Baffinland Iron Mines Corporation

APPENDIX A.5

APPLICATION FOR REVIEW DEPARTMENT OF FISHERIES AND OCEANS PRE-DEVELOPMENT WORK-PLAN STEENSBY ACCESS ROAD WATERCOURSE CROSSINGS A, B AND C

Contents

1.0 Introduction

The purpose of this portion of the PDW report is to provide the hydrologic, hydraulic and drainage infrastructure design input necessary for the approval and construction of three watercourse crossings associated with construction of the Steensby Access Road. Construction of the Steensby access road represents one component of the Mary River Iron Mines Pre-Development Work (PDW) scheduled to take place in 2012.

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The three watercourses affected by the construction of the Steensby access road are shown on Figure 1 and are labelled sites A, B, and C These three watercourse crossings are required to gain access to the proposed Steensby Airstrip, fuel farm, rail maintenance yard and other auxiliary facilities within the port area.

2.0 Crossing Locations and General Site Conditions

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The Steensby Port area consists of numerous lakes and streams in small, coastal watersheds and various components of larger catchments such as the watersheds of the Cockburn and Ikpikitturjuaq Rivers. Most of the freshwater in this region lies in areas of relatively low relief with perennial or intermittent outflows to the sea.

According to the North/South Fisheries assessment (North/South Consultants 2010), fish habitat in the Steensby Port LSA is largely concentrated in the lakes and ponds that dominate the landscape. Compared to the other LSAs, there are relatively few streams of suitable size or substrate composition to provide fish habitat and many streams in the Steensby Port LSA were determined to be non-fish bearing due to barriers to overwintering habitat and/or insufficient flows. Anadromous Arctic char are less common due to a lack of connection with the marine environment. Most of the available fish habitat in the LSA was identified in only four catchment areas.

Both species of fish known to Baffin Island (Arctic char and ninespine stickleback) were observed in the Steensby Port LSA during fish assessment surveys. It is noted that the ninespine stickleback are more abundant and widespread than Arctic char in this area. The predominance of fines over gravel and cobble substrate and low flows may contribute to the lower numbers of char compared to other LSAs. None of the streams in the Steensby area provide overwintering habitat for fish, as they all freeze to the bottom during the winter months.

The following section summarizes a general description of the location of the three watercourse crossings and includes site photos taken during the fish habitat assessment surveys completed by North/South Consultants in 2010.

2.1 Crossing C

Steensby access road culvert crossing C is located approximately 90m upstream of permanent rail crossing location CV-144-1. Crossing location C is also located approximately 1000 m north of the freight and fuel storage platform. The proposed access road crosses the watercourse C between two permanent water bodies.

North/South Consultants indentified a barrier to fish passage upstream of this crossing location. Figure 2 illustrates the general site conditions upstream and downstream of the proposed crossing location as well as a view of the low-flow channel at one of the survey sites along the watercourse.

Fish habitat quality of the watercourse is considered marginal for arctic char, and potential for ninespine stickleback for rearing, spawning and passage.

The channel substrate composition breaks down as follows: 35% flooded terrestrial vegetation, 20% small Cobble, 15% large cobble, 10% fines and 2% boulders. Riparian vegetation primarily consists of, grasses, moss, wildflowers and willow. The morphology of the stream is characterized as 10% riffle and 80% shallow pool and 10% deep pool. Additional channel characteristics can be described as follows:

Table 1: Channel Characteristics - Crossing C

Feature	
Floodplain width (m)	> 100
Channel confinement	Unconfined
Channel pattern	Sinuous/braided
Channel gradient (^{o})	1.0 - 3.0
Bank height (m)	0 - 0.20
Bank shape	undefined
Wetted width (m)	1.7
Max Depth (m)	0.17
High water width (m)	21.7

Upstream of survey site

Downstream of survey site

View across survey site

Figure 1: Site photos of Crossing C (North/South Consultants)

2.2 CROSSING A

Steensby access road culvert crossing A is located approximately 75m downstream of permanent rail crossing location Loop-CV-0-2. Crossing location A is situated immediately south of the freight and fuel storage platform. The watercourse is a tributary from a pond which empties directly into Steensby Inlet. North/South Consultants identified a barrier to fish passage from Steensby Inlet located near the mouth of the stream just upstream of the coastal waters. Figure 3 illustrates the general site conditions upstream and downstream of the proposed crossing location as well as a view of the low-flow channel at one of the survey sites along the watercourse.

