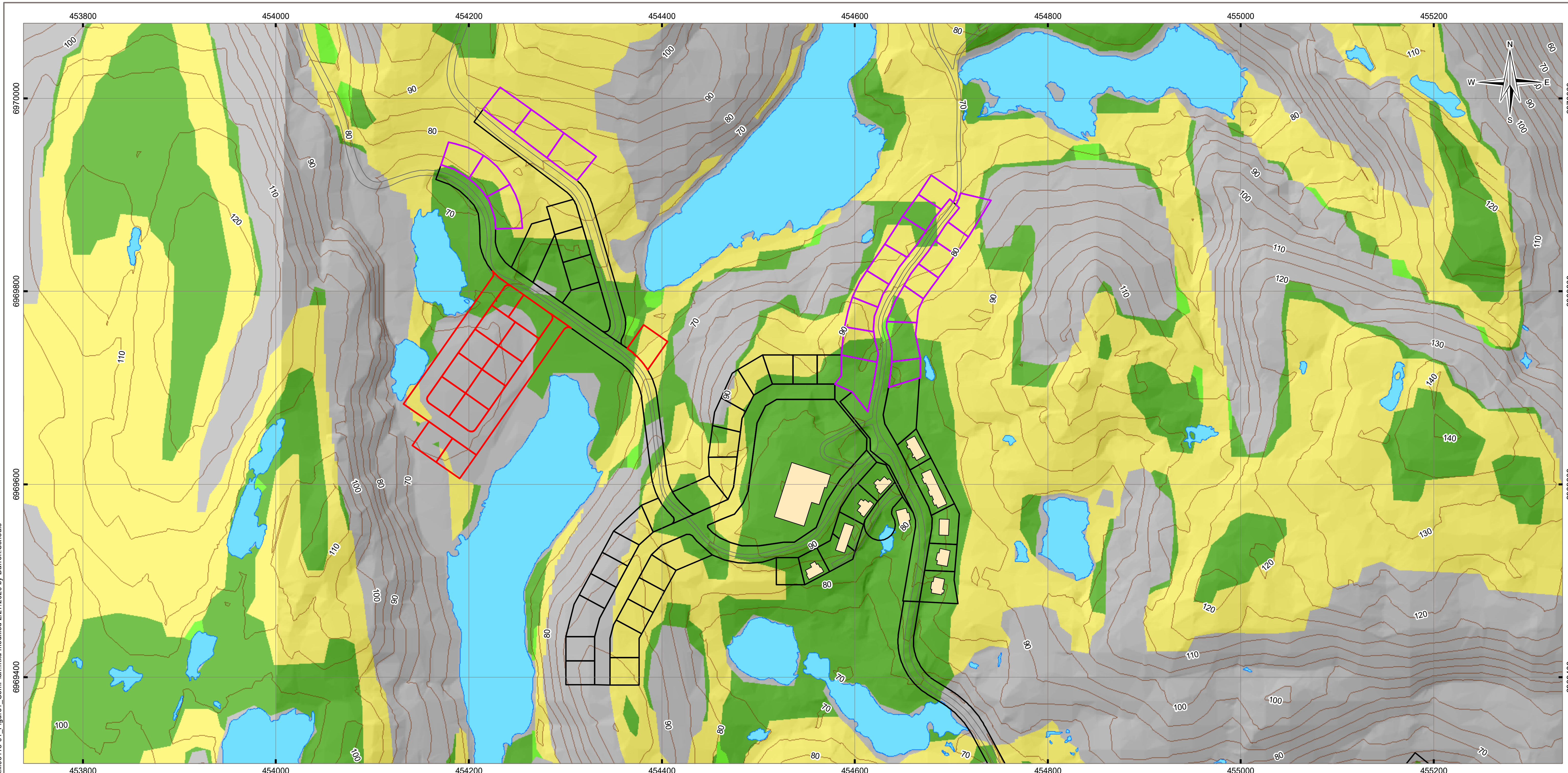
Unless expressly agreed to in the Services Agreement, TETRA TECH was not retained to investigate, address or consider, and has not investigated, addressed or considered any environmental or regulatory issues associated with the project.

1.8 LEVEL OF RISK

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the hydrotechnical information that was reasonably acquired to facilitate completion of the design.

APPENDIX B

COMMUNITY PLANS AND BYLAW NO. 127



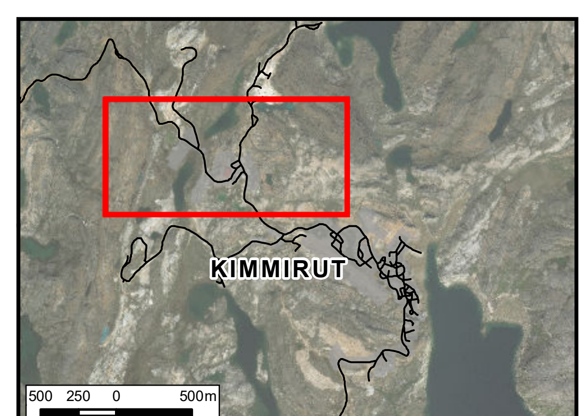
LEGEND

Development Suitability

- Suitable
- Possible
- Marginal
- Unsuitable

Base Data

- Parcel Requiring Site Improvements
- Proposed Parcel
- Current Parcel
- Building Footprint
- Gravel Road
- Topographic Contour (5 m)
- Waterbody



NOTES
Base data source:
1. Imagery from ESRI Basemap Gallery, DigitalGlobe, 2017
2. Water bodies, parcels, topographic contours, and hillshade from Nunavut base data

STATUS
ISSUED FOR USE

KIMMIRUT COMMUNITY PLAN

Revised Community Planning Map

PROJECTION	DATUM	CLIENT
UTM Zone 19	NAD83	Nunavut

Scale: 1:4,000
80 40 0 80
Metres

FILE NO.
WTRM03118-01_Figure1_ComPlan.mxd

TETRA TECH

OFFICE	DWN	CKD	APVD	REV
Tt-VANC	DL	YL	ER	0

DATE	PROJECT NO.
February 27, 2020	ENG.WTRM03118-02

Figure B1

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SCHEDULE 1 - COMMUNITY PLAN

SECTION 1 INTRODUCTION

1.1 Purpose of the Plan

The purpose of the Kimmirut Community Plan is to outline Council's policies for managing the physical development of the Hamlet for the next 20 years - to 2034. The Community Plan was created through a community consultation process and reflects the needs and desires of the Community. The Community Plan builds on previous plans, while incorporating new challenges, issues and needs identified by the Community.

1.2 Goals of the Community Plan

Community Plan policies emerge from the values of a community and its vision of how it would like to grow. The goals established for this Community Plan are:

1. To develop in an orderly fashion creating a safe, healthy, functional, and attractive community that reflects community values and culture.
2. To promote the Plan as a tool for making effective and consistent decisions regarding land use and development in the community.
3. To ensure an adequate supply of land for all types of uses to support the growth and change of the community.
4. To build upon community values of participation and unity to support community projects and local economic development.
5. To protect the natural beauty of "Nuna", protect viewpoints to the water, and retain waterfront and lakeshore areas for public uses and traditional activities.

1.3 Administration of the Plan

The Community Plan is enacted by By-law. Changes to the Plan can be made by amending the By-laws in accordance with the *Nunavut Planning Act*. The Community Plan should be reviewed and updated every five years as required by the *Nunavut Planning Act*. A Zoning By-law is also being enacted for the purpose of implementing detailed policies based on the Community Plan. All development must follow the intent of the Community Plan and Zoning By-law. The Community Plan includes Schedule 1 (Plan Policy Text), Schedule 2 (Community Plan and Zoning Map) and Schedule 3 (General Land Use Map).

SECTION 2. COMMUNITY GROWTH AND PHASING POLICIES

At the time of preparation of this Plan, the population of Kimmirut was approximately 455 people. This Plan is based on a future population of 591 people by 2034. It is estimated that an additional 67 dwelling units will be required to meet the projected population growth, representing the need for approximately 3 hectares of land for residential development. In addition, an appropriate mix and range of industrial, commercial, and community uses has been proposed to meet long-term needs. The policies of Council are:

a) Plan for a 2034 population of 591.
b) Identify sufficient land on the Community Plan to meet the needs of the projected 2034 population.
c) Review the Community Plan in 5 years, in 2019, to re-assess actual rates of growth and community needs.
d) Council will generally phase new land development as follows:
   - i.) 2014 - 2019:
     - Develop existing vacant lots within the Arena Subdivision (Phase 1 area).
     - Develop lots in the industrial subdivision near the power plant.
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     - Develop Phase 2 area within the Arena Subdivision.
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e) Council may change the phasing of development without amendment to this Plan.

SECTION 3. GENERAL POLICIES

The following policies of Council apply to all development in the Hamlet regardless of land use designation:

a) The development of lots shall be subject to the following lot development policies:
   i.) All service connections to buildings shall be easily accessed from the front yard on all lots and grouped together, where possible.
ii.) Access to new buildings will avoid, where possible, main entrances on the south-southeast side to reduce problems associated with snow drifting.
iii.) Buildings shall be sited to respect setbacks identified on the Zoning Chart.
iv.) Any building over 500 m2 in gross floor area shall consider potential wind impacts on surrounding development. A wind study may be required by the Development Officer.
v.) Culverts are required and shall be installed at the access points to lots.
vi.) On any portion of a lot where fill is introduced, drainage shall be directed towards the public road. Exceptions may be made by the Development Officer. Where possible, drainage troughs shall not be located in Utility Rights-of-Way or Easements.
vii.) Road widenings may be obtained as required at the time of development or redevelopment of a lot in situations where the road right of way is less than 16 metres wide.

b) Utilities or communication facilities shall be permitted in any land use designation. Other than designated Rights-of-Way or Easements for Utility or Communication lines, Easements alongside roadways, marked between the edge of the roadway and lot lines, will be used for distribution lines, with a minimum clearance, as specified in the Utility Corporation's Joint Use Agreement.
c) The Hamlet will pile snow in locations to minimize downwind snow drifting and where spring melt run-off can be properly channeled to drainage ditches or waterbodies.
d) The Hamlet will avoid piling snow within at least 30.5 metres (100 feet) of any watercourse.
e) No development is generally permitted within 30 metres from the normal high water mark of a waterbody or watercourse.
f) The Hamlet shall protect any cemeteries and sites of archaeological, ethnicographical, palaeontological or historical significance from disturbance. Any development in or near such sites shall follow the *Nunavut Archaeological and Palaeontological Regulations, 2001* of the Nunavut Act (Canada).
g) The Hamlet shall encourage development that minimizes emissions from fossil fuels, that are energy efficient and that consider alternative energy supply technology.
h) The Hamlet shall work with the Nunavut Planning Commission to ensure that the Kimmirut Community Plan and the future Baffin Regional Land Use Plan are compatible.

SECTION 4. LAND USE DESIGNATION

4.1 Residential

The Residential designation provides land for primarily residential uses, but also permits other small-scale conditional uses subject to the approval of Council. The policies of Council are intended to maintain an adequate supply of land for residential development, to build safe and livable neighbourhoods and to protect residential areas from incompatible development. The policies of Council are:

a) The Residential designation will be used primarily for housing with all types of dwelling types permitted. Other related residential uses such as a group home, a home occupation, or bed and breakfast will also be permitted.
b) Residential development will be phased so that a minimum of 4 vacant surveyed lots are available at any given time. Residential areas will be developed with an average residential density of 22 units per hectare and will include a mix of unit types including those for elders.

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The Community Use designation is intended to maintain an adequate supply of land for community uses, preferably in significant and important locations so that residents may enjoy easy access to public facilities and services. The policies of Council are:

a) The Community Use designation will be used primarily for public uses (i.e. social, cultural, religious, or educational) and government services.
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The Commercial designation is intended to support local economic development by maintaining an adequate supply of land for commercial uses in a key locations across the Hamlet offering good access for residents and visitors. The policies of Council are:

a) The Commercial designation will be used for commercial uses such as hotels, restaurants, retail, personal and business services, and offices.
b) Residential uses shall be permitted when located above a ground floor commercial use.
c) Commercial facilities will be located along main roads, where possible, to provide safe and convenient access by residents.
d) Council will encourage the re-use or redevelopment of existing commercial sites within the existing townsite.

4.4 Open Space

The Open Space designation is intended to protect shoreline environments, maintain access to the sea and to reserve open spaces within the built up area for recreational uses and cultural events. The policies of Council are:

a) The Open Space designation will be used primarily for parks, walking trails, traditional and recreational uses such as beach shacks, harbour uses, boat storage, dog teams, community docks, temporary storage of sealift materials and equipment during sealift operations, and municipal infrastructure such as a water pump house. All uses are conditional and at the discretion of Council.
b) A playground should be located within 300 metre walking distance from any residence in the community.
c) Unless otherwise noted, all Commissioner's Land forming part of the 100-foot strip (30.5 m) along the seashore measured from the ordinary high water mark will be designated Open Space.
d) No development is generally permitted within 30 metres from the normal high water mark of any river or major creek. Council may consider the filling of a waterbody where it is needed for future development provided that the appropriate approvals are obtained.
e) Open Space corridors will be protected for trail connections and drainage channels.

4.5 Industrial

The Industrial designation is intended to reduce the negative effects and dangers associated with industrial uses such as noise, dust, odours, truck travel and the storage of potentially hazardous substances by concentrating these uses on the periphery of the townsite. The policies of Council are:

a) Permitted uses in the Industrial designation will include all forms of manufacturing, processing, warehousing and storage uses as well as uses associated with marine transportation. Permitted uses will also include garages, power generation plants, and fuel storage.
b) Council will develop new industrial subdivisions near the current landfill site to minimize land use conflicts and to reserve land closer to the townsite for residential and community uses. Council will work with local businesses and government operations to identify opportunities to relocate over time non-conforming industrial uses (eg. garages, warehouses, power plant) to industrial areas.

4.6 Transportation

The Transportation designation is intended to protect and ensure the safe operation of airport and related activities such as the NavCanada communications site. The policies of Council are:

a) Permitted uses in the Transportation designation includes all activities related to air traffic and uses accessory to these activities such as related commercial activities and communications sites.
b) All development within the 4km boundary of the airport, as shown on Schedule 3, shall comply with the Kimmirut Airport Zoning Regulations. Development applications shall be referred to Nunavut Airports for review and approval where development is proposed adjacent to the airport and/or where development has the potential to interfere with airport operations.
c) All development within the Transportation Influence Zone of the communications facility is subject to the approval of NavCanada.
d) Council will discourage the use of travelled pathways that are not identified as public right-of-ways.

4.7 Hinterland

The Hinterland designation applies to all unsurveyed land within the Municipal Boundary not designated by another land use and is intended to protect the natural beauty and cultural resources of the land - 'Nuna' - while providing access for traditional, recreational and tourism activities, as well as quarrying. The policies of Council are:

a) The Hinterland designation generally permits traditional, tourism and passive recreational uses. Permitted uses also include dog teams, quarrying, and infrastructure projects for local economic development.
b) Council shall ensure that development does not negatively impact wildlife, wildlife habitat and harvesting and is consistent with the guiding principles of Inuit Qaujimajatuqangit (IQ).

4.8 Waste Disposal

The Waste Disposal designation is intended to identify existing or former waste disposal sites and ensure required development setbacks are followed. The policies of Council are:

a) The Waste Disposal designation permits no development except those uses accessory to the operation or remediation of a waste disposal site.
b) The Hamlet shall prohibit the development of residential uses and uses involving food storage or food preparation within the 450 metre setback from any existing or former waste disposal site, pursuant to the *General Sanitation Regulations* of the Public Health Act.
c) The Hamlet shall prohibit the development of any public road allowance or cemetery within a 90 metre setback from a waste disposal ground, pursuant to the General Sanitation Regulation of the *Public Health Act*.
d) The Hamlet will evaluate all possible options for an integrated waste management system, including:
   a. the suitability of the existing landfill site for long-term use;
   b. the use of an incinerator;
   c. metal recovery projects; and
   d. complementary strategies, such as source reduction, reuse, and recycling of waste materials.

4.9 Granular Resources

The Granular Resources designation is intended to protect aggregate deposits for future extraction. The policies of Council are:

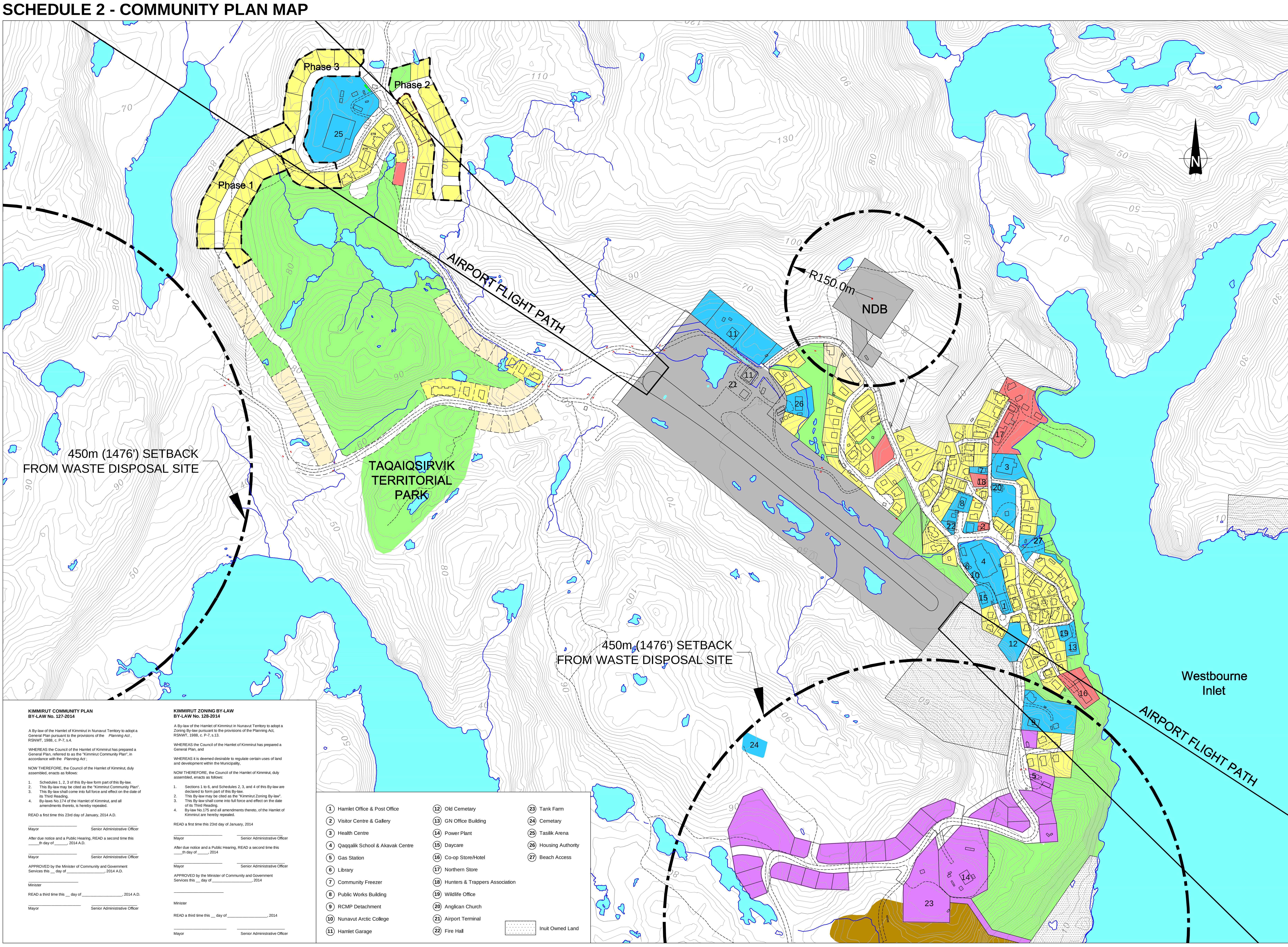
a) The Granular Resources designation does not permit any development except uses accessory to the operation or remediation of a quarry or gravel pit.

4.10 Municipal Reserve

The Municipal Reserve designation is intended to reserve land for the future growth of the community. The policies of Council are:

a) The Municipal Reserve designation does not permit any development except temporary uses approved by Council.
b) Municipal Reserve lands shall be redesignated by amendment to this Plan prior to being used for community expansion.
c) A conceptual road network may be shown on some of the Municipal Reserve lands which considers connections with existing road network, future land uses, prevailing wind direction, solar orientation, drainage and topography. The concept may need to be changed according to community needs during the detailed subdivision design process.

SCHEDULE 2 - COMMUNITY PLAN MAP



KIMMIRUT COMMUNITY PLAN
BY-LAW No. 127-2014

A By-law of the Hamlet of Kimmirut in Nunavut Territory to adopt a General Plan pursuant to the provisions of the *Planning Act*, RSNWT, 1988, c. P-7, s.4.

WHEREAS the Council of the Hamlet of Kimmirut has prepared a General Plan, referred to as the "Kimmirut Community Plan", in accordance with the *Planning Act*;

NOW THEREFORE, the Council of the Hamlet of Kimmirut, duly assembled, enacts as follows:

1. Schedules 1, 2, 3 of this By-law form part of this By-law.
2. This By-law may be cited as the "Kimmirut Community Plan".
3. This By-law shall come into full force and effect on the date of its Third Reading.
4. By-laws No.174 of the Hamlet of Kimmirut, and all amendments thereto, is hereby repealed.

READ a first time this 23rd day of January, 2014 A.D.

____________ Mayor   ____________ Senior Administrative Officer

After due notice and a Public Hearing, READ a second time this _____th day of ______, 2014 A.D.

____________ Mayor   ____________ Senior Administrative Officer

APPROVED by the Minister of Community and Government Services this __ day of _________________, 2014 A.D.

____________ Minister

READ a third time this __ day of __________________, 2014 A.D.

____________ Mayor   ____________ Senior Administrative Officer

KIMMIRUT ZONING BY-LAW
BY-LAW No. 128-2014

A By-law of the Hamlet of Kimmirut in Nunavut Territory to adopt a Zoning By-law pursuant to the provisions of the Planning Act, RSNWT, 1988, c. P-7, s.13.

WHEREAS the Council of the Hamlet of Kimmirut has prepared a General Plan, and

WHEREAS it is deemed desirable to regulate certain uses of land and development within the Municipality,

NOW THEREFORE, the Council of the Hamlet of Kimmirut, duly assembled, enacts as follows:

1. Sections 1 to 6, and Schedules 2, 3, and 4 of this By-law are declared to form part of this By-law.
2. This By-law may be cited as the "Kimmirut Zoning By-law".
3. This By-law shall come into full force and effect on the date of its Third Reading.
4. By-law No.175 and all amendments thereto, of the Hamlet of Kimmirut are hereby repealed.