Fish habitat quality of the watercourse is considered marginal for arctic char, and potential for ninespine stickleback for rearing, spawning and passage.

The channel substrate is primarily cobble (40% small cobble and 20 % large cobble) with approximately lesser amount of gravel (40%). Riparian vegetation consists of willow, moss, grasses and wildflowers. The morphology of the stream is characterized by a series of shallow pools (70 – 95 %) connected by riffles with occasional cascades. Additional channel characteristics can be described as follows:

Table 2: Channel Characteristics - Crossing A

Feature	
Floodplain width (m)	Not measured
Channel confinement	Unconfined
Channel pattern	Sinuous
Channel gradient (°)	1.0 – 5.0
Bank height (m)	Not measured
Bank shape	Not applicable
Wetted width (m)	1.6 – 5.0
Max Depth (m)	0.08
High water width (m)	1.6 – 5.0

Upstream of survey site

Downstream of survey site

View across survey site

Figure 2: Site photos of Crossing A (North/South Consultants)

2.2 CROSSING B

Steensby access road culvert crossing B is located to the south of the permanent rail loop. The drainage system associated with the crossing is independent of the rail at this location. Crossing location B is situated approximately 400 m north of the Steensby Airstrip. The watercourse is the outlet of the sole water body in this subwatershed (ST-29). Figure 4 illustrates the general site conditions upstream and downstream of the proposed crossing location as well as a view of the low-flow channel at one of the survey sites along the watercourse.

Fish habitat quality of the watercourse is considered marginal for arctic char, and potential for ninespine stickleback for rearing, spawning and passage.

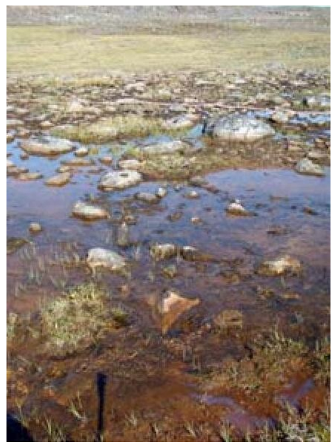
The channel substrate composition breaks down as follows: 50% fines, 25% gravel, 15% small Cobble, 5% large cobble and 5% boulders. Riparian vegetation primarily consists of, grasses and wildflowers. The morphology of the stream is characterized as 70% pool, 25% riffle and 5% cascade. Additional channel characteristics can be described as follows:

Table 3: Channel Characterstics - Crossing B

Feature	
Floodplain width (m)	> 100
Channel confinement	Unconfined
Channel pattern	Sinuous
Channel gradient (°)	1.0
Bank height (m)	0 -0.20
Bank shape	sloped
Wetted width (m)	15.0 - 25.5
Max Depth (m)	0.30
High water width (m)	2.0

Upstream of survey site

Downstream of survey site



View across survey site

Figure 3: Site photos of Crossing B (North/South Consultants)

Design Flood and Fish Passage Flows for the Steensby Access Road Crossings A, B and C were calculated. The results are summarized in Table 4 below. As noted above, the estimated flow is primarily a function of the drainage area contributing to the crossings. Since no change in the drainage area is anticipated under proposed/future conditions, there is no increase or change expected for the flows.

Table 4: Summary of Design Criteria Flows

CROSSING LOCATION	STATION	FLOOD FLOW (1:200 yr) m^3/s	FISH PASSAGE FLOW (1:10 yr – 3 day delay) m^3/s
C	3008+800	7.41	0.78
A	3010+693	5.40	0.56
B	3012+082	4.96	0.51

3.0 CULVERT DESIGN CRITERIA

The maximum velocity in the culverts was determined to be 5 m/s based on the resulting size of the scour and the size of rip rap needed to protect the natural streambed from excessive scour.

All culverts were designed to pass the 1 in 200 year flows.