READ a first time this 23rd day of January, 2014

____________ Mayor   ____________ Senior Administrative Officer

After due notice and a Public Hearing, READ a second time this ____th day of _____, 2014

____________ Mayor   ____________ Senior Administrative Officer

APPROVED by the Minister of Community and Government Services this __ day of __________________, 2014

____________ Minister

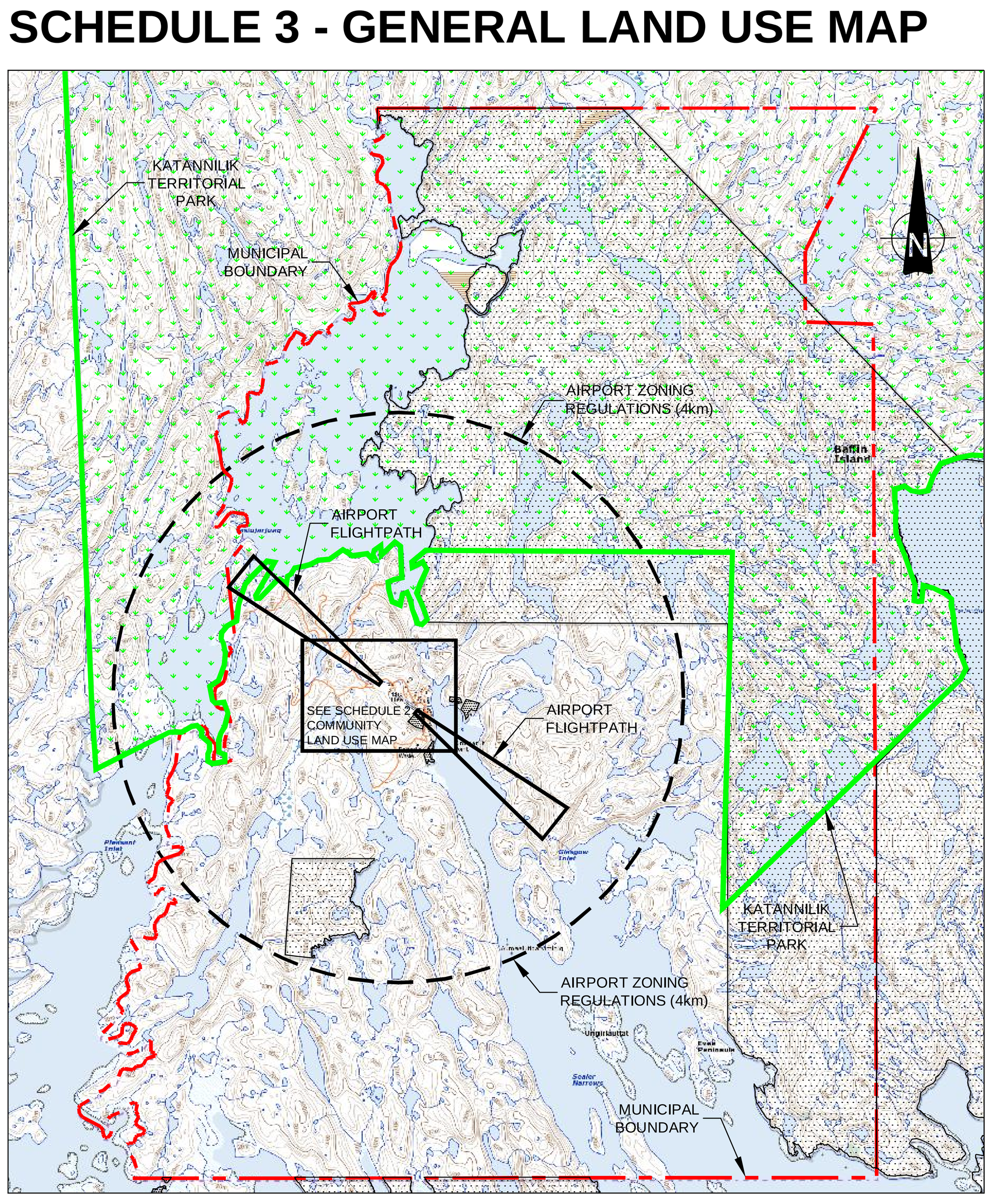
READ a third time this __ day of __________________, 2014

____________ Mayor   ____________ Senior Administrative Officer

1. Hamlet Office & Post Office
2. Visitor Centre & Gallery
3. Health Centre
4. Qaqqalik School & Akavak Centre
5. Gas Station
6. Library
7. Community Freezer
8. Public Works Building
9. RCMP Detachment
10. Nunavut Arctic College
11. Hamlet Garage
12. Old Cemetary
13. GN Office Building
14. Power Plant
15. Daycare
16. Co-op Store/Hotel
17. Northern Store
18. Hunters & Trappers Association
19. Wildlife Office
20. Anglican Church
21. Airport Terminal
22. Fire Hall
23. Tank Farm
24. Cemetary
25. Tasilik Arena
26. Housing Authority
27. Beach Access

Inuit Owned Land

SCHEDULE 3 - GENERAL LAND USE MAP

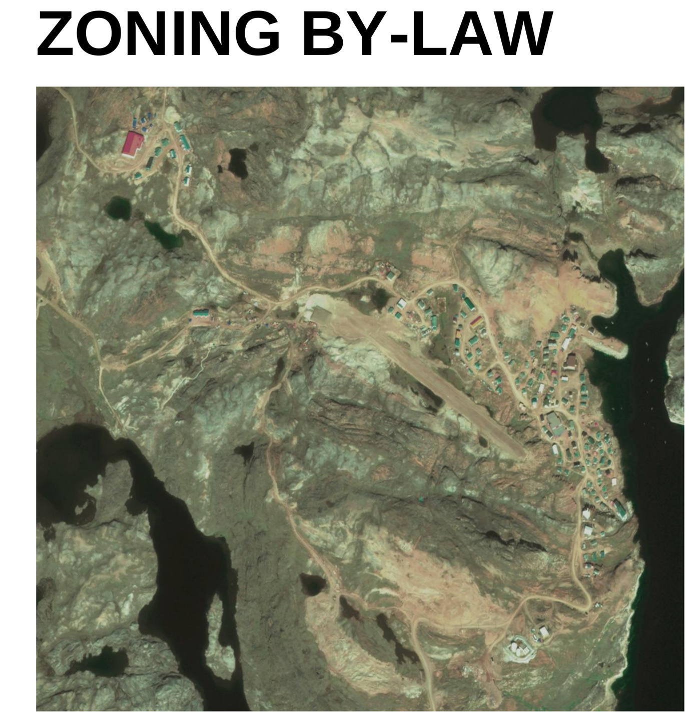


SCHEDULE 4 - ZONE REGULATIONS

	Permitted Uses	Conditional Uses	Zone Requirements
Residential	Dwelling, single-unit Dwelling, semi-detached or duplex Park or playground	Bed and breakfast Craft studio Day care centre Dwelling, row house Dwelling, multi-unit Dwelling, apartment Dwelling, mini home Elders facility Group home Home occupation Secondary suite	(a) Setbacks (minimum) Front = 6 metres Rear = 6 metres Rear, backing onto an OS Zone = 2.5 metres Side (Exterior) = 4 metres Side (Interior) = 6 metres, or as required by the Fire Marshal Building Height (maximum) 8.5 metres (28 feet) (b) Despite the provisions of Section 6.3(a), for semi-detached dwellings or rowhouse dwellings located on separate, adjacent lots, the side yard where units are attached may be reduced to zero. (c) Parking or storage of a commercial vehicle having a gross vehicle weight of 4,500 kg or more such as construction equipment including bulldozers, backhoes, high hoes, and pay loaders is not permitted. (d) The following provisions will apply to Secondary Suites: (i) The suite forms part of a single unit or semi-detached dwelling; (ii) The suite is structurally attached or located within the principal dwelling; (iii) The suite does not exceed a floor area of 25% of the principal dwelling, or 60m² of gross floor area, whichever is less.
Commercial	Bank Broadcasting studio Commercial recreation Communications facility Convenience store Craft studio Day care centre Hotel Office Parking lot Personal service Restaurant Retail store Service and repair shop	Automotive gas bar Automotive repair, sales, or rental shop Dwelling unit(s) in a non-residential building provided that the dwelling unit(s) are above the ground floor. Contractor's shop Home occupation Staff Housing Uses similar in character and purpose to those listed for this zone	(a) Setbacks (minimum) Front = 6 metres Rear = 6 metres Side (Exterior) = 4 metres Side (Interior) = 6 metres, or as required by the Fire Marshal Building Height (maximum) 3 storeys, not to exceed 13 metres (42.65 feet)
Community Use	Broadcasting studio Community freezer Community hall or centre Correctional facility Day care centre Educational facility Elders facility Emergency and protective services Place of Worship Government office Group home Health care facility Park or Playground Parking lot Post office	Cemetery Staff housing Uses similar in character and purpose to those listed for this zone	(a) Setbacks (minimum) Front = 6 metres Rear = 6 metres Side (Exterior) = 6 metres Side (Interior) = 6 metres, or as required by the Fire Marshal Building Height (maximum) 13 metres (42.65 feet)
Open Space	Archaeological site Beach shacks Boat storage Dock Monument, cairn, or statue Park or playground Shed to store equipment for traditional, cultural, and recreational activities taking place in the Zone. Snow fence Sports field Washroom facility	Communications facility Dog teams Temporary outdoor storage of sealift equipment during sealift Temporary tenting or camping Uses similar in character and purpose to those listed for this zone	(a) The following provisions applies to all development in the Open Space Zone: Gross Floor Area (maximum) 25 sq.m. Building Height (maximum) 3.1 metres (10 feet) (b) No building or structure shall be located closer than 10m to any side or rear lot line. (c) Dog teams may not be located closer than 30.5 m to a water body.
Industrial	Automotive gas bar Automotive repair, sales or facility Building supply or contractors shop Caretaker unit Communications facility Heavy equipment and vehicle yard Outdoor storage Rental shop Warehouse	Community freezer Barge staging and landing site with associated warehousing Food processing facility Fuel storage facility Hazardous goods storage Manufacturing plant Power generation facility Uses similar in character and purpose to those listed for this zone	(a) Setbacks (minimum) Front = 6 metres Rear = 8 metres Side (Exterior) = 6 metres Side (Interior) = 8 metres, or as required by the Fire Marshal Building Height (maximum) 10.7 metres (35 feet) (b) Only 1 caretaker unit is permitted on a lot. (c) Hazardous goods storage or tank farm uses shall not be permitted within 30.5 metres of any water course. (d) No commercial development involving food storage, handling or preparation shall be permitted within 450m of a waste handling facility.
Granular Resources		Quarry	
Waste Disposal		Waste disposal site Sewage treatment system (lagoon, etc.)	(a) No residential development or commercial development involving food storage, handling or preparation shall be permitted within 450 metres of a waste disposal site.
Hinterland	Archaeological site Dog team Temporary tenting or camping	Beach shack Cabin Quarry Cemetery Commercial harvesting Communications facility Permanent hunting and fishing cabins or camps Resource exploration and development Snow fence Tourist facilities Wind turbine Uses similar in character and purpose to those listed for this zone	(a) Any development within the Transportation Influence Zone as indicated on the Land Use Map shall be subject to the approval of NAV Canada. (b) No development is permitted within 150 metres downwind of any snow fence without the approval of council. (c) No development is permitted within 200 metres of a wind turbine. (d) No development is permitted within 100 metres of an Archaeological or Paleontological Site, unless approved by the Territorial Archaeologist or Director of Culture and Heritage from the Department of Culture and Heritage. (e) Cabins may not be located closer than 30.5m to a waterbody and/or road (whether it be surveyed or not).
Transportation	Airport and related uses Communications facility Service shop Sea lift facility		(a) Any development within a 4,000 m radius of the airport reference point, as indicated on the Land Use Map, is subject to the Kimmirut Airport Zoning Regulations and shall be subject to the approval of NAV Canada and Nunavut Airports. (b) No development shall occur within 150 metres of the Non-Directional Beacon (NDB) Site.
Municipal Reserve			(a) The Municipal Reserve Zone identifies lands that may be interesting for future redevelopment. No development is permitted in the MR Zone unless of temporary nature, subject to Council approval.

KIMMIRUT

COMMUNITY PLAN & ZONING BY-LAW



KIMMIRUT

COMMUNITY PLAN

BY-LAW NO. 127

March 2014

J.L.Richards

ENGINEERS · ARCHITECTS · PLANNERS

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BY-LAW No. 127-2014

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4. By-laws No.92-2006 of the Hamlet of Kimmirut, and all amendments thereto, are hereby repealed.

READ a first time this 23rd day of January, 2014 A.D.

________________________ ________________________
Mayor Senior Administrative Officer

After due notice and a Public Hearing, READ a second time this _____th day of ______, 201_ A.D.

________________________ ________________________
Mayor Senior Administrative Officer

APPROVED by the Minister of Community and Government Services this __ day of ___________________, 201_ A.D.

____
Minister

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SCHEDULE 1

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b) Residential uses shall be permitted when located above a ground floor commercial use.

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d) Council will encourage the re-use or redevelopment of existing commercial sites within the existing townsite.

4.4 Open Space

The Open Space designation is intended to protect shoreline environments, maintain access to the sea and to reserve open spaces within the built up area for recreational uses and cultural events. The policies of Council are:

a) The Open Space designation will be used primarily for parks, walking trails, traditional and recreational uses such as beach shacks, harbour uses, boat storage, dog teams, community docks, temporary storage of sealift materials and equipment during sealift operations, and municipal infrastructure such as a water pump house. All uses are conditional and at the discretion of Council.

b) A playground should be located within 300 metre walking distance from any residence in the community.

c) Unless otherwise noted, all Commissioner's Land forming part of the 100-foot strip (30.5 m) along the seashore measured from the ordinary high water mark will be designated Open Space.

d) No development is generally permitted within 30 metres from the normal high water mark of any river or major creek. Council may consider the filling of a waterbody where it is needed for future development provided that the appropriate approvals are obtained.

e) Open Space corridors will be protected for trail connections and drainage channels.

4.5 Industrial

The Industrial designation is intended to reduce the negative effects and dangers associated with industrial uses such as noise, dust, odours, truck travel and the storage of potentially hazardous substances by concentrating these uses on the periphery of the townsite. The policies of Council are:

a) Permitted uses in the Industrial designation will include all forms of manufacturing, processing, warehousing and storage uses as well as uses associated with marine transportation. Permitted uses will also include garages, power generation plants, and fuel storage.

b) Council will develop new industrial subdivisions near the current landfill site to minimize land use conflicts and to reserve land closer to the townsite for residential and community uses. Council will work with local businesses and government operations to identify opportunities to relocate over time non-conforming industrial uses (eg. garages, warehouses, power plant) to industrial areas.

4.6 Transportation

The Transportation designation is intended to protect and ensure the safe operation of airport and related activities such as the NavCanada communications site. The policies of Council are:

a) Permitted uses in the Transportation designation includes all activities related to air traffic and uses accessory to these activities such as related commercial activities and communications sites.

b) All development within the 4km boundary of the airport, as shown on Schedule 3, shall comply with the Kimmirut Airport Zoning Regulations. Development applications shall be referred to Nunavut Airports for review and approval where development is proposed adjacent to the airport and/or where development has the potential to interfere with airport operations.

c) All development within the Transportation Influence Zone of the communications facility is subject to the approval of NavCanada.

d) Council will discourage the use of travelled pathways that are not identified as public right-of-ways.

4.7 Hinterland

The Hinterland designation applies to all unsurveyed land within the Municipal Boundary not designated by another land use and is intended to protect the natural beauty and cultural resources of the land – 'Nuna' – while providing access for traditional, recreational and tourism activities, as well as quarrying. The policies of Council are:

a) The Hinterland designation generally permits traditional, tourism and passive recreational uses. Permitted uses also include dog teams, quarrying, and infrastructure projects for local economic development.

b) Council shall ensure that development does not negatively impact wildlife, wildlife habitat and harvesting and is consistent with the guiding principles of Inuit Qaujimajatuqangit (IQ).

4.8 Waste Disposal

The Waste Disposal designation is intended to identify existing or former waste disposal sites and ensure required development setbacks are followed. The policies of Council are:

a) The Waste Disposal designation permits no development except those uses accessory to the operation or remediation of a waste disposal site.

b) The Hamlet shall prohibit the development of residential uses and uses involving food storage or food preparation within the 450 metre setback from any existing or former waste disposal site, pursuant to the *General Sanitation Regulations* of the Public Health Act.

c) The Hamlet shall prohibit the development of any public road allowance or cemetery within a 90 metre setback from a waste disposal ground, pursuant to the General Sanitation Regulation of the *Public Health Act*.

d) The Hamlet will evaluate all possible options for an integrated waste management system, including:

   a. the suitability of the existing landfill site for long-term use;

   b. the use of an incinerator;

   c. metal recovery projects; and

   d. complementary strategies, such as source reduction, reuse, and recycling of waste materials.

4.9 Granular Resources

The Granular Resources designation is intended to protect aggregate deposits for future extraction. The policies of Council are:

a) The Granular Resources designation does not permit any development except uses accessory to the operation or remediation of a quarry or gravel pit.

4.10 Municipal Reserve

The Municipal Reserve designation is intended to reserve land for the future growth of the community. The policies of Council are:

a) The Municipal Reserve designation does not permit any development except temporary uses approved by Council.

b) Municipal Reserve lands shall be redesignated by amendment to this Plan prior to being used for community expansion.

c) A conceptual road network may be shown on some of the Municipal Reserve lands which considers connections with existing road network, future land uses, prevailing wind direction, solar orientation, drainage and topography. The concept may need to be changed according to community needs during the detailed subdivision design process.

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APPENDIX C

CULVERT THAWING METHODS

Culvert Thawing

Culverts are subject to freezing during winter and spring. During winter, ground water can continuously feed streams which either flow through culverts or over roadways causing icing. During spring breakup, daytime melting must be carried through culverts.

When a culvert freezes it can no longer do the job it was designed to do and trapped water will begin to cause problems and ultimately, money.

What's the Solution?

To thaw culverts, a combination of hot water/steam and high pressure water in a mobile environment is the effective method.

Mobile Pressure Washers

To thaw culverts quickly, a skid style hot water pressure washer/steamer, also known as a truck mounted pressure washer is the equipment of choice.

Self-contained and designed to hold up under the toughest of conditions, skid mounted pressure washers/steamers can be bolted onto the back of a truck, on an open deck trailer or in an enclosed trailer.

Enclosed Trailer Mounted Pressure Washer

Open Deck Mounted Pressure Washer

Skid Mounted Presure Washer

Culvert Nozzles

Culvert nozzles are required to dig effectively through ice. The reverse jets on the fixed and rotary nozzles pull the hose through the tube or sewer line and blast debris from the line or tube wall.

Backward ports drive the nozzle forward and flush debris
Forward ports blast into pipe and break up clogs & debris
Physically small for cornering ability up to 4200 PSI
Corrosion resistant stainless steel construction
A wide range of orifice sizes are available for various pressure and flow applications

Rotating style adds extra agitation and surface cleaning

United States Patent [19]

Olsson

[11] **Patent Number: 4,770,211**

[45] **Date of Patent: Sep. 13, 1988**

[54] **METHOD FOR THAWING OUT ROAD CULVERTS CHOKED WITH ICE**

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[22] PCT Filed: **Feb. 24, 1986**

[86] PCT No.: **PCT/SE86/00080**

§ 371 Date: **Oct. 24, 1986**

§ 102(e) Date: **Oct. 24, 1986**

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PCT Pub. Date: **Aug. 28, 1986**

[30] **Foreign Application Priority Data**

Feb. 25, 1985 [SE] Sweden 8500914

[51] **Int. Cl.**[4] **E03B 7/10**; F16L 53/00

[52] **U.S. Cl.** **138/32**; 138/28; 138/35

[58] **Field of Search** .... 138/26, 28, 32, 35; 254/262, 263, DIG. 14; 405/124, 130, 131; 137/301

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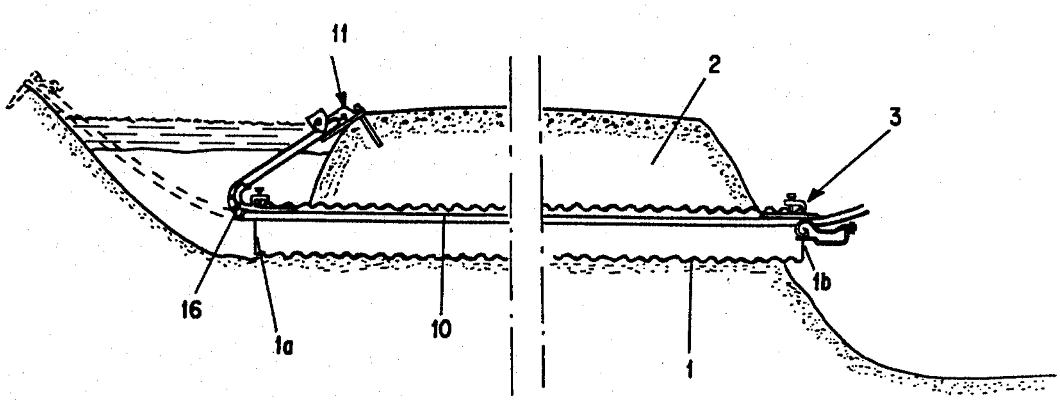
Primary Examiner—James E. Bryant, III
Attorney, Agent, or Firm—Witherspoon & Hargest

[57] **ABSTRACT**

Method for clearing a road culvert or the like which is choked with ice, wherein a substantially homogeneous rope of a material having at least a certain reversible extensibility is extended through the culvert from its inlet side to its outlet side and wherein the rope in its unloaded condition is clamped in connection with the outlet side and the inlet side respectively of the culvert so that the rope extends through the culvert.

4 Claims, 3 Drawing Sheets



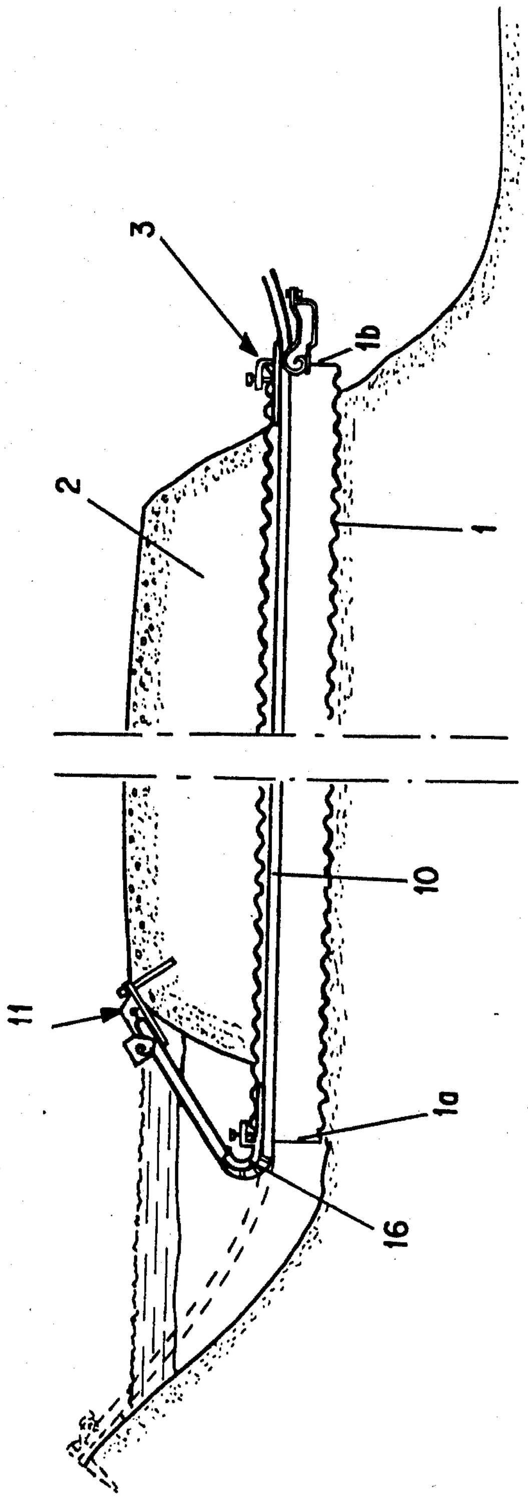


Fig. 1

Fig. 5

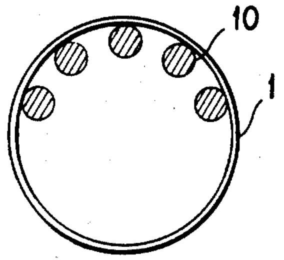
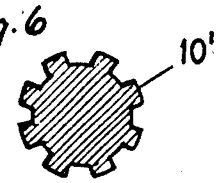