A maximum acceptable slope of culvert crossing was identified as 15%, based on discussions with suppliers and senior advisors. It is necessary to identify the maximum acceptable slope in order to avoid hydraulic consequences of steep culvert slopes.

3.1 CULVERT C

. Design considerations for the general arrangement of Culvert C included:

- minimizing the slope of culvert to improve fish passage characteristics;
- reducing the culvert skew angle and incorporating minor channel modifications to reduce the length of the proposed culvert;
- incorporating staggered inverts in order to improve flow characteristics during low flow conditions; and,
- incorporating 20% embedment and placement of natural substrate within the culvert barrel to improve channel and fish passage characteristics.

The cross-section of the realigned channel was developed to integrate with the culver arrangement and the proposed staggered culvert inverts. The invert of the centre culvert has been placed 0.8m below the flanking culverts to ensure that during low-flow conditions there is concentration of flow in the central barrel in order minimize wetted width and maximize flow depth. The secondary culverts (Figure 5)are required to convey large design storm events and act as relief culverts if the main barrel becomes blocked by ice and snow during spring freshet.

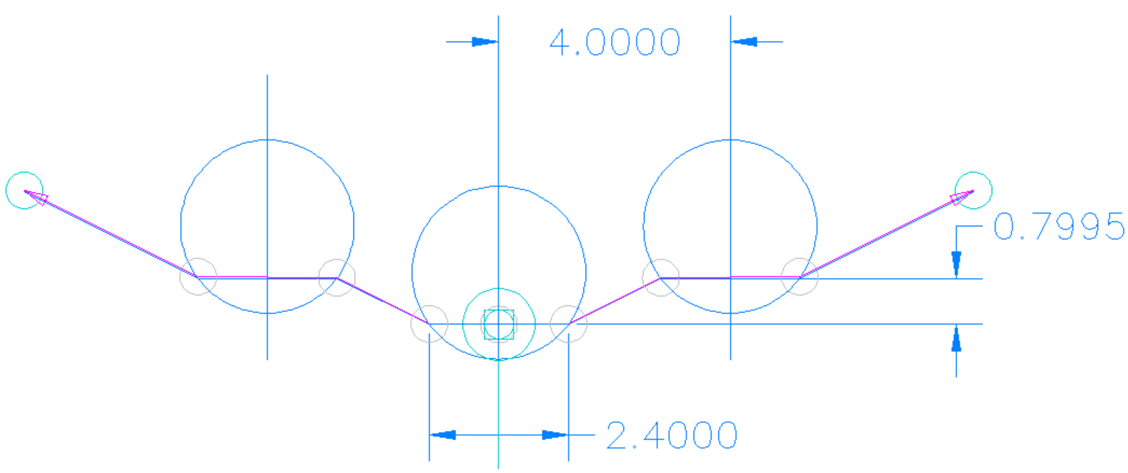


Figure 5: Cross Section

The required channel realignment and design profile was established to mimic the existing low-flow channel that cuts diagonally across the proposed access road alignment. The channel alignment and profile connects to the upstream water body approximately 1.0m below the normal water elevation (interpolated from Lidar survey data and site photos) and directs flow to the inlet of the culvert arrangement at 90 degrees to reduce inlet losses and erosion potential. The upstream end of the channel alignment widens out at the connection point with the upstream water body. The channel configuration was designed to funnel flows from the large, infrequent events to the culvert inlet as well as provide opportunity to deepen and expand the edge of the water body, compensating for the minor loss of shore-line along the easterly side of the access road embankment.

3.2 Culvert A

Design considerations for the general arrangement of Culvert A included:

- reducing the slope of the culvert by lowering the inlet invert to improve fish passage characteristics;
- reducing the culvert skew angle and incorporating a channel realignment to reduce the length of the proposed culvert and lower the channel to match the inlet invert of the culvert;
- incorporating 20% embedment and placement of natural substrate within the culvert barrel to improve channel and fish passage characteristics.