Fig. 6



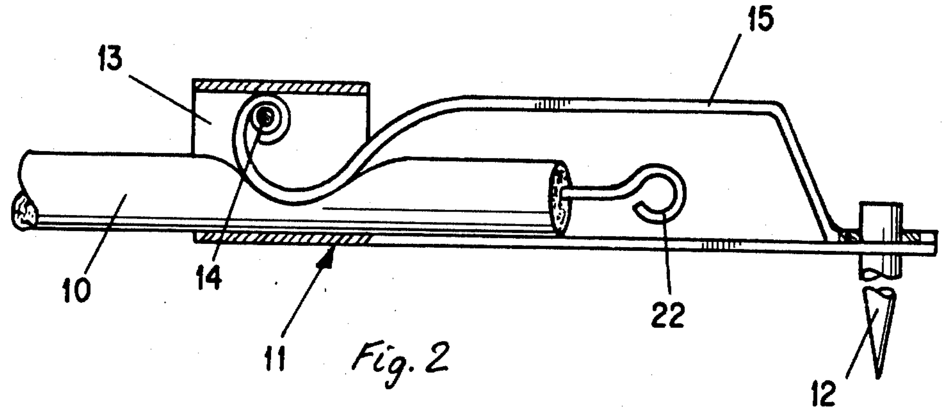


Fig. 2

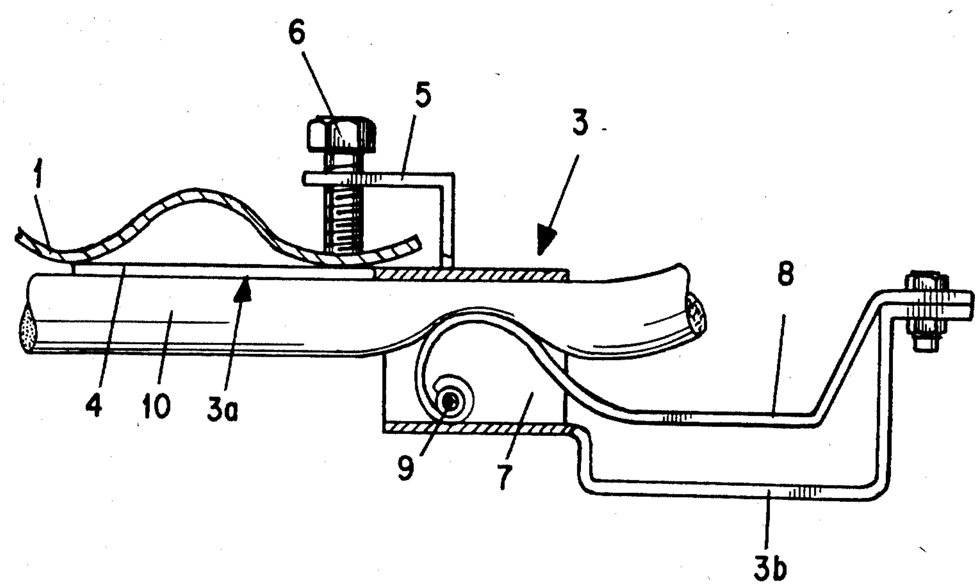
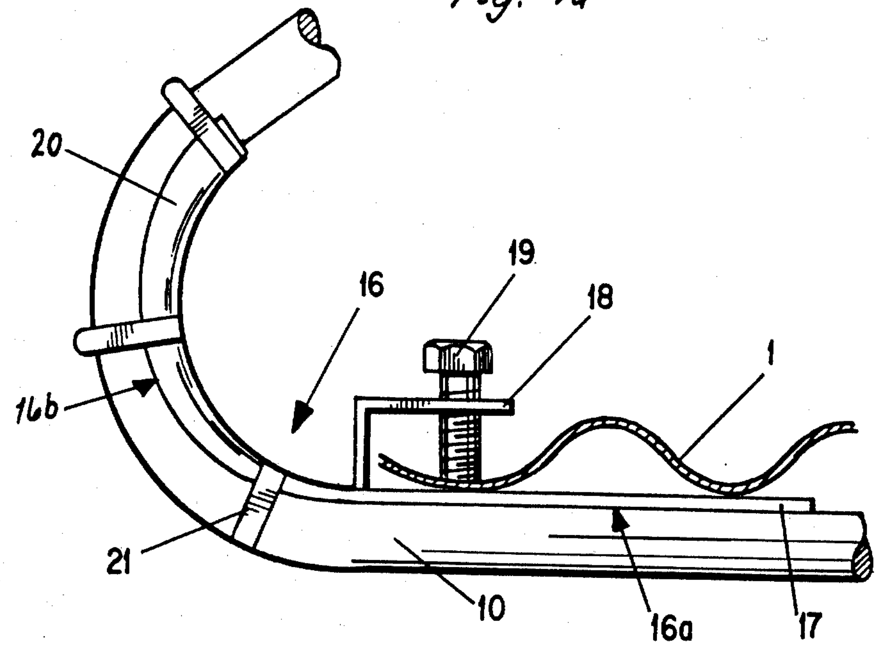


Fig. 3

Fig. 4a



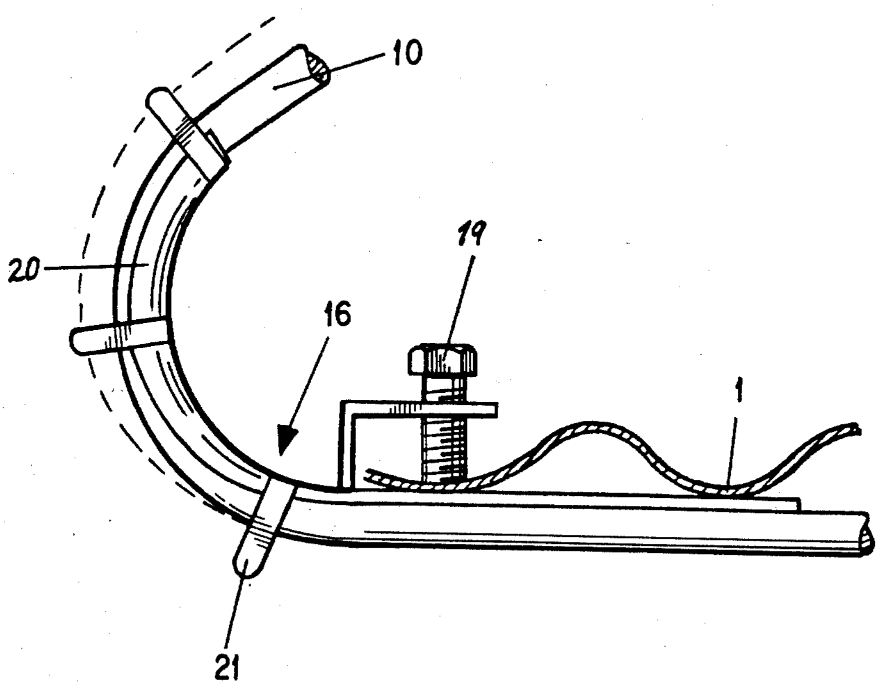


Fig. 4b

METHOD FOR THAWING OUT ROAD CULVERTS CHOKED WITH ICE

BACKGROUND OF THE INVENTION

The present invention relates to a method for thawing out road culverts choked with ice and also relates to an apparatus for carrying out said method.

A common problem in connection with winter maintenance is that road culverts become completely choked with ice, which makes it impossible to drain melted ice through the road culverts in warm weather, and especially by the spring flood. If such a road culvert that is completely choked with ice is not thawed out before the spring flood this may cause serious flooding and also a danger of parts of the road way being washed away.

In order to prevent the above mentioned, serious consequences of a road culvert choked with ice it is presently common practice to continously inspect road culverts which by experience are known to cause problems. When a road culvert choked with ice is found during such a periodical inspection, the procedure is presently to send out a clearing partrol, usually two persons, by car for thawing out the road culvert in question. Today steam generators are mostly used for thawing out road culverts in this manner, although attempts have also been made to use conventional building dryers. Already from the above it is clear that the thawing out of a road culvert in the conventional manner brings about relatively high costs which apart from transport costs also include wage costs for two persons and the cost for the steam generator.

Apart from the fact that the conventional clearing method discussed above is relatively expensive it also suffers from a number of more or less serious disadvantages that are clear from the following general description of the presently employed method using steam thawing. As indicated above a steam generator is transported out to the working place on a lorry or the like, and when the ends of the road culvert have been exposed the steam generator is started and is connected through hoses to steam pipes used for the thawing. In certain cases it is only necessary to thaw out a smaller passage through the culvert, whereupon the flow of water through this smaller passage continues to widen the passage in the ice until the culvert is completely cleared. In such a case it is, for obtaining the best result, absolutely necessary that the first thawing out of the smaller passage is carried out relatively close to the upper portion of the road culvert since the water will eat its way down through the ice towards the bottom of the culvert. Since road culverts may have a length of up to 15–20 meters, depending upon the width of the road, such a thawing out of a first small passage through the entire length of the road culvert is very difficult to achieve with a satisfactory result by means of a steam pipe. The reason for this is that if the steam pipe has such a length that it may reach through the entire length of the road culvert it will not be possible to keep it close to the upper portion of the road culvert throughout the entire length thereof and accordingly the steam pipe will deflect such that in the worst case it will leave the culvert close to its bottom. Accordingly it may also happen that the steam pipe will be stopped and cannot be brought through the entire length of the road culvert in case stones have fallen into the road culvert and remained therein on the bottom of the culvert.

In other cases it is not sufficient to thaw out only a smaller passage in the road culvert in order to avoid flooding, and therefore it will be necessary to clear the whole culvert in order to avoid the risk that a smaller passage is frozen again. It will also be realized that in the above discussed case where it proves impossible even to thaw out a first small passage in the road culvert by means of a steam pipe, it may become necessary to clear the whole culvert. In such a case when the whole culvert is to be cleared the procedure is such that a number of unperforated steam pipes, being upon in the outer end and having a length of approximately 3 meters are successively introduced from the outlet side of the culvert. When these unperforated pipes have been inserted to their full length they are withdrawn and are exchanged for perforated steam pipes which are fixed in position. Then steam is turned on to perform its thawing action until this length of the culvert may be cleared. This procedure is repeated until the culvert has been cleared throughout its length. The last portion of the length of the culvert is usually cleared from its inlet side, but it will be realized that if the culvert has a length of 10–15 meters and possibly even 20 meters it will be necessary for the persons performing the clearing to crawl into the culvert in order to be able to carry out a great deal of the work. Even if this work is not extremely risky it is cold and damp and generally unpleasant. Naturally such a clearing of a complete culvert is very time consuming, and especially so by larger culvert diameters and lengths.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method and an apparatus by means of which the above discussed disadvantages in connection with conventional methods may be eliminated as far as possible.

This object is achieved by means of a method and an apparatus of the kind indicated in the enclosed patent claims. From the patent claims the characteristic features of the invention are also clear.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplifying embodiments of the invention are described more closely below in connection with the enclosed drawings, on which:

FIG. 1 is a schematic illustration of the principles of the present invention in connection with a road embankment with a road culvert, both in cross section,

FIG. 2 illustrates a ground attachment of the apparatus according to the invention.

FIG. 3 illustrates a culvert attachment of the apparatus according to the invention.

FIG. 4*a* illustrates an edge cover in combination with the rope in its unloaded condition.

FIG. 4*b* illustrates the edge cover according to FIG. 4*a*, but with the rope in its loaded condition.

FIG. 5 illustrates a modified embodiment with several apparatuses according to the invention positioned in a road culvert, and

FIG. 6 illustrates another embodiment of the rope having an alternative cross-sectional shape.

Although the invention is described herein with reference only to the clearing of a road culvert, it should be obvious that the invention with the same advantage may be used for thawing out other types of culverts for draining off melted ice and/or rain-water. An example of this may be culverts used in fields by farmers in order to prevent flooding of the fields.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 schematically illustrates the use of the invention by a road culvert 1 extended through a road embankment 2 in order to conduct melted ice and/or rainwater from an inlet side 1*a* to an outlet side 1*b*. Mostly the outlet side 1*b* of the culvert is relatively freely accessible from the outside even if the road culvert 1 is completely choked with ice, and thus, for reasons which will be explained below, a culvert attachment 3 is positioned in connection with the outlet and 1*b* of the culvert. An embodiment of the culvert attachment 3 is illustrated in greater detail in FIG. 3 from which it is clear that the culvert attachment has a first portion 3*a* intended to be clamped to the culvert. In the illustrated embodiment the first portion 3*a* comprises an inner leg 4 and an outer leg 5 between which the culvert 1 is introduced and clamped by means of a bolt 6 engaging a threaded bore in the outer leg 5. The other portion 3*b* of the culvert attachment is formed integral with the first portion 3*a* and is at its outer end releasably connected to a clamping means 8, for instance by means of a screw-nut connection 8*a*. In the illustrated embodiment the clamping means 8 consists of a flat bar being bent into a helical shape in its free end for a pivotal mounting on a pin 9 being firmly connected to a plate secured to the culvert attachment substantially midway between its ends. Through the pivotal mounting of the clamping means 8 on the pin 9 a rope 10 that will be more closely described below may be released and clamped between the helical end of the clamping means 8 and a portion of the culvert attachment close to the middle thereof by swinging the clamping means 8 upwardly and downwardly respectively about the pin 9.

In connection with the inlet side 1*a* of the road culvert 1 and at a distance therefrom a ground attachment 11 is anchored in the road embarkment 2 or at some other suitable place in accordance with what will be discussed below. In FIG. 2 a suitable embodiment of the ground attachment 11 is illustrated which in one of its ends is provided with a peg 12 which is pointed in one of its ends and which is intended to be forced down into the ground for anchoring the ground attachment. In its other end the ground attachment 11 is provided with a plate 13 which essentially corresponds to the plate 7 on the culvert attachment of FIG. 3 and which accordingly is provided with a pin 14 for pivotal mounting of one end of a clamping means 15 which in turn corresponds to the clamping means 8 of FIG. 3. Thus, the clamping means 15 has a helically shaped end for mounting on the pin 14, and in its opposite end it is releasably attached to the ground attachment 11, preferably by means of a nut 15*a* screwed into a threaded upper portion of the anchoring peg 12. It will now be realized that in accordance with what has been described in connection with FIG. 3 the clamping means 15 is intended for releasably clamping the rope 10 between its helical end a portion of the ground attachment 11.

In the case illustrated in FIG. 1 where the ground attachment is anchored in connection with the road embankment 2 it also becomes necessary to provide an edge cover 16 at the inlet end 1*a* of the culvert, and this partly for guiding the rope 10 around the relatively sharp bend and at the same time also for protecting the rope. As is clear from FIGS. 4*a* and 4*b* the edge cover 16 in a suitable embodiment consists of a first portion 16*a* which to a great extent corresponds to the first portion 3*a* of the culvert attachment 3 and thus comprises an inner leg 17 and an outer leg 18 between which the culvert 1 is clamped by means of a bolt 19 screwed into a threaded bore in the outer leg 18. The other portion 16*b* of the edge cover provides the guiding proper for the rope 10 and for this purpose includes an upwardly bent guide rail 20 having a smooth curvature for deflecting the rope 10 between 90° and 180°, in the illustrated embodiment approximately 135°. For providing the best guiding the guide rail 20 has an inner, longitudinal groove having a shape essentially corresponding to that of the rope 10. For additionally securing and guiding the rope 10 in the guide rail 20 the latter is also provided with a number of guide loops 21 evenly distributed along the length of the guide rail, and through these loops the rope is threaded.

For reasons of clarity it should be mentioned that although the elongated means, which according to the invention is intended to be extended through a road culvert, herein is referred to as a rope this term is not intended to delimit the invention regarding the cross-sectional shape or surface of the elongated means. Although the rope in the illustrated embodiments has a substantially circular cross-sectional shape it is obvious that the term rope should also cover rectangular, triangular or other suitable cross-section shapes.

As mentioned above the rope 10 is intended to be extended through the road culvert 1 and to be clamped at the culvert attachment 3 as well as at the ground attachment 11. The rope is substantially solid or homogeneous (possibly with air bubbles contained in the material) and in the illustrated embodiments it has a basically circular sectional area. The rope is cut into a suitable length corresponding to the length of the road culvert to which it is to be attached. Characteristic of the rope is that it is manufactured from a material which at least to a certain degree may be reversibly extended, i.e. a material which when it is subject to a tension load undergoes a certain, not permanent, reduction in cross section. Thus, when the tension load is removed the rope shall resume its original shape. By an embodiment of the invention where a free passage is established through ice in the road culvert by simply pulling the rope out from the culvert, it is sufficient if the rope has a relatively low reversible extensibility sufficient for reducing the cross-sectional area of the rope to such a degree that it without problem is released from the surrounding ice. By another embodiment where the passage through the ice is established with the rope remaining in the culvert by extending the rope to such an extent that its cross-sectional area is greatly reduced, it must on the other hand be possible to subject the material to such a tension load that its cross-sectional area is substantially reduced to half without any danger of the material rupturing or breaking. A material that has been found suitable for the later embodiment and that complies with the requirements thereof is a synthetic rubber EPDM (SIS 1626-70).

In either or both of its ends the rope is provided with a hook 22 the function of which will be described below. In certain cases it may also be preferable to provide the free ends of the rope with a not shown web or stocking intended to protect the rope from external damage through for instance gravel and rocks.

According to an emboidment of the invention the clearing or thawing out of a road culvert is carried out in the following manner:

In good time before the winter, when the culvert is open, the above described equipment is installed, and when installed it can remain there year after year and it will not be necessary to dismount it unless some portion thereof is damaged. The assembly is carried out such that a culvert attachment **3** of the kind described above is clamped to the outlet side **1**_b_ of the culvert **1**. The ground attachment **11** may be secured by forcing the anchoring peg **12** into the ground by means of any suitable tool so that it is firmly anchored, and the anchoring may be carried out in alternative places depending upon the surrounding terrain. Hereby it is determining that the ground attachment shall be anchored at a spot where there is little danger that it will become covered by ice during winter. The reason for this is naturally that it must be easy to get hold of the end of the rope **10** being positioned in connecton therewith without having to expose said end by chopping off ice. Of importance for the positioning is also that the anchoring position must be as close as possible to the inlet end **1**_a_ of the culvert so that the length of the rope may be reduced. In view of this the positioning illustrated with full lines in FIG. **1** seems to be preferable in most cases, but it is also possible to position the ground attachment as illustrated with broken lines in FIG. **1**, in which case the rope will be extended obliquely upwardly in FIG. **1**.

As mentioned above the positioning of the ground attachment **11** illustrated with full lines in FIG. **1** also necessitates the mounting of an edge cover **16** at the inlet end **1**_a_ of the culvert for deflecting and guiding the rope **10**. By the alternative positioning illustrated with broken lines it would be possible to manage without any edge cover or with an edge cover of a simpler design. When the culvert attachment, the ground attachment and possibly an edge cover have been installed the rope **10** is extended through the culvert and, where appropriate, the rope is then threaded through the edge cover, and its ends are clamped to the culvert attachment and to the ground attachment respectively. The clamping is carried out in such a way that the clamping means **8** and **15** respectively is disengaged and is swung about the pin **9** and **14** respectively, whereupon the rope is installed in the respective attachment and is clamped in position by means of the clamping means which are secured by the nut **8**_a_ and **15**_a_ respectively. The rope **10** is clamped to the attachments in its substantially unloaded condition, i.e. without being subject to any essential tension load. However, especially in connection with longer road culverts it may be necessary to clamp the rope **10** when the same is subject to a certain, low tension load in order to make sure that the rope does not hang down towards the middle but runs close to the upper edge of the culvert **1** throughout its extension, and as discussed in the introduction this is essentially in order to make it possible for the water flowing through an opened passage to eat its way down in the ice so that the ice may be efficiently cleared away. The rope remains in the above described position and when it is discovered, during a routine inspection discussed above, that the culvert is completely choked with ice so that melted ice cannot be drained therethrough it will, by employing the invention, no longer be necessary to send out any special patrol for clearing the culvert, but in most cases the person carrying out the inspection may carry out the clearing by himself. By one embodiment the procedure is such that the rope is released at the culvert attachment **3** by the outlet side **1**_b_ of the culvert, possibly subsequent to exposing this side by removing snow, through disengaging the clamping means **8** and swinging the same about the pin **9**. The rope which in this embodiment should have a high reversible extensibility is then stretched or tensioned by hand from the outlet side **1**_b_ while remaining clamped at the ground attachment **11**, and through this tension load and due to the tensibility of the material the rope **10** is immediately released from the ice as its cross-sectional area is greatly reduced. Hereby a free passage for the melted ice is established around the circumference of rope and when this has been achieved the rope is clamped to the culvert attachment **3** again in its loaded condition so that the water may continue to flow in the passage in such a way that it wears its way through the ice and finally clears the whole culvert. When the culvert has been cleared the rope is released from the culvert attachment **3** again and is unloaded so that it resumes its original shape and finally it is clamped again so that the procedure may be repeated if the culvert should become choked with ice once more. As has been mentioned above it is obvious that the rope **10** by this embodiment should have as high a reversible extensibility as possible in order to establish the largest possible passage for the melted ice when it is stretched or tensioned. In this embodiment it may also be suitable if the rope has a rectangular cross-sectional shape in order to leave as wide a passage as possible for the melted ice to thereby ensure a positive clearing of the complete culvert.

When the ground attachment is positioned as illustrated with broken lines in FIG. **1** there is a danger that the reduction of the cross section of the rope at the end closest to the ground attachment, due to the great distance from the place where the tension load is applied, goes on so slowly that the water beginning to flow in freezes before sufficient flow has been established in order to keep the passage open. For that reason it may be preferable in all cases to use the variant illustrated with full lines in FIG. **1**, having an edge cover **16**. The reason for this is that when the rope is stretched about the edge cover the passage may be opened up more quickly by performing the tensioning or stretching in two different steps. In FIG. **4**_a_ the rope is illustrated guided about the edge cover in its unloaded condition, but in FIG. **4**_b_ the broken lines illustrate how the extension of the rope is blocked by the guide rail **20** of the edge cover so that the reduction of the cross-sectional area of the rope, when the rope is normally tensioned, has been fully established up to the guide rail and possibly a distance around the same, while the remaining portion of the rope still maintains its full cross-sectional dimension so that no melted ice or snow enters from above. At this state the rope is clamped at the culvert attachment **3** when in its loaded condition and the person moves to the ground attachment **11** and exposes the same when necessary. Then the rope is released at the ground attachment and since only a relatively short portion of the rope from the edge cover **16** and up to the ground attachment is unloaded this portion of the rope may quickly be stretched or tensioned so that a full flow through the established passage is immediately obtained and so that the above mentioned danger of freezing is elminated.

By certain road culverts which by experience are known to cause serious problems, or by road culverts having a large diameter it may suitable to provide several ropes **10** at a distance from each other in connection with the upper portion of the culvert, and for instance in the way schematicaly illustrated in FIG. **5**. Another alternative that may be considered in connection with larger road culverts is to employ thicker ropes therein, but in such a case it may be necessary to provide some kind of not shown auxiliary device having a gear mechanism for tensioning or stretching the rope.

In FIG. 6 a rope 10' is illustrated having an alternative cross-sectional shape with longitudinal grooves or channels. This rope is intended to be twisted in connection with the streching or tensioning thereof so that the grooves assume a screw line shape around the rope. Apart from the fact that this configuration establishes a somewhat larger passage for the melted ice it also gives the ice a non-uniform surface so that the melted ice more efficiently wears off the ice. This is even further emphasized if the grooves or channels initially are helically shaped in the rope.

In extremely difficult situations where the above described method is not sufficient or in cases where it is desirable to open up a culvert in spite of the fact that there is no water such as melted ice or snow present that can wear down through the ice during its flow through the culvert, it is in accordance with another embodiment also possible to use the invention together with a conventional steam unit or possibly together with a hot-air unit, such as a building dryer. For this purpose a hook 22 is provided in one or possibly both ends of the rope. By connecting a particular steam pipe (possibly a flexible steam hose), which is closed in one end and in said end is provided with a loop for engaging the hook 22 and which is perforated along a portion of its length, to the steam unit the complete culvert may be cleared from one side without the necessity for crawling into the culvert. This is achieved by hooking-up the loop of the steam pipe to the hook 22 of the rope, whereupon the steam pipe, through withdrawal of the rope, is pulled stepwise through the culvert as this is thawed out. Due to the fact that the steam pipe is pulled in through the passage established by the rope it will not be necessary to take up separate holes for the perforated steam pipe and moreover the complete culvert may be thawed out in one operation independent of the length of the culvert. This work is naturally speeded up even further if several ropes are installed in the culvert in accordance with FIG. 5, whereby a corresponding number of steam pipes may be used. It should be realized that by this embodiment it is, as mentioned, sufficient if the rope only has a certain reversible extensibility, since it is intended to establish a passage through the ice by being completely withdrawn from the culvert. Thus, the reduction of the cross-sectional area need only be sufficient to ensure that the rope is released from the ice.

Although preferred embodiments of the invention have been described and illustrated herein it should be obvious to those skilled in the art that a great number of changes and modifications may be carried out without departing from the scope of the invention. For instance it is possible to employ alternative designs for the culvert attachment, the ground attachment and the edge cover, both regarding their preferred clamping to the culvert, anchoring in the ground and clamping of the rope respectively. Thus, the scope of the invention should only be restricted by the enclosed patent claims.

I claim:

1. A method for clearing road culverts or the like having become choked with ice, comprising the steps of: extending a substantially homogenous rope of a material having at least a certain reversible extensibility through the culvert from its inlet side to its outlet side before it becomes choked with ice; clamping the rope in its unloaded condition in connection to the outlet side and inlet side of the culvert so that the rope extends through the culvert; and, once the culvert has become choked with ice, releasing the rope from its clamping in connection with the outlet side of the culvert; applying a tension load to the rope from the released end for reducing the cross-sectional area of the rope and thereby forming a free passage through the culvert around the circumference of the rope; clamping the rope again in connection with the outlet side of the culvert, in the loaded extended condition of the rope; and allowing a continuous flow of melted ice or snow in the passage formed around the circumference of the rope, thereby clearing the road culvert.

2. A method as described in claim 1, wherein a rope having a high reversible extensibility is used and wherein the rope is clamped close to the upper portion of the culvert.

3. A method as described in claim 2, wherein the rope in connection with the inlet side of the culvert is deflected from its extension within the culvert through an edge cover; the corresponding end of the rope is clamped at a distance from the inlet side of the culvert and both ends of the rope, one after the other, are released from the clamping, are tensioned or extended and clamped again.