Based on the hydrologic analysis completed for the site, a single 3000mm diameter culvert is required to convey the 1:200yr design flow at this location. The existing watercourse crosses the proposed access road alignment diagonally. If a culvert was constructed following the orientation of the watercourse it would measure more than 150m in length. In order to minimize the length of the culvert crossing the access road the culvert was orientated perpendicular to the access road alignment. The crossing location was established by placing the downstream end of the culvert at the location where the existing channel emerges from under the proposed embankment. The upstream end of the culvert was placed so that the culvert falls perpendicular to the access road alignment. Figure 6 graphically illustrates the configuration of the proposed channel, single 3000mm culvert, and 20% embedment of the culvert.

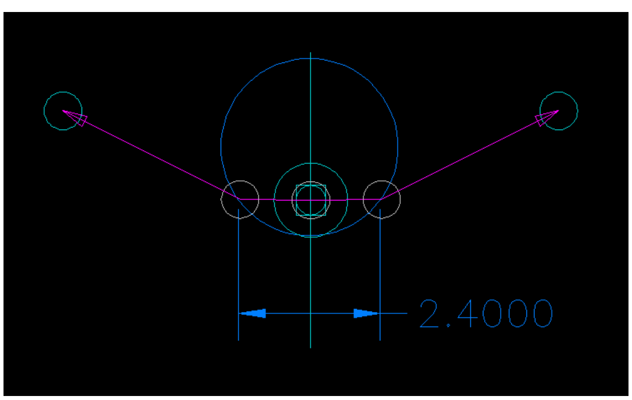


Figure 6: Cross Section

The location of the upstream end of the of the culvert subsequently required the realignment of approximately 150m of watercourse along the northerly side of the access road embankment in order to direct flows to the new crossing location. The design profile of the channel realignment was also lowered with a series of steps, closely mimicking the configuration of the existing watercourse. The stepped profile aimed to improve fish passage characteristics and to reduce the culvert slope to approximately 3%. Lowering of the channel profile also provides additional grade differential between the bottom of the channel and the high-point between watersheds located to the south-east of the crossing. The additional grade differential provides protection against large design flows spilling from one drainage area to the next during freshet when the culvert could be partially blocked by snow and ice. In total there is approximately 6m of grade separate between the culvert invert and the drainage divide to the south-east.

3.3 Culvert B

Design considerations for the general arrangement of Culvert B included:

- reducing the slope of the culvert by lowering the inlet invert to improve fish passage characteristics;
- reducing the culvert skew angle and incorporating a channel realignment to reduce the length of the proposed culvert and lower the channel to match the inlet invert of the culvert;
- incorporating 20% embedment and placement of natural substrate within the culvert barrel to improve channel and fish passage characteristics.

In order to minimize the length of the culvert crossing the access road the culvert was orientated perpendicular to the access road alignment. The crossing location was established by placing the downstream end of the culvert embankment. The upstream end of the culvert was placed so that the culvert falls perpendicular to the access road alignment. Figure 7 graphically illustrates the configuration of the proposed channel, single 3000mm culvert, and 20% embedment of the culvert.

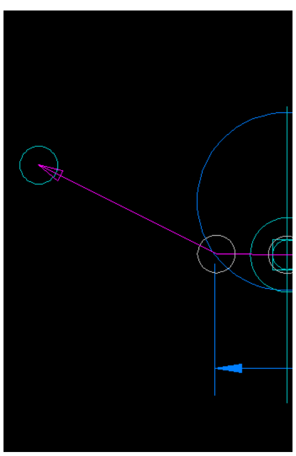


Figure 7: Cross Section

The location of the upstream end of the of the culvert subsequently required the realignment of approximately 75m of watercourse along the northerly side of the access road embankment in order to direct flows to the new crossing location. The design profile of the channel realignment was also lowered with a flattened section of profile located immediately upstream of the culvert inlet. The profile aims to improve fish passage characteristics by providing a resting pool upstream of the culvert and by reducing the culvert slope to approximately 3%. Lowering of the channel profile also provides additional grade differential between the bottom of the channel and the adjacent lands to the south-east of the crossing. Additional earth works are required at this site to define the watershed boundary just south of the crossing location.

4.0 Potential Effects and Proposed Mitigation

Measures to avoid or mitigate adverse effects on fish and fish habitat were built into the project through environmental design guidelines in the early planning stages. Wherever possible, the alignment has been designed to minimize water course crossings or encroachment of water bodies and is designed using the minimum footprint possible. Each watercourse crossing structure was determined through an assessment based on hydraulic and hydrology conditions and fish habitat presence or absence to design the appropriate crossing structure for the individual watercourse or water body conditions.