4. A method for clearing road culverts or the like having become choked with ice, comprising the steps of: extending a substantially homogeneous rope of a material having at least a certain reversible extensibility through the culvert from its inlet side to its outlet side before it becomes choked with ice; clamping the rope in its unloaded condition in connection to the outlet side and the inlet side of the culvert so that the rope extends through the culvert; and, once the culvert has become choked with ice, releasing both ends of the rope at their respective clamping positions; connecting a steam pipe perforated along a portion of its length to one end of the rope; connecting the steam pipe to a steam unit; applying a tension load to the end of the rope not connected to the steam pipe, for reducing the cross-sectional area of the rope so that it is released from the ice; successively pulling the rope out from the culvert for forming a free passage through the culvert and successively pulling the steam pipe into the passage in the ice established by withdrawing the rope; thereby successively clearing the culvert by means of steam supplied from the steam unit.

* * * * *

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United States Patent [19]

Sterling et al.

[11] **Patent Number: 5,986,237**

[45] **Date of Patent: Nov. 16, 1999**

[54] **METHOD FOR THAWING FROZEN ROAD CULVERTS**

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[22] Filed: **Sep. 25, 1997**

[51] **Int. Cl.**[6] **H05B 1/00**; H01C 3/06

[52] **U.S. Cl.** **219/213**; 219/549; 338/214

[58] **Field of Search** 219/213, 528, 219/544, 538, 546; 404/77, 79; 405/131, 128; 338/214

[56] **References Cited**

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Primary Examiner—Teresa Walberg

Assistant Examiner—Thor S. Campbell

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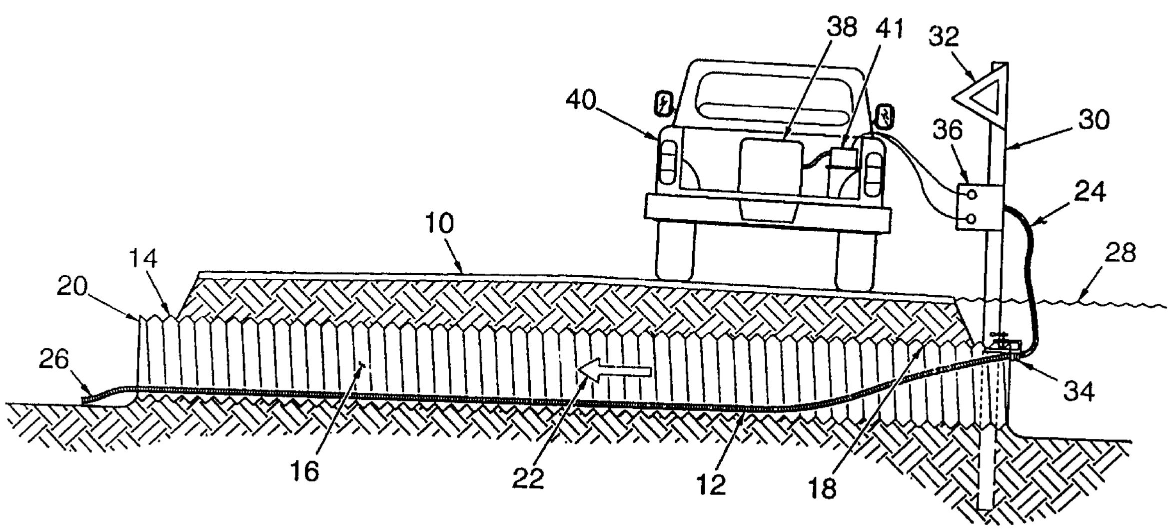
[57] **ABSTRACT**

A method for thawing frozen road culverts. The first step involves positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring. A connection end of the electrically conductive cable is anchored in an accessible location. The second step involves connecting a power source to the connection end of the electrically conductive cable after an ice blockage of the road culvert has occurred and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert.

7 Claims, 2 Drawing Sheets



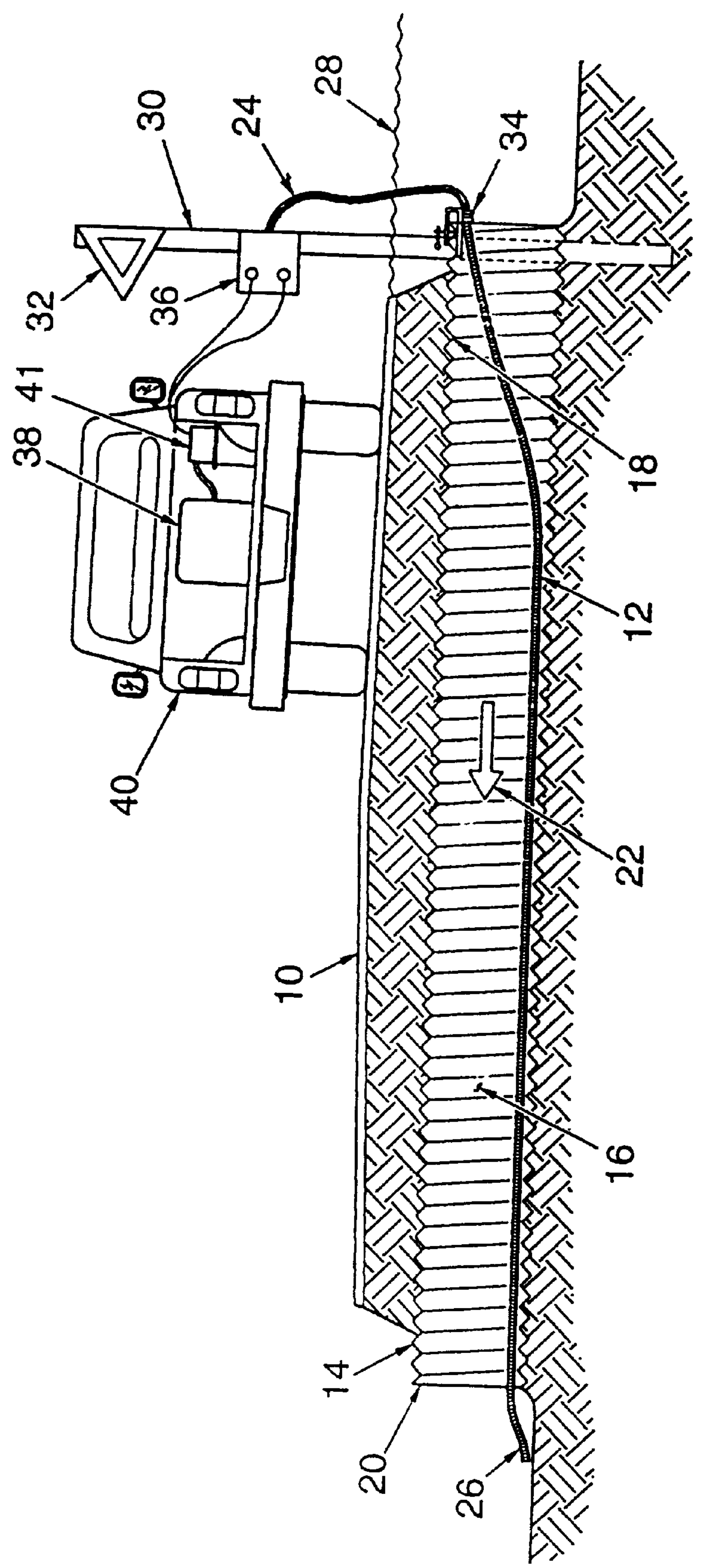


FIGURE 1

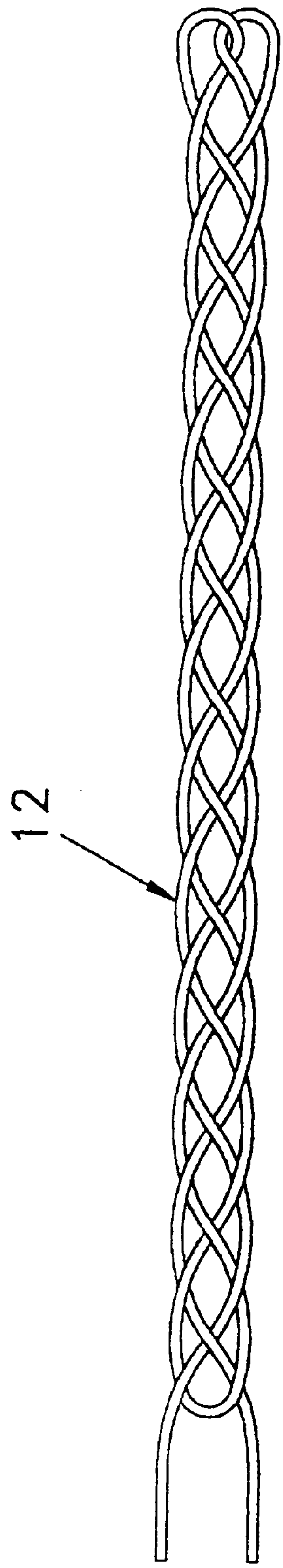


FIGURE 2

METHOD FOR THAWING FROZEN ROAD CULVERTS

FIELD OF THE INVENTION

The present invention relates to a method for thawing frozen road culverts.

BACKGROUND OF THE INVENTION

With the coming of spring every year there is a daily cycle of melting and freezing. The heat of the sun during the day causes snow to melt. As the sun goes down the temperature falls and water resulting from melting of the snow freezes.

Culverts are strategically placed under roads which are in a path followed by a flow of water from the melting snow. The culverts divert the flow of water so the road does not wash out. Unfortunately, the daily cycle of melting and freezing sometimes results in a culvert becoming blocked by an ice plug. If the ice plug is not removed in a timely fashion, the flow of water seeks an alternative path which often results in a washing out of portions of the road.

At the present time, steam truck crews are dispatched whenever it is noted that a culvert is plugged by ice. Removal of an ice plug from a culvert is generally a slow process. High pressure steam is injected into the ice plug, usually from a downstream side of the culvert, until a flow of water is restored. An ice plug that extends part way into a culvert generally can be removed by high pressure steam within three hours. Ice plugs that extend completely through a culvert can take considerably longer to remove.

The problem of road culverts plugging with ice has become so prevalent, that oversize culverts are frequently used for the express purpose of reducing the frequency of the problem.

SUMMARY OF THE INVENTION

What is required is a more time efficient method of thawing frozen road culverts.

According to one aspect of the present invention there is provided a method for thawing frozen road culverts. The first step involves positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring. A connection end of the electrically conductive cable is anchored in an accessible location. The second step involves connecting a power source to the connection end of the electrically conductive cable after an ice blockage of the road culvert has occurred and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert.

According to another aspect of the present invention, there provided, a combination including a road culvert and an electrically conductive cable. The road culvert has an interior bore with an upstream end and a downstream end relative to normal water flow. The electrically conductive cable is positioned in the interior bore and extends substantially the length of the road culvert from the upstream end toward the downstream end. A connection end of the electrically conductive cable is anchored in an accessible location, such that a power source connectable to the connection end of the electrically conductive cable to supply power to energize the electrically conductive cable.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings, wherein:

FIG. **1** is a front elevation view, in section, of a culvert that has been equipped with an electrically conductive cable in accordance with the teachings of the present method.

FIG. **2** is a detailed top plan view of a electrically conductive cable illustrated in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred method for thawing frozen road culverts will now be described with reference to FIG. **1**.

The teachings of the preferred method, as will hereafter be further described, require that an electrically conductive cable **12** be positioned in a road culvert **14**. Road is generally indicated by reference numeral **10**. Road culvert **14** has an interior bore **16** with an upstream end **18** and a downstream end **20** relative to a direction of normal water flow as indicated by arrow **22**. Electrically conductive cable **12** has a connection end **24** and a remote end **26**. Beneficial results have been obtained using electrically conductive cable **12** made from #10 insulated copper wire, although in applications requiring higher temperatures wire made from alloys that can withstand higher temperatures may be used. Electrically conductive cable **12** is positioned in interior bore **16** of road culvert **14** and, preferably, extends substantially the length of road culvert **14** from upstream end **18** toward downstream end **20**. It is essential that electrically conductive cable **12** is positioned at upstream end **18**, for it is at upstream end **18** that a lockage by ice is most likely to occur. It is not always ssential that electrically conductive cable **12** reach all the ay to downstream end **20**. Each installation must be made having regard to surface topography and other conditions prevailing. Some road culverts become blocked at both ends, others are prone only to upstream blockage. Connection end **24** of electrically conductive cable **12** is anchored in an accessible location. When choosing an accessible location must bear in mind the conditions that will prevail when an ice blockage condition is encountered. There is likely to be an accumulation of water upstream of road culvert **14**, so the accessible location ispeferably above a high water mark generally indicated by reference numeral **28**. There is also likely to be an accumulation of snow on the ground, so connection end **24** is preferably a sufficient height to be above any accumulation of snow. In order to achieve this objective, it is preferred that connection end **24** be mounted onto a post **30**. Post **30** can be marked with a sign **32** or otherwise marked so as to be readily identified by work crews. In order to ensure that electrically conductive cable **12** does not shift after installation, it is preferred that electrically conductive cable **12** be clamped by means of clamp **34** to upstream end **18** of road culvert **14**. Connection end **24** of electrically conductive cable **12** is preferably is connected to a junction box **36**. A power source **38** is used to supply power to electrically conductive cable **12**. For safety reasons, a low voltage direct current power source which generates six to forty volts is preferred. It will be appreciated that the power required will vary with the gauge and length of electrically conductive cable **12** used. It is not viewed as being cost effective to have a power source at every installation. It is viewed as being more practical to take power source **38** to the particular road culvert that is blocked, it is, therefore, preferred that power source **38** be mounted on a truck **40**. For reasons of safety, it is preferred that power source **38** have a control box **41** which include features that control current and provide overcurrent protection with a breaker trip mechanism.

The use and operation of the above described combination in accordance with the teachings of the preferred method will now be described. The first step involves positioning electrically conductive cable **12** in road culvert **14** prior to an ice blockage occurring. Of course, after an ice blockage has occurred it is too late to insert electrically conductive cable **12**. Historical data can be used to select those of road culverts **14** that are most prone to ice blockage. Connection end **24** of electrically conductive cable **24** is anchored in an accessible location, such as post **30**. It is preferred that cable be secured to road culvert **14** at upstream end **18** by means of clamp **34**. Cable **24** is then laid through road culvert **14**.

The second step involves connecting power source **38** to connection end **24** of electrically conductive cable **12** after an ice blockage (not shown) of road culvert **14** has occurred. As low voltage power source **38** is truck mounted, truck **40** can be dispatched. The connection of power source **38** to connection end **24** of electrically conductive cable **12** is made through junction box **36**. Power source **38** provides power to electrically conductive cable **12**. Tests have shown that energy generated by electrically conductive cable **12** causes a flow path to be created through the ice blockage in the immediate vicinity of electrically conductive cable **12**. The resulting flow of water then tends to accelerate the process of removing the blockage by rapidly washing away the ice. A trickle of water through road culvert **14** generally occurs in as little as two minutes and normal flow through road culvert **14** is generally restored within ten minutes. The rapid clearing of the blockage is believed to be due to more than just the heat generated by power passing through electrically conductive cable **12**.

Referring to FIG. **2**, in addition to thermal energy, there is believed to be an eddy current induced. In order to enhance this effect cable **12** is looped lengthwise back and forth in boustrophedonic fashion. The loops are then twisted together in order to make cable **12** more compact and easier to handle. Regardless of what forces are at work, the energy generated can be objectively shown to clear an ice blockage in a remarkably short time.

It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention as hereinafter defined in the Claims.

The embodiments of the invention in which an exclusine property or privilege is claimed are defined as follows:

1. A method for thawing frozen road culverts, comprising the steps of:

positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring, with a connection end of the electrically conductive cable anchored in an accessible location;

dispatching a mobile low voltage power source to the road culvert when a blockage occurs; and

connecting the power source to the connection end of the electrically conductive cable and supplying power to the electrically conductive cable, such that energy generated by power flowing through the electrically conductive cable causes a flow path to be created through an ice blockage in the road culvert.

2. In combination:

a road culvert having an interior bore;

an electrically conductive cable positioned in the interior bore and extending substantially the length of the road culvert;

a connection end of the electrically conductive cable being anchored in an accessible location, such that a power source is connectable to the connection end of the electrically conductive cable to supply power to energize the electrically conductive cable; and

a mobile low voltage power source for supplying power to the electrically conductive cable.

3. The combination as defined in claim **2**, wherein the road culvert has with an upstream end and a downstream end relative to normal water flow, the cable extending from the upstream end toward the downstream end.

4. The combination as defined in claim **2**, wherein the cable is looped lengthwise back and forth in boustrophedonic fashion.

5. The combination as defined in claim **4**, wherein the cable is twisted.

6. A method for thawing frozen road culverts, comprising the steps of:

positioning an electrically conductive cable in a road culvert prior to an ice blockage occurring, with a connection end of the electrically conductive cable anchored in an accessible location outside the road culvert and an opposite end of the cable being unattended and extending completely through the road culvert and projecting out through the opposite end thereof;

dispatching a mobile low voltage power source to the road culvert when a blockage occurs in the road culvert; and

connecting the power source to the connection end of the electrically conductive cable and supplying electrical power to the electrically conductive cable, such that energy generated by the electrical power flowing through the electrically conductive cable causes a flow path to be created through the ice blockage in the road culvert thereby assisting with thawing of the road culvert.

7. The combination of claim **2** wherein the accessible location of the connection end of the cable is located outside the road culvert so as to be accessible.

* * * * *

APPENDIX D

PHASED COST ESTIMATES

Community and Government Services - Government of Nunavut

Class 'D' Cost Estimate

Tetra Tech Project WTRM03118-01 - Kimmirut Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$242,972
Civil Works		$1,313,715
Miscellaneous		$60,000
	Sub-total	**$1,616,687**
Project Contingencies	40.0%	$646,675
	Total Estimated Construction Cost	**$2,263,361**

NMS Specs						
Preliminaries			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$146,971.50	$146,972
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$16,000.00	$16,000
01 71 00	0-3	Construction Surveys	lump sum	1	$80,000.00	$80,000
					Sub-total Preliminaries	**$242,972**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	500	$30.00	$15,000
33 42 13	1-2	Supply and Install 450 mm Steel Casing Culvert	m	372	$527.00	$196,044
33 42 13	1-3	Supply and Install 600 mm Steel Casing Culvert	m	197	$707.00	$139,279
33 42 13	1-4	Supply and Install 750 mm Steel Casing Culvert	m	50	$888.00	$44,400
33 42 13	1-5	Supply and Install 900 mm Steel Casing Culvert	m	24	$1,068.00	$25,632
33 42 13	1-6	Supply and Install 1400 mm Steel Casing Culvert	m	46	$1,610.00	$74,060
31 37 10	1-7	Supply and Place 50 kg Class Riprap	cu. m	310	$200.00	$62,000
31 37 10	1-8	Supply and Place 10 kg Class Riprap	cu. m	3,963	$100.00	$396,300
31 37 10	1-9	Supply and Place 50 - 75 mm Clear Crush	cu. m	231	$100.00	$23,100
31 32 21	1-10	Supply and Place Non-Woven Geotextile	sq. m	14,195	$20.00	$283,900
02 41 13	1-11	Culvert Removal and Off-Site Disposal	each	27	$2,000.00	$54,000
					Sub-total Site Services	**$1,313,715**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	2-1	Dewatering	lump sum	1	$20,000.00	$20,000
01 35 43	2-2	Sediments and Erosion Control Measures	lump sum	1	$40,000.00	$40,000
					Sub-total Miscellaneous	**$60,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

Community and Government Services - Government of Nunavut

Class 'D' Cost Estimate - Phase 1

Tetra Tech Project WTRM03118-01 - Kimmirut Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$58,252
Civil Works		$303,524
Miscellaneous		$15,000
	Sub-total	**$376,776**
Project Contingencies	40.0%	$150,711
	Total Estimated Construction Cost	**$527,487**

NMS Specs						
Preliminaries			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$34,252.40	$34,252
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$4,000.00	$4,000
01 71 00	0-3	Construction Surveys	lump sum	1	$20,000.00	$20,000
					Sub-total Preliminaries	**$58,252**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	60	$30.00	$1,800
33 42 13	1-2	Supply and Install 450 mm Steel Casing Culvert	m	20	$527.00	$10,540
33 42 13	1-3	Supply and Install 600 mm Steel Casing Culvert	m	24	$707.00	$16,968
33 42 13	1-4	Supply and Install 750 mm Steel Casing Culvert	m	17	$888.00	$15,096
33 42 13	1-6	Supply and Install 1400 mm Steel Casing Culvert	m	46	$1,610.00	$74,060
31 37 10	1-7	Supply and Place 50 kg Class Riprap	cu. m	238	$200.00	$47,600
31 37 10	1-8	Supply and Place 10 kg Class Riprap	cu. m	728	$100.00	$72,800
31 32 21	1-10	Supply and Place Non-Woven Geotextile	sq. m	2,733	$20.00	$54,660
02 41 13	1-11	Culvert Removal and Off-Site Disposal	each	5	$2,000.00	$10,000
					Sub-total Site Services	**$303,524**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	2-1	Dewatering	lump sum	1	$5,000.00	$5,000
01 35 43	2-2	Sediments and Erosion Control Measures	lump sum	1	$10,000.00	$10,000
					Sub-total Miscellaneous	**$15,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

Community and Government Services - Government of Nunavut

Class 'D' Cost Estimate - Phase 2

Tetra Tech Project WTRM03118-01 - Kimmirut Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$47,274
Civil Works		$193,736
Miscellaneous		$15,000
	Sub-total	**$256,010**
Project Contingencies	40.0%	$102,404
	Total Estimated Construction Cost	**$358,413**

NMS Specs						
Preliminaries			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$23,273.60	$23,274
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$4,000.00	$4,000
01 71 00	0-3	Construction Surveys	lump sum	1	$20,000.00	$20,000
					Sub-total Preliminaries	**$47,274**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	50	$30.00	$1,500
33 42 13	1-2	Supply and Install 450 mm Steel Casing Culvert	m	152	$527.00	$80,104
33 42 13	1-3	Supply and Install 600 mm Steel Casing Culvert	m	36	$707.00	$25,452
31 37 10	1-7	Supply and Place 50 kg Class Riprap	cu. m	20	$200.00	$4,000
31 37 10	1-8	Supply and Place 10 kg Class Riprap	cu. m	403	$100.00	$40,300
31 37 10	1-9	Supply and Place 50 - 75 mm Clear Crush	cu. m	31	$100.00	$3,100
31 32 21	1-10	Supply and Place Non-Woven Geotextile	sq. m	1,364	$20.00	$27,280
02 41 13	1-11	Culvert Removal and Off-Site Disposal	each	6	$2,000.00	$12,000
					Sub-total Site Services	**$193,736**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	3-1	Dewatering	lump sum	1	$5,000.00	$5,000
01 35 43	3-2	Sediments and Erosion Control Measures	lump sum	1	$10,000.00	$10,000
					Sub-total Miscellaneous	**$15,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

Community and Government Services - Government of Nunavut
Class 'D' Cost Estimate - Phase 3
Tetra Tech Project WTRM03118-01 - Kimmirut Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$48,110
Civil Works		$202,104
Miscellaneous		$15,000
	Sub-total	**$265,214**
Project Contingencies	40.0%	$106,086
	Total Estimated Construction Cost	**$371,300**

NMS Specs

Preliminaries			Unit	Est Quantity	Est. Unit Price	Est. Total
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$24,110.40	$24,110
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$4,000.00	$4,000
01 71 00	0-3	Construction Surveys	lump sum	1	$20,000.00	$20,000
					Sub-total Preliminaries	**$48,110**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	100	$30.00	$3,000
33 42 13	1-2	Supply and Install 450 mm Steel Casing Culvert	m	69	$527.00	$36,363
33 42 13	1-3	Supply and Install 600 mm Steel Casing Culvert	m	71	$707.00	$50,197
33 42 13	1-4	Supply and Install 750 mm Steel Casing Culvert	m	13	$888.00	$11,544
31 37 10	1-8	Supply and Place 10 kg Class Riprap	cu. m	511	$100.00	$51,100
31 37 10	1-9	Supply and Place 50 - 75 mm Clear Crush	cu. m	33	$100.00	$3,300
31 32 21	1-10	Supply and Place Non-Woven Geotextile	sq. m	1,730	$20.00	$34,600
02 41 13	1-11	Culvert Removal and Off-Site Disposal	each	6	$2,000.00	$12,000
					Sub-total Site Services	**$202,104**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	2-1	Dewatering	lump sum	1	$5,000.00	$5,000
01 35 43	2-2	Sediments and Erosion Control Measures	lump sum	1	$10,000.00	$10,000
					Sub-total Miscellaneous	**$15,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

Community and Government Services - Government of Nunavut
Class 'D' Cost Estimate - Phase 4
Tetra Tech Project WTRM03118-01 - Kimmirut Drainage Project

Preliminary Estimate of Probable Costs		Total
Preliminaries		$89,335
Civil Works		$614,351
Miscellaneous		$15,000
	Sub-total	**$718,686**
Project Contingencies	40.0%	$287,474
	Total Estimated Construction Cost	**$1,006,161**

NMS Specs						
Preliminaries			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 25 01	0-1	Mob / Demob, Temporary Facilities, Security, Quality Control, etc.	lump sum	1	$65,335.10	$65,335
01 35 14	0-2	Traffic Control, Barricades, and Temporary Signage	lump sum	1	$4,000.00	$4,000
01 71 00	0-3	Construction Surveys	lump sum	1	$20,000.00	$20,000
					Sub-total Preliminaries	**$89,335**
Civil Works			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
31 14 11	1-1	Excavation and Off-Site Disposal	cu.m	290	$30.00	$8,700
33 42 13	1-2	Supply and Install 450 mm Steel Casing Culvert	m	131	$527.00	$69,037
33 42 13	1-3	Supply and Install 600 mm Steel Casing Culvert	m	66	$707.00	$46,662
33 42 13	1-4	Supply and Install 750 mm Steel Casing Culvert	m	20	$888.00	$17,760
33 42 13	1-5	Supply and Install 900 mm Steel Casing Culvert	m	24	$1,068.00	$25,632
31 37 10	1-7	Supply and Place 50 kg Class Riprap	cu. m	52	$200.00	$10,400
31 37 10	1-8	Supply and Place 10 kg Class Riprap	cu. m	2,321	$100.00	$232,100
31 37 10	1-9	Supply and Place 50 - 75 mm Clear Crush	cu. m	167	$100.00	$16,700
31 32 21	1-10	Supply and Place Non-Woven Geotextile	sq. m	8,368	$20.00	$167,360
02 41 13	1-11	Culvert Removal and Off-Site Disposal	each	10	$2,000.00	$20,000
					Sub-total Site Services	**$614,351**
Miscellaneous			**Unit**	**Est Quantity**	**Est. Unit Price**	**Est. Total**
01 35 43	2-1	Dewatering	lump sum	1	$5,000.00	$5,000
01 35 43	2-2	Sediments and Erosion Control Measures	lump sum	1	$10,000.00	$10,000
					Sub-total Miscellaneous	**$15,000**

Notes:

1 Quantities shown on this table are estimates and provided for reference only.

APPENDIX E

INVENTORY OF EXISTING CULVERTS AND EROSION

Table 1: Existing Culverts Inventory

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 1	600	csp	blocked		
Culvert 2	500	csp	damaged		
Culvert 3	500	csp	partially blocked		
Culvert 4	1000	csp	damaged		
Culvert 5	500	csp	damaged		

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 6	500	csp	blocked		Reverse graded
Culvert 7	500	csp	blocked		
Culvert 8	150	pvc			
Culvert 9	500	csp	partially blocked		buried

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 10	500	csp	damaged		
Culvert 11	1200	csp	damaged		
Culvert 12	100		blocked		
Culvert 13	500		blocked		buried
Culvert 14	300				
Culvert 15	1000	csp	damaged		
Culvert 16	1200	csp	damaged		

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 17	750		blocked		buried
Culvert 18	600	csp	blocked		
Culvert 19	600	csp	damaged		
Culvert 20	600	csp	damaged		
Culvert 21	300				

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 22	600		damaged		
Culvert 23	2 x 150	steel casing	partially blocked		undersized
Culvert 24		csp			buried, anecdotal
Culvert 25			blocked		
Culvert 26	1200	csp	damaged		

Label	Diameter (mm)	Material	Condition	Picture	Notes
Culvert 27		csp	damaged		
Culvert 28			buried, anecdotal		buried, anecdotal
Culvert 29			blocked		not assessed
Culvert 30		csp	partially blocked		not assessed
Culvert 31			blocked		buried
Culvert 32	500		damaged		

Table 2: Erosion Inventory

Erosion ID	Picture ID	Notes
1		
2		
3		
4		
5		will impact access to building

Erosion ID	Picture ID	Notes
6		
7		

APPENDIX F

LIST OF PROPOSED CULVERTS

Table 1: Proposed Culverts

Name	Upgrade Type	Proposed Phase	Material	Wall Thickness (mm)	Length (m)	Diameter (mm)	Max. Flow (m^3/s)	Max. Velocity (m/s)	Max/Full Depth (%)
Culvert1	replace culvert	4	SWSP	10-12	7.5	450	0.05	2.57	31
Culvert2	replace culvert	4	SWSP	10-12	14.4	600	0.24	4.13	26
Culvert3	replace culvert	3	SWSP	10-12	17.0	450	0.09	3.39	27
Culvert4	replace culvert	3	SWSP	10-12	13.1	750	0.40	2.49	43
Culvert5	replace culvert	3	SWSP	10-12	19.9	600	0.11	2.08	32
Culvert6	replace culvert	3	SWSP	10-12	18.6	600	0.18	1.76	51
Culvert8	replace culvert	2	SWSP	10-12	12.2	450	0.04	1.92	35
Culvert10	replace culvert	2	SWSP	10-12	10.9	450	0.08	1.48	37
Culvert11	replace culvert	1	SWSP	10-12	24.9	1400	1.43	5.70	22
Culvert12	replace culvert	2	SWSP	10-12	5.7	450	0.00	0.54	3
Culvert13	replace culvert	4	SWSP	10-12	14.7	450	0.12	3.28	27
Culvert14	replace culvert	4	SWSP	10-12	12.9	450	0.13	4.49	24
Culvert15	replace culvert	4	SWSP	10-12	20.3	600	0.20	3.72	24
Culvert16	replace culvert	4	SWSP	10-12	15.6	450	0.13	2.20	41
Culvert17	replace culvert	4	SWSP	10-12	24.1	900	0.73	5.31	27
Culvert19	replace culvert	1	SWSP	10-12	23.3	600	0.19	3.87	29
Culvert20	replace culvert	1	SWSP	10-12	16.8	750	0.31	4.99	22
Culvert21	replace culvert	4	SWSP	10-12	15.3	450	0.10	1.20	54
Culvert22	replace culvert	4	SWSP	10-12	19.8	750	0.38	3.33	34
Culvert23	replace culvert	2	SWSP	10-12	5.8	450	0.06	1.78	46

Name	Upgrade Type	Proposed Phase	Material	Wall Thickness (mm)	Length (m)	Diameter (mm)	Max. Flow (m^3/s)	Max. Velocity (m/s)	Max/Full Depth (%)
Culvert24	replace culvert	2	SWSP	10-12	35.2	600	0.25	5.03	23
Culvert25	replace culvert	2	SWSP	10-12	24.0	450	0.05	1.60	31
Culvert26	replace culvert	1	SWSP	10-12	7.8	1400	1.35	4.64	24
Culvert27	replace culvert	1	SWSP	10-12	12.8	1400	1.35	3.69	29
Culvert28	replace culvert	3	SWSP	10-12	10.9	450	0.08	3.79	23
Culvert31	replace culvert	3	SWSP	10-12	31.8	600	0.12	1.12	42
Culvert32	replace culvert	4	SWSP	10-12	24.5	450	0.06	1.45	32
Culvert33	new culvert	4	SWSP	10-12	8.1	600	0.17	4.72	24
Culvert34	new culvert	4	SWSP	10-12	17.0	450	0.14	2.75	35
Culvert35	new culvert	3	SWSP	10-12	12.2	450	0.08	2.03	36
Culvert36	new culvert	3	SWSP	10-12	12.0	450	0.15	3.10	33
Culvert37	new culvert	2	SWSP	10-12	10.8	450	0.08	2.54	29
Culvert38	new culvert	4	SWSP	10-12	12.6	600	0.21	2.59	33
Culvert39	new culvert	2	SWSP	10-12	11.9	450	0.00	0.91	2
Culvert40	new culvert	2	SWSP	10-12	13.3	450	0.00	2.35	4
Culvert41	new culvert	2	SWSP	10-12	14.6	450	0.01	1.86	9
Culvert42	new culvert	2	SWSP	10-12	11.7	450	0.04	1.24	42
Culvert43	new culvert	2	SWSP	10-12	14.8	450	0.08	1.64	42
Culvert44	new culvert	2	SWSP	10-12	8.1	450	0.07	3.42	22
Culvert45	new culvert	2	SWSP	10-12	7.8	450	0.05	3.41	25
Culvert46	new culvert	4	SWSP	10-12	10.6	600	0.19	2.99	36

Name	Upgrade Type	Proposed Phase	Material	Wall Thickness (mm)	Length (m)	Diameter (mm)	Max. Flow (m^3/s)	Max. Velocity (m/s)	Max/Full Depth (%)
Culvert47	new culvert	4	SWSP	10-12	9.8	450	0.03	1.53	36
Culvert48	new culvert	4	SWSP	10-12	13.0	450	0.06	2.11	40
Culvert49	new culvert	1	SWSP	10-12	19.7	450	0.06	0.81	54
Culvert50	new culvert	3	SWSP	10-12	16.0	450	0.06	2.61	24

Table 2: Culvert Riprap Apron Locations (Including Headwall and Endwall Protection)

Culvert Name	Culvert Diameter (mm)	Riprap Class (kg)	Riprap Thickness (mm)	Inlet		Outlet		Total Riprap Volume (m^3)
				Riprap Length (m)	Riprap Volume (m^3)	Riprap Length (m)	Riprap Volume (m^3)	
Culvert1	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert2	600	25	450	1.2	4.1	3.0	6.7	10.9
Culvert3	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert4	750	10	350	1.5	5.0	3.8	8.2	13.2
Culvert5	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert6	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert8	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert10	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert11	1400	50	550	2.8	27.4	7.0	44.9	72.3
Culvert12	450	25	450	0.9	2.3	2.3	3.8	6.1
Culvert13	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert14	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert15	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert16	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert17	900	50	550	1.8	11.3	4.5	18.6	29.9
Culvert19	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert20	750	50	550	1.5	7.9	3.8	12.9	20.8
Culvert21	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert22	750	10	350	1.5	5.0	3.8	8.2	13.2
Culvert23	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert24	600	50	550	1.2	5.0	3.0	8.2	13.3
Culvert25	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert26	1400	50	550	2.8	27.4	7.0	44.9	72.3
Culvert27	1400	50	550	2.8	27.4	7.0	44.9	72.3
Culvert28	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert31	600	10	350	1.2	3.2	3.0	5.2	8.5

Culvert Name	Culvert Diameter (mm)	Riprap Class (kg)	Riprap Thickness (mm)	Inlet		Outlet		Total Riprap Volume (m^3)
				Riprap Length (m)	Riprap Volume (m^3)	Riprap Length (m)	Riprap Volume (m^3)	
Culvert32	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert33	600	25	450	1.2	4.1	3.0	6.7	10.9
Culvert34	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert35	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert36	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert37	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert38	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert39	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert40	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert41	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert42	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert43	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert44	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert45	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert46	600	10	350	1.2	3.2	3.0	5.2	8.5
Culvert47	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert48	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert49	450	10	350	0.9	1.8	2.3	3.0	4.8
Culvert50	450	10	350	0.9	1.8	2.3	3.0	4.8
Total Volume Riprap for Culvert Aprons (m^3):								**523**

APPENDIX G

PCSWMM MODEL PARAMETERS

Table 1: Subcatchment PCSWMM Model Parameters

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S2	J49	1.1659	72.87	160	14.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S22	J273	0.6326	43.6	145	15.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S25	J104	0.4805	28.59	168	17.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S31	J225	0.3709	33.45	111	18.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S37	J141	0.4023	22.93	175	19.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S46	J225	0.2992	28.68	104	18.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S53	J254	0.5614	76.66	73.2	18.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S77	SU9	0.3725	122.9	30.3	10.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S80	SU9	0.3373	117.8	28.6	15.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S81	J1723	0.3791	42.89	88.4	19.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S93	J347	0.784	64.65	121	15.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S100	J49	0.4858	94.94	51.2	17.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S102	J254	0.3009	40.13	75	20.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S113	J286	0.5272	70.78	74.5	35.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S154	J286	0.4402	58.51	75.2	43.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S160	J112	0.6921	128.7	53.8	11.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S163	J1713	0.9623	134.3	71.6	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S180	J1872	0.872	76.51	114	10.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S182	J373	0.3659	67.56	54.2	28.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S184	J511	0.5109	97.12	52.6	2.16	0	0.01	0.1	0.05	0.05	4	2	4	7
S196	J121	0.4791	66.46	72.1	8.81	0	0.01	0.1	0.05	0.05	4	2	4	7
S208	J389	0.5949	53.55	111	30.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S213	J424	0.264	82.44	32	11.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S217	J1692	0.822	118.2	69.6	22.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S219	J441	0.3829	64.71	59.2	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S222	J424	0.2938	78.88	37.2	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S225	J439	0.4285	30.09	142	31.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S226	J441	0.3016	50.05	60.3	8.28	0	0.01	0.1	0.05	0.05	4	2	4	7
S227	J159	0.5368	64.41	83.3	1.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S228	J159	0.9926	72.27	137	18.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S236	J493	0.3714	125.3	29.6	31.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S237	J497	0.4416	75.39	58.6	25.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S238	J493	0.6725	62.52	108	14.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S243	J485	0.3522	51.76	68.1	23.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S246	J533	1.0309	190.2	54.2	36.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S248	J489	0.5711	70.18	81.4	9.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S249	J515	0.5863	69.96	83.8	15	0	0.01	0.1	0.05	0.05	4	2	4	7
S252	J497	0.3585	92.74	38.7	17.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S253	J460	0.5163	92.09	56.1	14.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S262	J285	0.5453	81.65	66.8	16.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S264	J495	0.5363	41.27	130	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S265	J485	0.2673	52.42	51	18.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S267	J495	0.2817	50.58	55.7	18.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S270	J537	0.8904	97.99	90.9	14.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S271	J541	0.4991	61.01	81.8	13.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S275	J274	0.0602	32.19	18.7	8.12	0	0.01	0.1	0.05	0.05	4	2	4	7
S276	J283	0.2962	17.31	171	17.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S277	J525	1.3905	79.14	176	17.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S280	J506	0.6609	68.17	97	9.76	0	0.01	0.1	0.05	0.05	4	2	4	7
S284	J1781	0.1634	47.7	34.3	12.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S285	J511	0.5392	69.28	77.8	18.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S287	J278	0.0015	4.056	3.7	11.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S288	J515	0.5745	73.46	78.2	14.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S293	J1769	1.0153	58.38	174	18.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S296	J285	0.3713	81.5	45.6	13	0	0.01	0.1	0.05	0.05	4	2	4	7
S299	J523	0.6743	76.97	87.6	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S300	J1822	0.7559	114.3	66.1	24.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S302	J276	0.0165	20.23	8.16	8.17	0	0.01	0.1	0.05	0.05	4	2	4	7
S305	J1740	0.185	36.91	50.1	15.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S308	J98	0.6301	95.24	66.2	6.98	0	0.01	0.1	0.05	0.05	4	2	4	7
S313	J615	0.4502	43.28	104	13.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S314	J545	0.3168	72.41	43.7	13.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S315	J545	0.4703	39.81	118	17	0	0.01	0.1	0.05	0.05	4	2	4	7
S316	J553	0.4596	53.36	86.1	10.5	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S319	J594	0.3627	35.39	102	11.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S323	J564	0.7557	58.68	129	24.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S324	SU5	0.9136	100.7	90.7	19	0	0.01	0.1	0.05	0.05	4	2	4	7
S327	J615	0.2492	75.37	33.1	10.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S328	SU8	0.4411	56.87	77.6	19.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S330	SU8	0.4618	54.22	85.2	18.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S332	J283	0.2237	6.423	348	15	0	0.01	0.1	0.05	0.05	4	2	4	7
S334	J586	0.2607	27	96.6	22.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S335	J537	0.2508	72.42	34.6	18.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S336	J621	0.5419	54.95	98.6	17.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S339	J272	0.0101	14.05	7.19	9.41	0	0.01	0.1	0.05	0.05	4	2	4	7
S340	J280	0.0009	2.916	3.09	25.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S341	J290	0.0013	4.207	3.09	14.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S342	J1822	1.4971	153.5	97.5	22.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S343	J1804	1.1095	35.39	314	25	0	0.01	0.1	0.05	0.05	4	2	4	7
S344	J606	0.3517	50.4	69.8	14.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S345	J292	0.0046	3.126	14.7	9.99	0	0.01	0.1	0.05	0.05	4	2	4	7
S346	J621	0.8249	91.99	89.7	21.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S347	J588	0.3136	64.7	48.5	20.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S350	J674	0.5111	43.17	118	39	0	0.01	0.1	0.05	0.05	4	2	4	7
S352	J586	0.4501	103.6	43.4	23.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S354	J617	0.3479	31.01	112	23.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S357	J588	0.3903	54.64	71.4	21.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S358	J649	0.8084	71.43	113	31.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S361	J525	0.5536	79.48	69.7	32.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S364	J638	0.7162	47.19	152	30.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S365	J1757	0.3457	29.03	119	31.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S367	J634	0.8298	86.96	95.4	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S370	J678	0.5248	64.33	81.6	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S373	J629	0.2769	41.42	66.9	32.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S377	J629	0.9266	184.4	50.2	20.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S378	J742	0.6565	58.83	112	37	0	0.01	0.1	0.05	0.05	4	2	4	7
S381	J680	0.6861	61.64	111	24.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S385	J671	0.5798	56.51	103	25.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S386	J241	0.5338	89.33	59.8	29.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S388	J306	0.6151	82.32	74.7	27.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S391	J683	0.4052	58.04	69.8	18.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S392	J765	0.4744	83.37	56.9	28.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S396	J680	0.4678	69.11	67.7	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S398	J634	0.4792	54.78	87.5	21.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S401	Su5	0.1363	32.32	42.2	3.52	0	0.01	0.1	0.05	0.05	4	2	4	7
S406	SU8	0.5091	56.46	90.2	9.82	0	0.01	0.1	0.05	0.05	4	2	4	7
S408	J706	0.2085	48.46	43	21.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S409	J792	0.5704	72.01	79.2	22.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S410	SU5	0.4736	89.89	52.7	7.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S412	J671	0.7324	107.8	67.9	22.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S413	SU5	0.4114	47.22	87.1	13.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S415	J748	0.0777	8.551	90.9	24.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S416	J737	0.9494	96.55	98.3	32.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S417	J1766	0.2777	53.98	51.4	20.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S418	J1726	0.6458	60.99	106	26.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S420	J765	0.2946	35.9	82.1	28.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S421	J748	0.4061	59.03	68.8	37.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S424	J29	0.437	120.6	36.2	14.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S425	J1789	0.6448	78.25	82.4	23.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S428	J737	0.3604	48.85	73.8	8.54	0	0.01	0.1	0.05	0.05	4	2	4	7
S429	J1804	0.2558	7.433	344	34	0	0.01	0.1	0.05	0.05	4	2	4	7
S431	J221	0.6109	67.27	90.8	29.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S433	SU5	0.3498	104.9	33.3	14.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S438	J714	0.7282	40.22	181	19.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S441	J241	0.3507	26.75	131	29.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S445	J716	0.4719	25.02	189	19.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S448	J809	0.5673	68.93	82.3	22	0	0.01	0.1	0.05	0.05	4	2	4	7
S449	J40	0.4962	64.18	77.3	37.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S450	J1726	0.7243	73.33	98.8	22.4	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S455	J732	0.3237	27.27	119	23.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S456	J714	0.2872	62.68	45.8	17.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S462	J760	0.3762	63.47	59.3	27.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S463	J730	0.5391	49.27	109	18.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S464	J763	0.3507	87.08	40.3	22.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S466	J40	0.4133	74.41	55.5	38.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S468	J777	0.3549	39.91	88.9	21	0	0.01	0.1	0.05	0.05	4	2	4	7
S470	J763	0.5254	47.47	111	28.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S471	J813	0.8801	141	62.4	16.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S472	J855	0.4505	108.6	41.5	17.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S476	J771	0.3138	62.12	50.5	14	0	0.01	0.1	0.05	0.05	4	2	4	7
S477	J771	0.2607	55.01	47.4	14.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S478	J234	0.1397	31.3	44.6	11.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S479	J39	0.7285	65.62	111	32.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S480	J1898	0.0369	10.55	35	5.02	0	0.01	0.1	0.05	0.05	4	2	4	7
S481	J244	0.0064	7.771	8.24	9.37	0	0.01	0.1	0.05	0.05	4	2	4	7
S482	J782	0.6636	41.04	162	18.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S483	J799	0.4982	54.59	91.3	29.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S484	J230	0.1134	57.62	19.7	16.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S485	J805	0.838	68.05	123	48.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S486	SU1	0.9946	78.52	127	9.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S491	J222	0.0091	12.84	7.09	10.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S492	J822	0.2596	78.2	33.2	27.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S493	SU2	0.8823	80.4	110	21.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S496	J270	0.0496	13.73	36.1	10.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S500	J213	0.0245	22.79	10.7	37.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S503	J227	0.0984	68	14.5	12.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S504	J837	0.2779	54.21	51.3	26.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S507	J45	0.7657	126.1	60.7	15.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S509	J217	0.0013	3.469	3.75	28.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S515	J263	0.5923	89.1	66.5	15.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S516	J45	0.6201	102.5	60.5	16.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S517	J316	0.0527	33.76	15.6	11.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S518	J261	0.09	61.47	14.6	7.78	0	0.01	0.1	0.05	0.05	4	2	4	7
S522	J859	0.2618	26.41	99.1	14.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S523	J861	0.4015	53.06	75.7	19.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S524	J232	0.0449	21.26	21.1	2.03	0	0.01	0.1	0.05	0.05	4	2	4	7
S525	J89	0.7371	49.59	149	41.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S526	J91	0.549	44.07	125	45.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S528	SU1	0.5601	112.9	49.6	8.45	0	0.01	0.1	0.05	0.05	4	2	4	7
S529	J228	0.0384	24.28	15.8	9.43	0	0.01	0.1	0.05	0.05	4	2	4	7
S533	J82	0.0126	2.497	50.5	54.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S538	J859	0.3963	46.98	84.4	8.02	0	0.01	0.1	0.05	0.05	4	2	4	7
S539	J202	0.4581	67	68.4	14.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S541	J855	0.2522	42.62	59.2	11.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S542	J268	0.0097	12.48	7.77	25	0	0.01	0.1	0.05	0.05	4	2	4	7
S545	J212	0.0061	5.866	10.4	9.03	0	0.01	0.1	0.05	0.05	4	2	4	7
S546	J268	0.0014	3.91	3.58	26.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S547	J837	0.6698	150.2	44.6	17.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S549	J1775	0.5584	69.63	80.2	10.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S552	J930	0.3727	69.41	53.7	10.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S558	J930	0.6998	80.64	86.8	11.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S559	J196	1.0786	76.45	141	13.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S562	J200	0.0528	22.88	23.1	27.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S564	J73	0.0431	18.99	22.7	14.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S565	J81	0.0032	4.722	6.78	13.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S566	J887	0.8797	58.74	150	20.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S568	J28	0.0081	7.116	11.4	16.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S572	J1775	0.7874	88.76	88.7	24.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S573	culv12in	0.0027	5.051	5.35	14.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S575	J76	0.0238	19.76	12	10.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S576	J1846	0.3818	87.76	43.5	14.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S578	J28	0.0001	2.899	0.35	8.64	0	0.01	0.1	0.05	0.05	4	2	4	7
S580	J120	0.0092	12.04	7.64	9.63	0	0.01	0.1	0.05	0.05	4	2	4	7
S582	J119	0.0018	3.547	5.08	7.49	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S583	J942	0.4065	76.65	53	15.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S585	J102	0.1376	45.22	30.4	43.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S588	J89	0.0305	30.3	10.1	23.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S590	J895	0.2261	28.93	78.1	21.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S593	J918	0.6927	93.42	74.1	15.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S595	J178	0.484	77.05	62.8	13.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S596	J1745	0.5997	93.74	64	19.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S597	J118	0.0231	17.3	13.4	11.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S598	J65	0.0148	17.06	8.67	20.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S599	J117	0.146	36.39	40.1	19.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S600	J65	0.0088	4.06	21.7	11.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S602	J911	0.4182	46.49	90	24.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S603	J88	0.0047	10.37	4.53	14.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S604	J942	0.3153	40.6	77.7	17.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S609	J178	0.0262	13.7	19.1	13.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S610	J905	0.3802	101.5	37.5	20.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S612	J86	0.0339	13.43	25.3	18.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S613	J103	0.0173	20.8	8.32	27.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S614	J56	0.3815	112.8	33.8	24	0	0.01	0.1	0.05	0.05	4	2	4	7
S618	J198	0.3391	88.56	38.3	22.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S621	J58	0.0191	10.61	18	14.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S622	J962	1.0689	94.67	113	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S623	J83	0.0916	44.27	20.7	18.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S626	SU3	0.5615	63.29	88.7	11.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S627	J136	0.0021	6.878	3.05	20.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S628	J59	0.0044	8.644	5.09	21.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S629	J964	0.6377	98.41	64.8	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S631	J67	0.0152	14.84	10.2	11.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S635	J198	0.0018	2.958	6.09	9.35	0	0.01	0.1	0.05	0.05	4	2	4	7
S636	J63	0.0017	4.413	3.85	9.46	0	0.01	0.1	0.05	0.05	4	2	4	7
S640	J1001	0.6147	76.23	80.6	26.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S642	J174	0.0148	9.367	15.8	11.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S647	J196	0.1696	500	3.39	12.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S648	J84	0.0067	3.029	22.1	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S651	J1745	0.028	7.941	35.3	11.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S652	SU4	0.157	24.69	63.6	17.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S653	J957	0.7035	36.37	193	19	0	0.01	0.1	0.05	0.05	4	2	4	7
S655	J957	0.3411	37.37	91.3	24.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S656	J170	0.0321	18.86	17	15.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S661	J77	0.004	3.37	11.9	12.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S663	J33	0.0226	17.3	13.1	15.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S664	J33	0.0161	13.96	11.5	16.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S665	J976	0.657	81.34	80.8	26	0	0.01	0.1	0.05	0.05	4	2	4	7
S666	J57	0.9316	146.3	63.7	11.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S672	J1758	0.1722	39.68	43.4	33.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S674	J976	0.2872	42.34	67.8	24.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S677	J116	0.0018	7.015	2.57	0.19	0	0.01	0.1	0.05	0.05	4	2	4	7
S678	J27	0.0283	13.56	20.9	8.54	0	0.01	0.1	0.05	0.05	4	2	4	7
S679	J189	0.0734	46.02	15.9	42.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S680	J50	0.0113	7.65	14.8	4.54	0	0.01	0.1	0.05	0.05	4	2	4	7
S683	SU3	0.4146	27.92	148	19.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S684	J1869	0.6046	134.4	45	9.99	0	0.01	0.1	0.05	0.05	4	2	4	7
S685	J1042	0.3966	65.09	60.9	23.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S686	J1005	1.0542	100.5	105	29	0	0.01	0.1	0.05	0.05	4	2	4	7
S690	J191	0.0064	10.42	6.15	15.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S692	J192	0.2896	73.59	39.4	36.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S693	J1042	0.4198	51.27	81.9	17.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S694	SU3	0.6854	94.83	72.3	27.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S695	J1033	0.625	86.82	72	24.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S697	J25	0.0145	12.25	11.8	9.68	0	0.01	0.1	0.05	0.05	4	2	4	7
S701	J1055	0.2583	30.84	83.8	24.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S702	J94	0.9716	95.36	102	27.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S705	J6	0.0184	18.73	9.83	10.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S706	J52	0.0449	28.9	15.5	7.46	0	0.01	0.1	0.05	0.05	4	2	4	7
S709	J5	0.0531	36.41	14.6	9.1	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S710	J3	0.0142	10.99	12.9	7.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S711	J1749	0.365	96.57	37.8	14	0	0.01	0.1	0.05	0.05	4	2	4	7
S712	J4	0.0027	9.448	2.86	1.49	0	0.01	0.1	0.05	0.05	4	2	4	7
S714	J1059	0.5391	73.45	73.4	14.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S718	J1057	0.5728	43.4	132	29.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S721	J1061	0.5046	61.06	82.6	23	0	0.01	0.1	0.05	0.05	4	2	4	7
S724	J1078	0.7016	59.11	119	19.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S728	J1070	0.3344	32.33	103	17.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S730	J1099	0.3017	44.18	68.3	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S731	J1061	0.3975	63.97	62.1	24.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S734	J1078	0.3616	65.25	55.4	23.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S743	J36	0.0373	12.01	31.1	41.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S744	J15	0.6761	126.8	53.3	25.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S747	J1793	0.2776	53.18	52.2	22.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S751	J1099	0.8765	56.92	154	20.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S753	J1135	0.2645	113.2	23.4	21.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S756	J1114	0.3365	78.47	42.9	15.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S761	J16	0.0036	8.232	4.37	7.88	0	0.01	0.1	0.05	0.05	4	2	4	7
S762	J26	0.0142	15.95	8.9	9.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S763	J26	0.0084	12.74	6.59	6.51	0	0.01	0.1	0.05	0.05	4	2	4	7
S765	J1118	0.4999	40.25	124	26.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S766	J16	0.0363	19.24	18.9	7.31	0	0.01	0.1	0.05	0.05	4	2	4	7
S767	J1133	0.7282	62.97	116	32.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S768	J26	0.0635	28.54	22.3	8.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S769	J1763	0.6545	74.21	88.2	19.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S770	J1763	0.6548	168.4	38.9	26.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S772	J14	0.0044	8.795	5	13.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S773	J14	0.0009	2.266	3.97	35.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S775	J15	0.0644	31.63	20.4	41.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S777	J14	0.0066	11.25	5.87	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S779	J1130	1.1671	91.11	128	14.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S780	J14	0.0092	14.99	6.14	12.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S782	J14	0.0776	30.27	25.6	15.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S784	J14	0.0081	10.08	8.04	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S786	J1133	0.2703	28.68	94.2	35.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S787	J1114	0.3493	81.24	43	9.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S788	J1135	0.2862	29.58	96.7	31.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S791	J1170	0.6959	60.74	115	36.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S793	J1138	0.7899	68.84	115	31.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S794	J47	0.6086	29.91	203	24.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S795	J1170	0.38	30.78	123	34.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S805	J1801	0.7385	122.4	60.4	24.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S806	J129	0.0135	11.51	11.7	17.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S807	J1717	0.0028	2.428	11.5	23.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S808	J128	0.0069	10.94	6.31	12.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S809	J1147	0.5285	52.45	101	26.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S811	J1162	0.8227	72.18	114	17.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S815	J1164	0.5057	30.4	166	38.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S820	J113	0.2323	40.05	58	23.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S821	J1188	0.6246	109.6	57	16.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S822	J1185	0.713	65.62	109	15.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S823	J54	0.6169	50.49	122	32.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S825	J1701	0.4706	100.7	46.7	23.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S827	J1196	1.3472	120.9	111	15	0	0.01	0.1	0.05	0.05	4	2	4	7
S829	J1233	0.8079	144.6	55.9	19.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S831	J1206	0.4412	61.3	72	15.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S832	J101	0.5055	103.9	48.7	42.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S833	J1206	0.326	72.22	45.1	24.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S834	J1200	0.3963	37.8	105	26.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S835	J1233	0.2795	33.38	83.7	29.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S836	J1266	1.5426	110	140	30.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S839	J1204	0.6008	68.96	87.1	14	0	0.01	0.1	0.05	0.05	4	2	4	7
S849	J20	0.0381	35.64	10.7	31.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S850	J19	0.2475	29.73	83.2	47.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S851	J99	0.1532	40.66	37.7	24.4	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S853	J1268	0.5964	58.09	103	23.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S854	culv3in	0.7226	59.13	122	28.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S855	J182	0.289	36.45	79.3	22	0	0.01	0.1	0.05	0.05	4	2	4	7
S856	J1256	0.5235	40.83	128	23.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S857	J1334	0.2959	26.29	113	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S858	J1220	0.4684	73.48	63.7	19	0	0.01	0.1	0.05	0.05	4	2	4	7
S860	J1797	0.2678	65.83	40.7	19.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S861	J1196	1.3977	97.97	143	13.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S862	J35	0.4924	104.1	47.3	46.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S866	J42	0.0007	2.753	2.54	52.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S867	J43	0.1772	46.16	38.4	37.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S869	J12	0.3245	39.22	82.7	34.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S870	J78	0.4679	51.66	90.6	19.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S874	J43	0.0042	5.536	7.59	38.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S876	J78	0.2606	34.28	76	21.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S881	J30	0.4273	46.48	91.9	17.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S883	J182	0.9009	199.9	45.1	15	0	0.01	0.1	0.05	0.05	4	2	4	7
S886	culv3in	0.5703	101.7	56.1	27.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S887	J1760	0.6874	147.1	46.7	14.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S891	J30	0.7853	64.63	122	19	0	0.01	0.1	0.05	0.05	4	2	4	7
S893	J1262	0.4394	24.18	182	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S894	J1890	0.0142	6.714	21.2	36.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S895	J1277	0.6456	62.32	104	11	0	0.01	0.1	0.05	0.05	4	2	4	7
S900	J185	0.0045	11.29	3.99	5.18	0	0.01	0.1	0.05	0.05	4	2	4	7
S901	J184	0.0764	40.03	19.1	9.24	0	0.01	0.1	0.05	0.05	4	2	4	7
S902	J31	0.0691	35.7	19.4	19	0	0.01	0.1	0.05	0.05	4	2	4	7
S904	J11	0.0028	3.113	9	13.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S905	J183	0.006	8.682	6.91	4.43	0	0.01	0.1	0.05	0.05	4	2	4	7
S906	J1839	0.3109	62.63	49.6	22	0	0.01	0.1	0.05	0.05	4	2	4	7
S907	J80	0.0099	12.59	7.86	18.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S908	J1283	0.361	69.92	51.6	21.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S910	J75	0.0025	4.052	6.17	17.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S912	J11	0.0012	2.56	4.69	21.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S925	J22	0.0109	9.661	11.3	10.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S926	J70	0.0112	7.446	15	22.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S928	J1847	0.2548	20.88	122	26.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S930	J41	0.3284	53.18	61.7	16.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S932	J1309	0.2856	39.5	72.3	14.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S933	J1309	0.8593	87.88	97.8	11.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S937	J1328	0.3034	38.11	79.6	32.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S940	J1324	0.4154	37.07	112	8.89	0	0.01	0.1	0.05	0.05	4	2	4	7
S941	J1339	0.1123	18.95	59.3	16.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S942	J1339	1.0631	111.6	95.3	15.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S943	J13	0.1653	33.39	49.5	16.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S945	J66	0.0055	8.084	6.8	8.36	0	0.01	0.1	0.05	0.05	4	2	4	7
S947	J1847	0.2843	65.94	43.1	31.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S948	J1387	0.6624	109.9	60.3	20.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S949	J1411	0.5226	155.4	33.6	13.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S950	J1368	1.2444	140.7	88.5	41	0	0.01	0.1	0.05	0.05	4	2	4	7
S952	J1360	0.2945	25.03	118	21.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S956	J1394	0.391	56.58	69.1	42.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S958	J1387	0.2824	65.72	43	15.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S967	J1351	0.3587	43.87	81.8	11.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S971	J1372	0.5117	61.34	83.4	15.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S974	J1427	0.5265	42.81	123	28.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S975	J1823	0.5259	51.44	102	19.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S979	J1436	0.3556	35.02	102	43.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S981	J1394	0.7242	170.5	42.5	31.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S988	J1419	0.622	76.12	81.7	24.4	0	0.01	0.1	0.05	0.05	4	2	4	7
S994	J1398	0.4495	72.24	62.2	12.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S1000	J1455	0.2638	49.34	53.5	26.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S1004	J1411	0.5197	64.75	80.3	10.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S1019	J1467	0.6952	46.49	150	29.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S1021	J1455	0.3966	49.03	80.9	13.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S1033	J1494	0.5199	81.1	64.1	21.6	0	0.01	0.1	0.05	0.05	4	2	4	7

Name	Outlet	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Imperv. (%)	N Imperv	N Perv	Dstore Imperv (mm)	Dstore Perv (mm)	Max. Infil. Rate (mm/hr)	Min. Infil. Rate (mm/hr)	Decay Constant (1/hr)	Drying Time (days)
S1039	J1525	0.5438	25.25	215	20.5	0	0.01	0.1	0.05	0.05	4	2	4	7
S1170	J57	0.0614	33.38	18.4	5.41	0	0.01	0.1	0.05	0.05	4	2	4	7
S698_1	J7	0.4986	110.7	45.1	13.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S698_2	J55	0.0773	110.7	6.99	13.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S732_1	J36	0.0192	33.03	5.81	12.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S732_2	J46	0.3848	33.03	117	12.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S703_1	J8	0.0713	70.03	10.2	9.77	0	0.01	0.1	0.05	0.05	4	2	4	7
S703_2	J62	0.0868	70.03	12.4	9.77	0	0.01	0.1	0.05	0.05	4	2	4	7
S911_1	J1334	0.1533	105.8	14.5	15.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S911_2	J68	0.8225	105.8	77.8	15.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S519_1	J1720	0.0857	47.52	18	42.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S519_2	J805	0.1658	47.52	34.9	42.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S452_2	J17	0.3311	63.56	52.1	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S452_3	J18	0.3553	63.56	55.9	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S452_4	J271	0.1177	63.56	18.5	20	0	0.01	0.1	0.05	0.05	4	2	4	7
S443_1	J248	0.2604	78.26	33.3	28.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S443_3	J61	0.3339	78.26	42.7	28.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S443_4	J69	0.2528	78.26	32.3	28.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S739_1	J90	0.45	123.5	36.5	18	0	0.01	0.1	0.05	0.05	4	2	4	7
S739_2	SU6	0.2069	123.5	16.8	18	0	0.01	0.1	0.05	0.05	4	2	4	7
S374_1	J34	0.1871	71.73	26.1	21.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S374_2	J53	0.2242	71.73	31.3	21.1	0	0.01	0.1	0.05	0.05	4	2	4	7
S868_1	J99	0.0346	27.03	12.8	25.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S868_2	J44	0.0908	27.03	33.6	25.9	0	0.01	0.1	0.05	0.05	4	2	4	7
S758_1	J10	0.0658	25.28	26	12.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S360_1	J107	0.4801	85.76	56	16.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S360_2	J34	0.2817	85.76	32.8	16.2	0	0.01	0.1	0.05	0.05	4	2	4	7
S348_1	J109	0.2269	54.29	41.8	14	0	0.01	0.1	0.05	0.05	4	2	4	7
S348_2	J297	0.1133	54.29	20.9	14	0	0.01	0.1	0.05	0.05	4	2	4	7
S792_1	J54	0.0604	71.17	8.49	31	0	0.01	0.1	0.05	0.05	4	2	4	7
S792_3	J137	0.1148	71.17	16.1	31	0	0.01	0.1	0.05	0.05	4	2	4	7
S286_1	J110	0.4958	62.46	79.4	12.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S286_2	J274	0.0691	62.46	11.1	12.7	0	0.01	0.1	0.05	0.05	4	2	4	7
S307_1	J106	0.1369	51.35	26.7	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S307_2	J274	0.1834	51.35	35.7	12.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S796_1	J125	0.2235	77.6	28.8	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S796_3	J143	0.1176	77.6	15.2	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S796_4	J135	0.1014	77.6	13.1	25.8	0	0.01	0.1	0.05	0.05	4	2	4	7
S758_3	J26	0.0763	25.28	30.2	12.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S758_4	J16	0.1863	25.28	73.7	12.3	0	0.01	0.1	0.05	0.05	4	2	4	7
S792_2	J138	0.0482	71.17	6.77	31	0	0.01	0.1	0.05	0.05	4	2	4	7
S792_4	J144	0.1018	71.17	14.3	31	0	0.01	0.1	0.05	0.05	4	2	4	7
S792_6	J111	0.1622	71.17	22.8	31	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_1	J200	0.0529	61.7	8.57	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_5	J142	0.0125	61.7	2.03	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_4	J142	0.1232	61.7	20	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_7	J146	0.1518	61.7	24.6	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_6	J147	0.1703	61.7	27.6	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_8	J145	0.1492	61.7	24.2	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_2	J168	0.1035	61.7	16.8	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S537_9	J150	0.0406	61.7	6.58	32.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S667_2	J27	0.6974	96.72	72.1	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S667_3	J38	0.1045	96.72	10.8	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7
S667_4	J27	0.0365	96.72	3.77	17.6	0	0.01	0.1	0.05	0.05	4	2	4	7

Table 2: Junctions PCSWMM Model Parameters

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J3	455600.43	6968878.3	19.50
J4	455612.38	6968882.8	18.30
J5	455633.07	6968889.1	17.70
J6	455655.16	6968893.2	16.29
J7	455697.96	6968870.7	12.00
J8	455718.85	6968884.2	9.90
J35	455690.04	6968509.5	36.09

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J42	455709.74	6968506.5	35.60
J43	455712.64	6968496.5	35.00
J44	455725.52	6968499	34.95
J67	455503.27	6969019.8	39.94
J115	454921.19	6968953.3	63.40
J116	454919.08	6968962.4	64.00
J117	454956.32	6969069.9	60.39
J118	454968.27	6969076.2	58.70
J119	455012.53	6969102.2	55.51
J120	455018.86	6969110.7	55.11
J158	454362.51	6969747.2	65.00
J159	454350.33	6969731.6	65.97
J182	455083.91	6968404.7	76.00
J183	455076.2	6968405.9	75.59
J184	455066.25	6968412.4	75.01
J185	455058.87	6968416.2	74.76
culv3out	455709.39	6968471.4	39.84
culv12in	455686.89	6969120.1	12.35
J9	455570.34	6968388.3	69.80
J19	455691.72	6968521	35.97
J20	455710.21	6968519.4	35.60
J28	455691.46	6969116.7	11.80
J29	454729.05	6969324.5	69.90
J1	455418.64	6968373.4	90.07
J12	455592.87	6968418.5	66.99
J22	455368.55	6968342.3	85.70
J30	455523.73	6968360.5	73.16
J31	455596.03	6968401.9	65.39
J13	455330.59	6968223.5	75.24
J41	455287.86	6968309.7	79.01
J66	455380.21	6968320.4	84.89
J70	455340.38	6968347.7	81.98
J75	455217.98	6968390.4	79.86
J78	455240.69	6968385.8	78.38
J80	455690.81	6968400.4	58.92
culv3in	455694	6968464.2	42.01
J93	455711.29	6968506.3	35.45
J99	455783.21	6968503.5	24.54
J101	455703.16	6968572.2	37.65
J111	455729.38	6968724.1	18.47
J113	455766.4	6968633.4	20.56
J125	455760.97	6968683.9	15.01
J126	455744.45	6968717.7	17.02
J128	455772.78	6968681.5	14.08
J129	455793.65	6968686.1	10.07
J16	455718.34	6968765.2	16.99
J36	455637.99	6968810.6	19.95
J15	455650.77	6968751.9	20.72
J26	455715.87	6968777.1	16.05
J46	455705.83	6968818.1	14.97
J48	455705.73	6968829.1	14.92
J25	455617.65	6968919.7	18.57
J27	455630.97	6968964	15.00
J33	455635.37	6968987.6	14.60
J50	455656.18	6968961.9	15.88
J56	455656.83	6969037	10.26
J58	455690.14	6969048.3	6.57
J59	455714.33	6969038.2	4.12
J63	455706.44	6969029.2	6.48
J65	455682.72	6969064.6	9.81
J72	455694.66	6969058.9	5.46
J73	455707.29	6969107.2	9.99
J76	455714.23	6969094.4	8.85
J81	455706.85	6969119.6	10.93
J82	455661.86	6969103	12.08
J77	455717.73	6968988.4	11.33
J87	455726.44	6969002.5	7.86

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J86	455657.09	6969056.2	10.70
J88	455657.16	6969071	11.30
J89	455658.96	6969078.6	11.50
J91	455664.45	6969088.9	11.80
J84	455604.44	6969010.1	22.21
J102	455611.62	6969055.5	19.71
J103	455619.65	6969056.6	18.44
J136	455592.33	6969032.9	26.49
J142	455584.52	6969033.4	27.83
J168	455507.91	6969046.3	40.76
J170	455590.94	6968981.7	23.70
J174	455446.47	6969002	46.99
J178	455495.53	6969032.3	41.42
J189	455553.27	6968932.1	24.59
J191	455561.18	6968922.6	23.92
J192	455587.94	6968893.9	20.98
J194	455596.52	6968884.7	20.72
J198	455374.67	6969016.4	42.40
J200	455494.71	6969077.3	44.20
J202	455484.09	6969069.8	43.34
J212	455458.45	6969148.3	53.92
J213	455443.03	6969192.3	54.88
J221	455372.17	6969242.1	51.18
J222	455370.78	6969229.3	49.82
J227	455268.1	6969190.1	48.60
J228	455288.32	6969188.1	47.70
J230	455249.06	6969202.3	49.50
J232	455236.53	6969193	50.00
J241	455227.69	6969260.2	50.05
J244	455180.55	6969251.2	51.82
J248	455092.22	6969230.6	51.20
J261	455004.78	6969183.4	55.13
J263	454991.64	6969172.5	55.21
J264	454927.8	6969169.3	57.72
J267	454895.53	6969165.1	59.00
J268	454910.4	6969157.4	57.11
J270	454857.69	6969219.5	60.80
J271	454840.03	6969210.8	61.00
J272	454601.02	6969547.6	85.00
J274	454629.37	6969587.9	84.68
J276	454639.96	6969575.9	83.27
J278	454678.03	6969631.3	87.59
J283	454682.63	6969567.4	81.08
J285	454690.36	6969569.7	83.06
J290	454701.53	6969545.1	86.45
J292	454705.21	6969528.9	86.88
J297	454668.24	6969472.6	81.36
J306	454742.19	6969332.3	70.00
J316	454913.9	6969187.9	59.00
J280	454659.01	6969546.2	80.60
J133	455101.4	6969208.3	50.40
J234	455232.32	6969219.5	50.02
J215	455325.72	6969232.9	53.05
J217	455425.96	6969216.3	55.42
J95	455318.01	6968949.4	42.90
J52	455647.59	6968891.4	17.11
J83	455611.1	6969036.9	21.75
J11	455240.61	6968377.7	77.09
J49	454195.32	6969884.1	70.70
J141	454227.32	6969974.1	83.52
J225	454318.32	6969921.1	78.57
J254	454147.32	6969900.1	70.97
J273	454315.32	6969905.1	77.00
J286	454096.32	6969879.1	76.39
J347	454295.32	6969822.1	66.00
J373	454156.32	6969777.1	69.00
J389	454134.32	6969765.1	73.02

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J424	454620.32	6969742.1	84.96
J439	454123.32	6969692.1	72.37
J441	454559.32	6969733.1	83.92
J460	454658.32	6969697.1	85.97
J485	454724.32	6969650.1	91.14
J489	454246.32	6969663.1	66.70
J493	454131.32	6969660.1	70.90
J495	454939.32	6969650.1	104.41
J497	454864.32	6969633.1	95.99
J506	454240.32	6969637.1	66.80
J509	454629.32	6969597.1	84.99
J511	454329.32	6969632.1	65.96
J515	454435.32	6969631.1	78.21
J523	454968.32	6969613.1	108.95
J525	455141.32	6969343.1	72.14
J533	454144.32	6969590.1	67.00
J537	455243.32	6969485.1	118.04
J541	454819.32	6969559.1	92.89
J545	454218.32	6969598.1	66.90
J553	455035.32	6969550.1	118.99
J564	454851.32	6969581.1	92.97
J586	454207.32	6969516.1	66.99
J588	454812.32	6969507.1	92.24
J594	454452.32	6969501.1	81.04
J606	454457.32	6969473.1	76.59
J615	454571.32	6969420.1	70.97
J617	454193.32	6969484.1	66.99
J621	455079.32	6969407.1	96.00
J629	454192.32	6969470.1	66.99
J634	454475.32	6969439.1	71.00
J638	455376.32	6969319.1	66.80
J649	455239.32	6969314.1	62.87
J671	454188.32	6969395.1	66.99
J674	455192.32	6969343.1	68.46
J678	454991.32	6969361.1	90.50
J680	454807.32	6969340.1	76.85
J683	454493.32	6969424.1	70.99
J706	454799.32	6969338.1	76.05
J714	454639.32	6969324.1	70.98
J716	454505.32	6969327.1	74.00
J730	454490.32	6969310.1	74.03
J732	454207.32	6969308.1	66.99
J737	454264.32	6969378.1	66.99
J742	455180.32	6969274.1	51.50
J748	455106.32	6969245.1	51.30
J760	454152.32	6969246.1	79.00
J763	454209.32	6969281.1	66.92
J765	455001.32	6969246.1	58.97
J771	454628.32	6969259.1	85.01
J777	454144.32	6969238.1	79.00
J782	454242.32	6969251.1	66.80
J792	455319.32	6969187.1	44.33
J799	454742.32	6969168.1	69.04
J805	455673.55	6969143.6	13.69
J809	454903.32	6969198.1	59.10
J813	454118.32	6969195.1	82.00
J822	455380.32	6969188.1	42.84
J837	454070.32	6969145.1	82.00
J855	455350.32	6969138.1	42.99
J859	455163.32	6969140.1	50.99
J861	454122.32	6969201.1	82.00
J887	454981.32	6969121.1	56.83
J895	455123.32	6969096.1	52.93
J905	454984.32	6969068.1	56.95
J911	455122.32	6969076.1	52.17
J918	454053.32	6969080.1	82.91
J930	455365.32	6969064.1	43.00

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J942	455175.32	6969075.1	49.66
J957	455229.32	6968998.1	44.00
J962	454924.32	6968950.1	62.91
J964	454978.32	6969038.1	60.44
J976	455264.32	6968967.1	43.00
J1001	455541.32	6968948.1	28.33
J1005	455181.32	6968945.1	57.39
J1033	454928.32	6968916.1	63.92
J1042	454927.32	6968930.1	62.93
J1055	455366.32	6968909.1	43.00
J1057	455180.32	6968868.1	71.71
J1059	455784.32	6968863.1	3.00
J1061	455394.32	6968835.1	46.87
J1070	454959.32	6968845.1	80.93
J1078	454984.32	6968831.1	81.94
J1099	455318.32	6968784.1	60.88
J1114	455022.32	6968736.1	97.97
J1118	455446.32	6968769.1	47.97
J1130	455188.32	6968693.1	84.17
J1133	455529.32	6968737.1	37.89
J1135	455551.32	6968734.1	36.97
J1138	455575.32	6968730.1	36.00
J1147	455288.32	6968676.1	73.00
J1162	455215.32	6968668.1	82.07
J1164	455614.32	6968668.1	40.06
J1170	455631.32	6968727.1	30.77
J1185	455050.32	6968502.1	82.00
J1188	455337.32	6968626.1	79.86
J1196	455251.32	6968393.1	78.88
J1200	455394.32	6968571.1	83.34
J1204	455354.32	6968550.1	86.95
J1206	455064.32	6968459.1	78.43
J1220	455419.32	6968519.1	90.17
J1233	454928.32	6968464.1	64.00
J1256	455535.32	6968374.1	69.25
J1262	454826.32	6968435.1	34.00
J1266	455854.32	6968549.1	3.00
J1268	455054.32	6968423.1	73.67
J1277	455006.32	6968442.1	73.94
J1283	455635.32	6968398.1	63.00
J1309	455139.32	6968354.1	75.99
J1324	455251.32	6968333.1	75.89
J1328	455789.32	6968236.1	8.45
J1334	455552.32	6968392.1	68.55
J1339	455498.32	6968194.1	63.52
J1351	455243.32	6968268.1	76.01
J1360	455354.32	6968220.1	72.40
J1368	455771.32	6968238.1	10.01
J1372	455250.32	6968238.1	76.01
J1387	455444.32	6968218.1	64.85
J1394	455715.32	6968187.1	13.67
J1398	455376.32	6968209.1	71.00
J1411	455458.32	6968184.1	63.96
J1419	455571.32	6968132.1	42.34
J1427	455655.32	6968115.1	19.99
J1436	455676.32	6968135.1	16.73
J1455	455507.32	6968134.1	57.04
J1467	455641.32	6968022.1	15.45
J1494	455665.32	6968004.1	9.27
J1525	455706.32	6967961.1	3.99
J1692	454373.32	6969748.1	64.96
J1701	455365.32	6968608.1	81.96
J1713	454165.32	6969768.1	69.01
J1717	455822.32	6968687.1	3.22
J1720	455742.32	6969133.1	3.46
J1723	454144.32	6969888.1	70.94
J1726	454826.19	6969233	61.42

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J1740	454634.32	6969540.1	80.82
J1745	455257.32	6969004.1	44.00
J1749	455470.32	6968838.1	41.30
J1757	455219.32	6969292.1	53.05
J1758	454937.32	6968973.1	62.91
J1760	455196.32	6968348.1	76.01
J1763	455338.32	6968762.1	58.99
J1766	454763.32	6969299.1	69.13
J1769	454862.32	6969586.1	92.98
J1775	455101.32	6969100.1	53.36
J1781	454928.32	6969639.1	102.97
J1789	455007.32	6969228.1	55.01
J1793	455368.32	6968805.1	51.12
J1797	455038.32	6968441.1	73.97
J1801	455317.32	6968698.1	68.94
J1804	455139.32	6969263.1	51.40
J1822	454235.32	6969544.1	67.00
J1823	455765.32	6968066.1	3.51
J1839	455685.32	6968387.1	61.40
J1846	455741.32	6969056.1	3.00
J1847	455836.32	6968266.1	4.00
J1869	455427.12	6968859.5	42.05
J1872	454293.32	6969651.1	66.60
J1890	454821.32	6968441.1	33.91
J1898	455165.32	6969252.1	52.00
J21	454684.33	6969618.5	86.81
J34	454692.17	6969391.8	71.60
J39	455480.11	6969121.1	48.00
J40	455398.38	6969238.1	51.53
J45	454831.09	6969193.1	60.06
J47	455657.29	6968734.1	22.19
J51	455649.1	6968764	20.40
J54	455707.53	6968626.9	31.77
J32	455037.57	6969112.8	53.66
J37	454932.73	6969153.3	56.20
J55	455614.17	6968832.9	19.86
J57	455498.49	6968867.8	40.96
J60	455704.54	6968841.7	14.46
J62	455704.03	6968852.5	13.69
J64	455523.12	6968314.5	74.90
J68	455544.66	6968357.2	69.98
J71	455576.05	6968393.1	69.33
J94	455587.27	6968868.6	20.10
J17	454759.67	6969281.3	68.02
J18	454807.9	6969233.3	62.99
J61	455063.2	6969229.7	53.64
J69	455035.21	6969228.9	54.80
J90	455478.17	6968804.4	41.94
J196	455354.32	6968990.1	42.40
J53	454666.66	6969416.4	76.97
SU6	455485.32	6968822.1	41.50
J1751	454685.32	6969349.1	70.60
J92	454456.59	6969828.6	63.00
J10	455706.37	6968813.9	15.08
J96	454710.64	6969674.5	94.26
J97	454758.69	6969580.2	95.55
J98	454758.75	6969535.3	90.14
J107	454760	6969457.8	87.75
J108	454715.33	6969368.1	70.92
J109	454702.77	6969517.4	86.07
J104	454253.68	6969953.5	81.95
J112	454340.32	6969757.6	66.00
J114	454173.09	6969806.5	70.50
J121	454191.39	6969768.9	69.03
J122	454224.25	6969814.5	68.90
J132	454152.13	6969712.4	74.00
J137	455707.66	6968659.4	25.63

Name	X-Coordinate	Y-Coordinate	Invert Elev. (m)
J130	455718.24	6968661.9	24.06
J134	455732.62	6968665.9	17.13
J135	455744.65	6968668.9	15.41
J138	455694.57	6968681.4	30.57
J14	455818.76	6968754.5	3.20
J23	454241.15	6969806.9	68.10
J24	454286.53	6969775.2	67.23
J123	454303.84	6969763	67.04
J124	454206.31	6969655.8	70.59
J127	454127.2	6969676.5	71.96
J139	454298.86	6969907.2	77.86
J140	454242.22	6969825.1	70.80
J100	454570.73	6969556.7	90.95
J105	454641.65	6969547.5	80.33
J106	454589.01	6969584.9	89.80
J110	454605.87	6969605.5	88.79
J143	455750.21	6968650.8	16.00
J144	455707.74	6968665.3	23.70
J145	455541.37	6968996.4	34.25
J146	455555.15	6969004.4	32.52
J147	455529.57	6969001.6	35.68
J148	455521.04	6968996.8	35.25
J149	455530.47	6968999.8	35.48
J150	455496.87	6969072.8	43.50
J38	455653.77	6968935.6	17.00
J2	455713.05	6968793.5	15.62
J74	455711.26	6968799	15.48
J79	455673.91	6969098.3	12.60
J85	455743.29	6968663.8	15.60
J131	455129.84	6969083.6	51.80
J151	455408.66	6968959	42.00

Table 3: Conduits PCSWMM Model Parameters

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
Culvert27	J3	J4	culvert	12.753	0.023	CIRCULAR	1.4	0	0.095
Culvert11	J7	J8	culvert	24.896	0.023	CIRCULAR	1.4	0	0.085
Culvert5	J35	J42	culvert	19.93	0.023	CIRCULAR	0.5	0	0.025
Culvert4	J43	J44	culvert	13.145	0.023	CIRCULAR	0.7	0	0.004
C115	J115	J116	culvert	9.378	0.023	CIRCULAR	0.3	0	-0.064
C117	J117	J118	culvert	13.52	0.023	CIRCULAR	0.3	0	0.126
C119	J119	J120	culvert	10.543	0.023	CIRCULAR	0.3	0	0.038
C182	J182	J183	culvert	7.814	0.023	CIRCULAR	0.5	0	0.052
C184	J184	J185	culvert	8.331	0.023	CIRCULAR	0.5	0	0.030
Culvert6	J19	J20	culvert	18.567	0.023	CIRCULAR	0.5	0	0.020
Culvert12	culv12in	J28	culvert	5.668	0.023	CIRCULAR	0.3	0	0.097
Culvert22	J159	J158	culvert	19.828	0.023	CIRCULAR	0.7	0	0.049
C697	J22	J30	swale	159.881	0.03	TRAPEZOIDAL	0.15	0.15	0.079
Culvert34	J12	J31	culvert	16.957	0.023	CIRCULAR	0.45	0	0.095
C176	J75	J78	swale	23.183	0.03	TRAPEZOIDAL	0.15	0.15	0.064
Culvert3	culv3in	culv3out	culvert	17.014	0.023	CIRCULAR	0.4	0	0.129
C429	J42	J93	ditch	1.56	0.03	TRAPEZOIDAL	0.5	0.45	0.097
C435	J93	J43	ditch	9.954	0.03	TRAPEZOIDAL	0.5	0.45	0.045
C471	J35	J19	ditch	11.595	0.03	TRAPEZOIDAL	0.5	0.45	0.011
C484	J101	J19	ditch	52.491	0.03	TRAPEZOIDAL	0.5	0.45	0.032
Culvert36	J125	J128	culvert	12.045	0.023	CIRCULAR	0.45	0	0.078
C698	J128	J129	ditch	21.379	0.03	TRAPEZOIDAL	0.5	0.45	0.191
C80	J66	J41	swale	119.477	0.03	TRAPEZOIDAL	0.15	0.15	0.049
C181	J70	J78	swale	107.045	0.03	TRAPEZOIDAL	0.15	0.15	0.034
C113	J41	J13	ditch	97.15	0.03	TRAPEZOIDAL	0.5	0.45	0.039
C7	J1	J30	ditch	114.694	0.03	TRAPEZOIDAL	0.5	0.45	0.149
C383	culv3out	J43	ditch	26.922	0.03	TRAPEZOIDAL	0.5	0.45	0.183
C332	culv3in	J35	ditch	46.083	0.03	TRAPEZOIDAL	0.5	0.45	0.129
C444	J20	J93	ditch	13.441	0.03	TRAPEZOIDAL	0.5	0.45	0.011
C426	J44	J99	ditch	59.024	0.03	TRAPEZOIDAL	0.5	0.45	0.179
C20	J111	J16	swale	44.849	0.03	TRAPEZOIDAL	0.15	0.15	0.033
Culvert8	J16	J26	culvert	12.154	0.023	CIRCULAR	0.3	0	0.078

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
Culvert10	J46	J48	culvert	10.943	0.023	CIRCULAR	0.45	0	0.005
C53	J28	J73	ditch	18.477	0.03	TRAPEZOIDAL	0.5	0.45	0.099
Culvert41	J73	J76	culvert	14.563	0.023	CIRCULAR	0.3	0	0.079
C82	J81	J73	swale	13.083	0.03	TRAPEZOIDAL	0.15	0.15	0.072
Culvert40	J65	J72	culvert	13.272	0.023	CIRCULAR	0.3	0	0.348
Culvert39	J63	J59	culvert	11.923	0.023	CIRCULAR	0.3	0	0.202
C105	J77	J87	ditch	17.163	0.03	TRAPEZOIDAL	0.5	0.45	0.207
C136	J272	J274	swale	49.237	0.03	TRAPEZOIDAL	0.15	0.15	0.007
Culvert50	J274	J276	culvert	16.034	0.023	CIRCULAR	0.4	0	0.088
C247	J285	J283	ditch	8.067	0.03	TRAPEZOIDAL	0.5	0.45	0.254
C250	J290	J285	ditch	31.197	0.03	TRAPEZOIDAL	0.5	0.45	0.109
Culvert31	J283	J280	culvert	31.779	0.023	CIRCULAR	0.6	0	0.015
Culvert19	J316	J264	culvert	23.269	0.023	CIRCULAR	0.5	0	0.055
Culvert20	J267	J268	culvert	16.782	0.023	CIRCULAR	0.7	0	0.114
C722	J230	J227	ditch	22.618	0.03	TRAPEZOIDAL	0.5	0.45	0.040
Culvert15	J227	J228	culvert	20.317	0.023	CIRCULAR	0.6	0	0.044
Culvert16	J232	J230	culvert	15.588	0.023	CIRCULAR	0.45	0	0.032
Culvert21	J306	J29	culvert	15.281	0.023	CIRCULAR	0.45	0	0.007
Culvert30	J263	J261	culvert	17.075	0.023	CIRCULAR	0.8	0	0.005
Culvert17	J248	J133	culvert	24.121	0.023	CIRCULAR	0.9	0	0.033
C420	J234	J230	ditch	24.047	0.03	TRAPEZOIDAL	0.5	0.45	0.022
C339	J244	J234	swale	61.362	0.03	TRAPEZOIDAL	0.15	0.15	0.029
C363	J215	J221	ditch	47.96	0.03	TRAPEZOIDAL	0.5	0.45	0.039
Culvert14	J221	J222	culvert	12.852	0.023	CIRCULAR	0.45	0	0.106
C520	J212	J202	ditch	83.116	0.03	TRAPEZOIDAL	0.5	0.45	0.128
Culvert48	J200	J202	culvert	13.013	0.023	CIRCULAR	0.3	0	0.066
C618	J202	J178	ditch	40.281	0.03	TRAPEZOIDAL	0.5	0.45	0.048
C635	J174	J178	swale	59.416	0.03	TRAPEZOIDAL	0.15	0.15	0.094
Culvert13	J178	J67	culvert	14.665	0.023	CIRCULAR	0.45	0	0.102
Culvert46	J189	J191	culvert	10.6	0.023	CIRCULAR	0.5	0	0.064
C725	J191	J192	ditch	42.345	0.03	TRAPEZOIDAL	0.5	0.45	0.070
Culvert38	J192	J194	culvert	12.616	0.023	CIRCULAR	0.6	0	0.020
C727	J194	J3	ditch	7.447	0.03	TRAPEZOIDAL	0.5	0.45	0.167
Culvert53	J198	SU4	culvert	14.908	0.023	CIRCULAR	0.4	0	0.094
C730	J95	J196	culvert	54.531	0.023	CIRCULAR	0.3	0	0.009
Culvert43	J88	J86	culvert	14.769	0.023	CIRCULAR	0.4	0	0.041
C731	J86	J56	ditch	19.292	0.03	TRAPEZOIDAL	0.5	0.45	0.023
Culvert24	J56	J58	culvert	35.167	0.023	CIRCULAR	0.6	0	0.106
C733	J103	J86	ditch	37.832	0.03	TRAPEZOIDAL	0.5	0.45	0.209
Culvert45	J142	J136	culvert	7.825	0.023	CIRCULAR	0.3	0	0.174
C737	J33	J56	ditch	57.007	0.03	TRAPEZOIDAL	0.5	0.45	0.076
Culvert44	J102	J103	culvert	8.107	0.023	CIRCULAR	0.4	0	0.159
C739	J50	J56	swale	75.532	0.03	TRAPEZOIDAL	0.15	0.15	0.075
Culvert25	J27	J33	culvert	24.038	0.023	CIRCULAR	0.4	0	0.017
C741	J170	J27	ditch	43.781	0.03	TRAPEZOIDAL	0.5	0.45	0.203
Culvert26	J52	J6	culvert	7.79	0.023	CIRCULAR	1.4	0	0.106
C735	J136	J83	ditch	19.264	0.03	TRAPEZOIDAL	0.5	0.45	0.254
C744	J84	J83	ditch	28.272	0.03	TRAPEZOIDAL	0.5	0.45	0.016
C745	J83	J102	ditch	18.809	0.03	TRAPEZOIDAL	0.5	0.45	0.109
Culvert33	J78	J11	culvert	8.121	0.023	CIRCULAR	0.5	0	0.160
C26	J196	SU4	stream	23.146	0.03	TRAPEZOIDAL	1	10	0.061
C31	J930	SU2	stream	29.497	0.03	TRAPEZOIDAL	1	3	0.054
C33	J855	J930	stream	79.082	0.03	TRAPEZOIDAL	1	3	0.000
C35	J792	J855	stream	76.659	0.03	TRAPEZOIDAL	1	3	0.017
C36	J228	J792	stream	32.698	0.03	TRAPEZOIDAL	1	3	0.104
C43	J1898	J244	ditch	15.31	0.03	TRAPEZOIDAL	0.5	0.45	0.012
C45	J1898	J248	ditch	76.327	0.03	TRAPEZOIDAL	0.5	0.45	0.010
C61	J316	J1789	ditch	102.673	0.03	TRAPEZOIDAL	0.5	0.45	0.039
C65	J809	J316	ditch	14.683	0.03	TRAPEZOIDAL	0.5	0.45	0.007
C68	J270	J809	ditch	50.408	0.03	TRAPEZOIDAL	0.5	0.45	0.034
C71	J1726	J270	ditch	34.299	0.03	TRAPEZOIDAL	0.5	0.45	0.018
C79	J158	J1692	stream	11.261	0.03	TRAPEZOIDAL	1	3	0.003
C86	J1766	J1726	ditch	92.188	0.03	TRAPEZOIDAL	0.5	0.45	0.084
C87	J306	J1766	ditch	39.358	0.03	TRAPEZOIDAL	0.5	0.45	0.022
C94	J1751	J29	stream	53.918	0.03	TRAPEZOIDAL	1	3	0.013
C101	J1872	J511	stream	40.932	0.03	TRAPEZOIDAL	1	10	0.016
C106	J489	J1872	stream	52.07	0.03	TRAPEZOIDAL	1	10	0.002

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C108	SU5	J1751	stream	104.525	0.03	TRAPEZOIDAL	1	5	0.003
C114	J506	J489	stream	29.008	0.03	TRAPEZOIDAL	1	10	0.003
C116	J1262	J1890	stream	7.813	0.03	TRAPEZOIDAL	1	3	0.011
C121	J545	J506	stream	45.111	0.03	TRAPEZOIDAL	1	10	0.002
C137	J1494	J1525	stream	62.804	0.03	TRAPEZOIDAL	1	3	0.084
C139	J1822	J545	stream	72.531	0.03	TRAPEZOIDAL	1	10	0.001
C143	J1233	J1262	stream	117.975	0.03	TRAPEZOIDAL	1	3	0.263
C145	J1467	J1494	stream	31.576	0.03	TRAPEZOIDAL	1	3	0.200
C150	J895	J131	stream	14.082	0.03	TRAPEZOIDAL	1	3	0.080
C155	J1740	SU5	stream	173.887	0.03	TRAPEZOIDAL	1	3	0.063
C164	J1775	J895	stream	22.571	0.03	TRAPEZOIDAL	1	3	0.019
C166	J617	J586	stream	39.703	0.03	TRAPEZOIDAL	1	10	0.000
C169	J629	J617	stream	15.438	0.03	TRAPEZOIDAL	1	10	0.000
C174	J1277	J1233	stream	90.501	0.03	TRAPEZOIDAL	1	3	0.110
C191	J1797	J1277	stream	32.927	0.03	TRAPEZOIDAL	1	3	0.001
C193	J1869	J1749	stream	48.744	0.03	TRAPEZOIDAL	1	3	0.015
C194	J671	J629	stream	79.519	0.03	TRAPEZOIDAL	1	10	0.000
C196	J1268	J1797	stream	24.145	0.03	TRAPEZOIDAL	1	3	-0.012
C202	J185	J1268	stream	11.598	0.03	TRAPEZOIDAL	1	3	0.094
C205	J748	J248	stream	20.299	0.03	TRAPEZOIDAL	1	3	0.005
C183	J183	J184	stream	12.029	0.03	TRAPEZOIDAL	1	3	0.049
C220	J1455	J1467	stream	194.488	0.03	TRAPEZOIDAL	1	3	0.219
C221	J1061	J1869	stream	42.51	0.03	TRAPEZOIDAL	1	3	0.114
C227	J964	J905	stream	35.074	0.03	TRAPEZOIDAL	1	3	0.100
C229	J1055	J1869	stream	87.068	0.03	TRAPEZOIDAL	1	3	0.011
C230	J6	J7	ditch	50.545	0.03	TRAPEZOIDAL	0.75	0.6	0.085
C238	J1793	J1061	stream	40.175	0.03	TRAPEZOIDAL	1	3	0.106
C241	J732	J671	stream	93.648	0.03	TRAPEZOIDAL	1	10	0.000
C252	J5	J52	ditch	14.71	0.03	TRAPEZOIDAL	0.75	0.6	0.040
C266	J1309	J182	stream	77.617	0.03	TRAPEZOIDAL	1	3	0.000
C267	J1411	J1455	stream	76.421	0.03	TRAPEZOIDAL	1	3	0.091
C272	J763	J732	stream	28.782	0.03	TRAPEZOIDAL	1	10	-0.002
C278	J4	J5	ditch	21.741	0.03	TRAPEZOIDAL	0.75	0.6	0.028
Culvert2	J1839	J80	culvert	14.375	0.023	CIRCULAR	0.6	0	0.175
C293	J564	J541	stream	39.72	0.03	TRAPEZOIDAL	1	3	0.002
C294	J1757	J241	stream	35.136	0.03	TRAPEZOIDAL	1	3	0.086
C296	J525	J1804	stream	83.056	0.03	TRAPEZOIDAL	1	3	0.258
C297	J1763	J1793	stream	55.938	0.03	TRAPEZOIDAL	1	3	0.142
C298	J1758	J964	stream	78.601	0.03	TRAPEZOIDAL	1	3	0.031
C305	J1769	J564	stream	12.087	0.03	TRAPEZOIDAL	1	3	0.001
C309	J1387	J1411	stream	40.083	0.03	TRAPEZOIDAL	1	3	0.022
C313	J58	J1846	stream	54.306	0.03	TRAPEZOIDAL	1.5	5	0.066
C317	J822	SU2	stream	151.274	0.03	TRAPEZOIDAL	1	3	0.009
C327	J1760	J1309	stream	61.44	0.03	TRAPEZOIDAL	1	3	0.000
C330	J1283	J1839	ditch	51.746	0.03	TRAPEZOIDAL	0.5	0.45	0.031
C333	J1042	J1758	stream	44.56	0.03	TRAPEZOIDAL	1	3	0.000
C345	J497	J1769	stream	49.468	0.03	TRAPEZOIDAL	1	3	0.061
C348	J1033	J1042	stream	14.249	0.03	TRAPEZOIDAL	1	3	0.070
C349	J760	J763	stream	81.632	0.03	TRAPEZOIDAL	1	10	0.150
C353	J1001	J189	ditch	20.758	0.03	TRAPEZOIDAL	0.5	0.45	0.183
C357	J1745	SU3	stream	70.746	0.03	TRAPEZOIDAL	1	10	0.028
C358	J222	J822	stream	50.875	0.03	TRAPEZOIDAL	1	3	0.139
C362	J1801	J1763	stream	68.44	0.03	TRAPEZOIDAL	1	3	0.147
C364	J777	J760	stream	11.318	0.03	TRAPEZOIDAL	1	3	0.000
C372	J49	SU9	stream	43.857	0.03	TRAPEZOIDAL	1	3	0.005
C373	J31	J1283	ditch	39.726	0.03	TRAPEZOIDAL	0.5	0.45	0.060
C384	J1398	J1387	stream	75.43	0.03	TRAPEZOIDAL	1	3	0.082
C386	J11	J1760	stream	53.622	0.03	TRAPEZOIDAL	1	3	0.020
C388	J1368	J1328	stream	19.339	0.03	TRAPEZOIDAL	1	3	0.081
C399	J1419	J1823	stream	215.878	0.03	TRAPEZOIDAL	1	3	0.183
C400	J1196	J78	stream	13.07	0.03	TRAPEZOIDAL	1	3	0.039
C401	J737	J1822	stream	176.979	0.03	TRAPEZOIDAL	1	10	0.000
C403	J1360	J1398	stream	24.713	0.03	TRAPEZOIDAL	1	3	0.057
C412	J861	J777	stream	45.402	0.03	TRAPEZOIDAL	1	3	0.066
C423	J813	J861	stream	7.213	0.03	TRAPEZOIDAL	1	3	0.000
C439	J1781	J497	stream	70.601	0.03	TRAPEZOIDAL	1	3	0.099
C451	J13	J1360	stream	24.575	0.03	TRAPEZOIDAL	1	3	0.116

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C452	J1147	J1801	stream	42.069	0.03	TRAPEZOIDAL	1	3	0.097
C453	J1070	J1033	stream	83.61	0.03	TRAPEZOIDAL	1	3	0.208
C467	J1135	J1138	stream	25.747	0.03	TRAPEZOIDAL	1	3	0.038
C468	J976	SU3	stream	34.561	0.03	TRAPEZOIDAL	1	3	0.029
C474	J1188	J1801	stream	78.29	0.03	TRAPEZOIDAL	1	3	0.141
C481	J1206	J1797	stream	33.991	0.03	TRAPEZOIDAL	1	3	0.132
C497	J347	J112	stream	82.746	0.03	TRAPEZOIDAL	1	3	0.000
C499	J1256	J1334	ditch	24.797	0.03	TRAPEZOIDAL	0.5	0.45	0.028
C500	J765	J1789	stream	19.462	0.03	TRAPEZOIDAL	1	3	0.208
C506	J621	J525	stream	94.767	0.03	TRAPEZOIDAL	1	3	0.260
C508	J533	J1822	stream	127.344	0.03	TRAPEZOIDAL	1	3	0.000
C510	J638	J221	stream	82.506	0.03	TRAPEZOIDAL	1	3	0.193
C514	J1005	J957	stream	77.617	0.03	TRAPEZOIDAL	1	3	0.175
C515	J495	J1781	stream	16.01	0.03	TRAPEZOIDAL	1	3	0.090
C517	J1133	J1135	stream	25.041	0.03	TRAPEZOIDAL	1	3	0.037
C518	J649	J1757	stream	30.02	0.03	TRAPEZOIDAL	1	3	0.346
C526	J523	J1781	stream	49.744	0.03	TRAPEZOIDAL	1	3	0.121
C529	J1170	J47	stream	29.193	0.03	TRAPEZOIDAL	1	3	0.307
C532	J1394	J1368	stream	85.935	0.03	TRAPEZOIDAL	1	3	0.043
C533	J30	J1256	ditch	17.888	0.03	TRAPEZOIDAL	0.5	0.45	0.224
C538	J1701	J1188	stream	33.935	0.03	TRAPEZOIDAL	1	3	0.062
C543	J887	J1775	stream	150.567	0.03	TRAPEZOIDAL	1	3	0.023
C558	J706	J1766	stream	58.029	0.03	TRAPEZOIDAL	1	3	0.120
C559	J1723	SU9	stream	44.767	0.03	TRAPEZOIDAL	1	3	0.010
C561	J1130	J1763	stream	177.954	0.03	TRAPEZOIDAL	1	3	0.143
C566	J1324	J1760	stream	65.088	0.03	TRAPEZOIDAL	1	3	-0.002
C570	J837	J813	stream	79.029	0.03	TRAPEZOIDAL	1	3	0.000
C572	J680	J706	stream	8.574	0.03	TRAPEZOIDAL	1	3	0.093
C1999	J683	SU8	stream	35.039	0.03	TRAPEZOIDAL	1	3	0.028
C576	J1339	J1419	stream	103.428	0.03	TRAPEZOIDAL	1	3	0.209
C582	J1185	J1206	stream	51.505	0.03	TRAPEZOIDAL	1	3	0.069
C583	J537	J1757	stream	200.486	0.03	TRAPEZOIDAL	1	3	0.343
C595	J615	SU5	stream	43.316	0.03	TRAPEZOIDAL	1	3	0.025
C597	SU6	J1749	stream	22.233	0.03	TRAPEZOIDAL	1	3	0.009
C603	J942	J1745	stream	114.553	0.03	TRAPEZOIDAL	1	3	0.049
C605	J1162	J1147	stream	78.058	0.03	TRAPEZOIDAL	1	3	0.117
C611	J1200	J1701	stream	47.518	0.03	TRAPEZOIDAL	1	3	0.029
C633	J254	J1723	stream	12.374	0.03	TRAPEZOIDAL	1	3	0.003
C654	J1436	J1394	stream	69.582	0.03	TRAPEZOIDAL	1	3	0.044
C655	J493	J533	stream	74.448	0.03	TRAPEZOIDAL	1	3	0.053
C660	J509	J274	stream	9.34	0.03	TRAPEZOIDAL	1	3	0.033
C661	J286	J1723	stream	54.432	0.03	TRAPEZOIDAL	1	3	0.101
C662	J782	J737	stream	141.679	0.03	TRAPEZOIDAL	1	10	-0.001
C665	J805	J1720	stream	72.809	0.03	TRAPEZOIDAL	1	3	0.142
C673	J129	J1717	stream	28.794	0.03	TRAPEZOIDAL	1.5	5	0.245
C682	J373	J1713	stream	12.733	0.03	TRAPEZOIDAL	1	3	-0.001
C687	J674	J742	stream	72.701	0.03	TRAPEZOIDAL	1	3	0.240
C688	SU8	J615	stream	49.662	0.03	TRAPEZOIDAL	1	3	0.001
C690	J799	J45	stream	101.276	0.03	TRAPEZOIDAL	1	3	0.089
C691	J1164	J47	stream	80.939	0.03	TRAPEZOIDAL	1	3	0.226
C702	J606	J634	stream	40.504	0.03	TRAPEZOIDAL	1	3	0.139
C706	J1351	J1324	stream	70.806	0.03	TRAPEZOIDAL	1	3	0.002
C710	J1427	J1436	stream	29.824	0.03	TRAPEZOIDAL	1	3	0.110
C712	J918	J837	stream	71.028	0.03	TRAPEZOIDAL	1	3	0.013
C715	J553	J523	stream	102.239	0.03	TRAPEZOIDAL	1	3	0.099
C717	J1204	J1701	stream	60.36	0.03	TRAPEZOIDAL	1	3	0.083
C747	J225	J273	stream	18.69	0.03	TRAPEZOIDAL	1	3	0.084
C749	J1114	J1078	stream	109.848	0.03	TRAPEZOIDAL	1	3	0.148
C752	J716	SU5	stream	115.998	0.03	TRAPEZOIDAL	1	3	0.035
C762	J1057	J976	stream	145.578	0.03	TRAPEZOIDAL	1	3	0.201
C767	J389	J373	stream	25.765	0.03	TRAPEZOIDAL	1	3	0.158
C771	J515	J1692	stream	140.562	0.03	TRAPEZOIDAL	1	3	0.095
C774	J1220	J1200	stream	66.255	0.03	TRAPEZOIDAL	1	3	0.104
C780	J771	J714	stream	73.849	0.03	TRAPEZOIDAL	1	3	0.193
C782	J678	J765	stream	120.511	0.03	TRAPEZOIDAL	1	3	0.271
C788	J460	J424	stream	59.701	0.03	TRAPEZOIDAL	1	3	0.017
C790	J730	J716	stream	22.709	0.03	TRAPEZOIDAL	1	3	0.001

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C799	J1372	J1351	stream	32.384	0.03	TRAPEZOIDAL	1	3	0.000
C803	J594	J606	stream	30.292	0.03	TRAPEZOIDAL	1	3	0.149
C812	J118	J905	stream	18.773	0.03	TRAPEZOIDAL	1	3	0.094
C817	J511	J159	stream	116.961	0.03	TRAPEZOIDAL	1	10	0.000
C820	J586	J1822	stream	39.613	0.03	TRAPEZOIDAL	1	10	0.000
C827	J1804	J748	stream	37.785	0.03	TRAPEZOIDAL	1	3	0.003
C839	J1328	J1847	stream	62.7	0.03	TRAPEZOIDAL	1	3	0.071
C846	J957	J1745	stream	32.382	0.03	TRAPEZOIDAL	1	3	0.000
C851	J742	J1804	stream	43.141	0.03	TRAPEZOIDAL	1	3	0.002
C853	J1099	J1793	stream	60.656	0.03	TRAPEZOIDAL	1	3	0.163
C855	J1078	J1070	stream	31.622	0.03	TRAPEZOIDAL	1	3	0.032
C857	J962	J1758	stream	26.544	0.03	TRAPEZOIDAL	1	3	0.000
C858	J714	J1751	stream	54.067	0.03	TRAPEZOIDAL	1	3	0.007
C860	J634	J683	stream	27.767	0.03	TRAPEZOIDAL	1	3	0.000
C871	J859	SU1	stream	83.168	0.03	TRAPEZOIDAL	1	3	0.024
C199_1	J278	J21	swale	14.351	0.03	TRAPEZOIDAL	0.15	0.15	0.055
C199_2	J21	J285	ditch	54.908	0.03	TRAPEZOIDAL	0.5	0.45	0.068
C716_1	J485	J21	swale	51.677	0.03	TRAPEZOIDAL	0.15	0.15	0.084
C822_2	J280	J1740	stream	28.562	0.03	TRAPEZOIDAL	1	3	-0.008
C493_1	J213	J39	ditch	81.647	0.03	TRAPEZOIDAL	0.5	0.45	0.085
C493_2	J39	J200	ditch	46.226	0.03	TRAPEZOIDAL	0.5	0.45	0.082
C456_1	J217	J40	ditch	36.082	0.03	TRAPEZOIDAL	0.5	0.45	0.108
C456_2	J40	J221	ditch	26.799	0.03	TRAPEZOIDAL	0.5	0.45	0.013
C124_1	J271	J45	ditch	19.879	0.03	TRAPEZOIDAL	0.5	0.45	0.048
C124_2	J45	J267	ditch	72.643	0.03	TRAPEZOIDAL	0.5	0.45	0.015
C8_2	J47	J15	ditch	19.837	0.03	TRAPEZOIDAL	0.5	0.45	0.074
C22_1	J51	J36	ditch	47.962	0.03	TRAPEZOIDAL	0.5	0.45	0.009
C22_2	J15	J51	ditch	12.317	0.03	TRAPEZOIDAL	0.5	0.45	0.026
C416_1	J1138	J51	stream	89.438	0.03	TRAPEZOIDAL	1	3	0.177
C578_1	J101	J54	ditch	55.014	0.03	TRAPEZOIDAL	0.5	0.45	0.108
C642	J126	J125	swale	37.779	0.03	TRAPEZOIDAL	0.15	0.15	0.053
C5	J1720	OF1	stream	2.97	0.03	TRAPEZOIDAL	1.5	5	-999.000
C8	J1846	OF2	stream	3.441	0.03	TRAPEZOIDAL	1.5	5	1.780
C9	J59	OF4	stream	20.589	0.03	TRAPEZOIDAL	1.5	5	0.204
C10	J87	OF3	stream	9.832	0.03	TRAPEZOIDAL	1.5	5	1.328
C11	J8	OF5	stream	51.781	0.03	TRAPEZOIDAL	1	1	0.195
C12	J1059	OF6	stream	5.176	0.03	TRAPEZOIDAL	1.5	5	0.711
C15	J1717	OF8	stream	3.831	0.03	TRAPEZOIDAL	1.5	5	1.551
C16	J1266	OF9	stream	2.94	0.03	TRAPEZOIDAL	1	3	-999.000
C18	J1847	OF10	stream	10.936	0.03	TRAPEZOIDAL	1	3	0.393
C21	J1823	OF11	stream	9.471	0.03	TRAPEZOIDAL	1	3	0.399
C22	J1525	OF12	stream	9.012	0.03	TRAPEZOIDAL	1	3	0.493
C32	J1890	OF13	stream	5.173	0.03	TRAPEZOIDAL	1	3	-999.000
C28_1	SU2	J198	stream	25.794	0.03	TRAPEZOIDAL	1	3	0.000
C215_1	J905	J32	stream	77.289	0.03	TRAPEZOIDAL	1	3	0.043
C215_2	J32	J1775	stream	70.819	0.03	TRAPEZOIDAL	1	3	0.004
C28	J120	J32	stream	18.836	0.03	TRAPEZOIDAL	1	3	0.078
C37_1	J268	J37	stream	23.178	0.03	TRAPEZOIDAL	1	3	0.039
C37_2	J37	J263	stream	63.11	0.03	TRAPEZOIDAL	1	5	0.016
C37	J264	J37	stream	16.771	0.03	TRAPEZOIDAL	1	3	0.091
C659_1	J261	SU1	stream	121.448	0.03	TRAPEZOIDAL	1	10	0.051
C659_2	SU1	J232	stream	155.674	0.03	TRAPEZOIDAL	1	5	0.000
C38	J133	SU1	stream	9.092	0.03	TRAPEZOIDAL	1	10	0.156
C39_1	J36	J55	ditch	32.767	0.03	TRAPEZOIDAL	0.5	0.45	0.003
C24	J57	J94	ditch	94.987	0.03	TRAPEZOIDAL	0.75	0.6	0.225
C25	J1749	J57	culvert	40.937	0.023	CIRCULAR	1	0	0.008
C39	J76	J1846	stream	46.93	0.03	TRAPEZOIDAL	1.5	5	0.126
C40	J72	J1846	stream	46.752	0.03	TRAPEZOIDAL	1.5	5	0.053
C93_1	J48	J60	ditch	12.691	0.03	TRAPEZOIDAL	0.5	0.45	0.036
Culvert37	J60	J62	culvert	10.83	0.023	CIRCULAR	0.4	0	0.071
C93_4	J62	J7	ditch	20.102	0.03	TRAPEZOIDAL	0.5	0.45	0.085
C41	J99	J1266	stream	87.47	0.03	TRAPEZOIDAL	1	2	0.254
C42_1	J64	J68	ditch	48.076	0.03	TRAPEZOIDAL	0.5	0.45	0.103
C42_2	J68	J9	ditch	40.329	0.03	TRAPEZOIDAL	0.5	0.45	0.004
Culvert1	J9	J71	culvert	7.49	0.023	CIRCULAR	0.3	0	0.064
C47_2	J71	J31	ditch	22.197	0.03	TRAPEZOIDAL	0.5	0.45	0.180
C42	J80	culv3in	ditch	119.395	0.03	TRAPEZOIDAL	0.5	0.45	0.143

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C102_1	J82	J91	swale	14.967	0.03	TRAPEZOIDAL	0.15	0.15	0.019
C59	J241	J234	ditch	48.203	0.03	TRAPEZOIDAL	0.5	0.45	0.001
Culvert49	J271	J270	culvert	19.672	0.023	CIRCULAR	0.45	0	0.010
C437	J1334	J12	ditch	49.403	0.03	TRAPEZOIDAL	0.5	0.45	0.032
C39_5	J94	J3	ditch	17.229	0.03	TRAPEZOIDAL	0.75	0.6	0.035
C39_3	J55	J3	ditch	47.589	0.03	TRAPEZOIDAL	0.5	0.45	0.007
C742	J25	J27	ditch	46.402	0.03	TRAPEZOIDAL	0.5	0.45	0.077
C494_3	J29	J17	ditch	52.977	0.03	TRAPEZOIDAL	0.5	0.45	0.035
C494_1	J17	J18	ditch	68.672	0.03	TRAPEZOIDAL	0.5	0.45	0.074
C494_2	J18	J271	ditch	39.328	0.03	TRAPEZOIDAL	0.5	0.45	0.051
C6_2	J61	J248	ditch	29.046	0.03	TRAPEZOIDAL	0.5	0.45	0.084
C6_3	J1789	J69	ditch	27.921	0.03	TRAPEZOIDAL	0.5	0.45	0.008
C6_4	J69	J61	ditch	28.01	0.03	TRAPEZOIDAL	0.5	0.45	0.041
C755_1	J1118	J90	stream	48.104	0.03	TRAPEZOIDAL	1	3	0.126
C755_2	J90	SU6	stream	21.956	0.03	TRAPEZOIDAL	1	3	0.020
C2	SU3	J95	stream	23.717	0.03	TRAPEZOIDAL	1	3	0.004
C385_3	J297	J53	ditch	56.301	0.03	TRAPEZOIDAL	0.5	0.45	0.078
C385_4	J53	J34	ditch	35.461	0.03	TRAPEZOIDAL	0.5	0.45	0.153
C6	J1692	J92	stream	115.861	0.03	TRAPEZOIDAL	1	5	0.017
C17	J441	J92	stream	140.302	0.03	TRAPEZOIDAL	1	5	0.151
C34	J424	J92	stream	185.232	0.03	TRAPEZOIDAL	1	5	0.119
C46	J92	OF14	stream	9.813	0.03	TRAPEZOIDAL	1	10	0.102
C64_2	J10	J46	ditch	4.229	0.03	TRAPEZOIDAL	0.5	0.45	0.026
C50	J97	J98	swale	44.938	0.03	TRAPEZOIDAL	0.15	0.15	0.121
C54	J98	J107	ditch	77.586	0.03	TRAPEZOIDAL	0.5	0.45	0.031
C385_1	J34	J108	ditch	33.145	0.03	TRAPEZOIDAL	0.5	0.45	0.021
C385_5	J108	J306	ditch	44.885	0.03	TRAPEZOIDAL	0.5	0.45	0.021
C60	J107	J108	stream	111.716	0.03	TRAPEZOIDAL	1	1	0.152
C772_1	J588	J107	stream	103.267	0.03	TRAPEZOIDAL	1	3	0.043
C253_1	J541	J98	stream	74.838	0.03	TRAPEZOIDAL	1	3	0.037
C338_1	J292	J109	swale	11.746	0.03	TRAPEZOIDAL	0.15	0.15	0.069
C338_2	J109	J297	ditch	68.427	0.03	TRAPEZOIDAL	0.5	0.45	0.069
C55	J96	J485	swale	27.999	0.03	TRAPEZOIDAL	0.15	0.15	0.112
C62	J97	J485	swale	77.874	0.03	TRAPEZOIDAL	0.15	0.15	0.057
C63	J141	J104	ditch	33.47	0.03	TRAPEZOIDAL	0.5	0.45	0.047
C64	J104	J273	ditch	78.567	0.03	TRAPEZOIDAL	0.5	0.45	0.063
C66	J273	J158	ditch	165.908	0.03	TRAPEZOIDAL	0.5	0.45	0.073
Culvert32	J112	J158	culvert	24.511	0.023	CIRCULAR	0.45	0	0.041
C335_1	SU9	J114	stream	48.208	0.03	TRAPEZOIDAL	1	3	0.000
C335_2	J114	J1713	stream	46.677	0.03	TRAPEZOIDAL	1	3	0.032
C832_1	J1713	J121	stream	26.629	0.03	TRAPEZOIDAL	1	3	-0.001
C69	J121	J122	ditch	56.473	0.03	TRAPEZOIDAL	0.5	0.45	0.002
C84	J132	J121	ditch	68.814	0.03	TRAPEZOIDAL	0.5	0.45	0.072
C578_3	J54	J137	ditch	32.498	0.03	TRAPEZOIDAL	0.5	0.45	0.192
C614_2	J135	J125	ditch	23.603	0.03	TRAPEZOIDAL	0.5	0.45	0.017
Culvert28	J137	J130	culvert	10.867	0.023	CIRCULAR	0.4	0	0.147
C13	J130	J134	ditch	16.357	0.03	TRAPEZOIDAL	0.5	0.45	0.468
Culvert35	J134	J135	culvert	12.204	0.023	CIRCULAR	0.4	0	0.142
C73	J138	J47	ditch	64.535	0.03	TRAPEZOIDAL	0.5	0.45	0.131
C14	J14	OF7	stream	11.158	0.03	TRAPEZOIDAL	1	2	0.299
Culvert52	J122	J23	culvert	18.571	0.023	CIRCULAR	0.45	0	0.043
C70_3	J23	J24	ditch	55.397	0.03	TRAPEZOIDAL	0.5	0.45	0.016
Culvert51	J24	J123	culvert	21.174	0.023	CIRCULAR	0.6	0	0.009
C70_5	J123	J159	ditch	56.244	0.03	TRAPEZOIDAL	0.5	0.45	0.019
C19	J124	J24	swale	144.048	0.03	TRAPEZOIDAL	0.15	0.15	0.023
C781_1	J439	J127	stream	16.367	0.03	TRAPEZOIDAL	1	3	0.025
C781_2	J127	J493	stream	17.417	0.03	TRAPEZOIDAL	1	3	0.061
C27	J132	J127	ditch	43.765	0.03	TRAPEZOIDAL	0.5	0.45	0.047
C29	J139	J140	ditch	100.861	0.03	TRAPEZOIDAL	0.5	0.45	0.070
C70	J140	J112	swale	119.13	0.03	TRAPEZOIDAL	0.15	0.15	0.040
C612_1	J276	J105	ditch	28.94	0.03	TRAPEZOIDAL	0.5	0.45	0.102
C612_2	J105	J1740	stream	10.41	0.03	TRAPEZOIDAL	1	3	-0.047
C58	J139	J112	swale	164.054	0.03	TRAPEZOIDAL	0.15	0.15	0.072
C56_1	J100	J106	swale	33.641	0.03	TRAPEZOIDAL	0.15	0.15	0.034
C56_3	J106	J110	swale	26.697	0.03	TRAPEZOIDAL	0.15	0.15	0.038
C56_4	J110	J274	swale	84.877	0.03	TRAPEZOIDAL	0.15	0.15	0.048
C614_3	J113	J143	swale	24.059	0.03	TRAPEZOIDAL	0.15	0.15	0.193

Name	Inlet Node	Outlet Node	Tag	Length (m)	Roughness	Cross-Section	Geom1 (m)	Geom2 (m)	Slope (m/m)
C578_5	J144	J111	swale	63.885	0.03	TRAPEZOIDAL	0.15	0.15	0.082
C44_3	J145	J146	swale	16.934	0.03	TRAPEZOIDAL	0.15	0.15	0.102
C44_4	J146	J142	swale	46.068	0.03	TRAPEZOIDAL	0.15	0.15	0.102
C44_2	J168	J147	swale	49.736	0.03	TRAPEZOIDAL	0.15	0.15	0.103
C461_1	J67	J148	ditch	29.06	0.03	TRAPEZOIDAL	0.5	0.45	0.164
C461_2	J148	J1001	ditch	52.823	0.03	TRAPEZOIDAL	0.5	0.45	0.132
Culvert47	J147	J148	culvert	9.77	0.023	CIRCULAR	0.3	0	0.044
C44_6	J149	J145	swale	12.226	0.03	TRAPEZOIDAL	0.15	0.15	0.101
C56	J150	J168	swale	28.706	0.03	TRAPEZOIDAL	0.15	0.15	0.096
C75	J38	J50	swale	26.481	0.03	TRAPEZOIDAL	0.15	0.15	0.042
C47	J89	J88	ditch	7.841	0.03	TRAPEZOIDAL	0.5	0.45	0.026
Culvert42	J91	J89	culvert	11.7	0.023	CIRCULAR	0.3	0	0.026
C64_3	J26	J2	ditch	16.809	0.03	TRAPEZOIDAL	0.5	0.45	0.026
Culvert23	J2	J74	culvert	5.752	0.023	CIRCULAR	0.3	0	0.026
C64_5	J74	J10	ditch	15.755	0.03	TRAPEZOIDAL	0.5	0.45	0.025
C1	J79	culv12in	swale	25.351	0.03	TRAPEZOIDAL	0.15	0.15	0.010
C614_1	J143	J85	swale	15.058	0.03	TRAPEZOIDAL	0.15	0.15	0.027
C614_5	J85	J135	ditch	5.342	0.03	TRAPEZOIDAL	0.5	0.45	0.036
C769_1	J911	J131	stream	10.651	0.03	TRAPEZOIDAL	1	3	0.035
C769_2	J131	J942	stream	61.916	0.03	TRAPEZOIDAL	1	3	0.035
C23_1	SU4	J151	stream	58.834	0.03	TRAPEZOIDAL	1	3	-0.017
C23_2	J151	J57	stream	134.792	0.03	TRAPEZOIDAL	1	3	0.008

APPENDIX H

EXAMPLE CULVERT END STIFFENER

Photo 1: Example Culvert End Stiffener