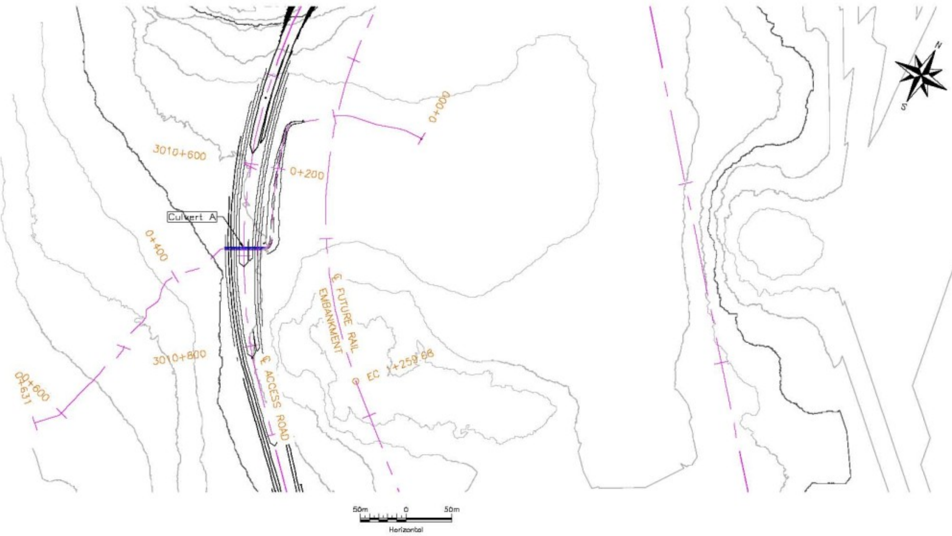
Based on the culvert design and fish resources known for the area, mitigation measures and best construction practices are expected to avoid any impacts or loss of habitat. The potential impacts to fish and fish habitat associated with the access road crossings are summarized in the Table 5 below:

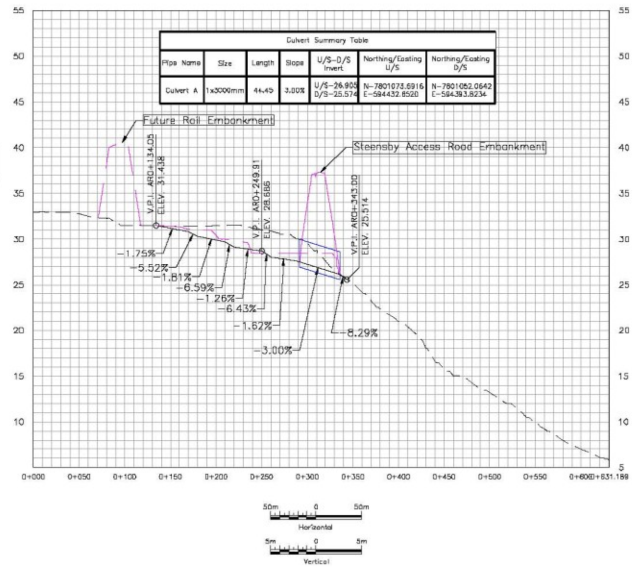
Table 5: Potential Impacts and Mitigation

Potential Environmental Impact	Proposed Mitigation to Eliminate Impact
Direct loss of fish habitat from structure installation.	• Compensation to meet “no net loss” and monitoring of compensation effectiveness. • Watercourse channel will be restored to the original stream characteristics. .
Potential for fish stranding or mortality during construction	• Where possible construction will occur during winter season when watercourses are typically dry or frozen to bottom to avoid impacts to fish passage. • Fish rescue during culvert construction when construction timing cannot occur in open water season • Temporary crossing culvert will be monitored for blockages and cleaned when necessary. This will ensure passage of juvenile and adult fish • .
Potential for barriers to fish passage .	• Meet DFO requirements for fish passage in culvert design •
Potential for loss of riparian habitat within the footprint	• Restoration of riparian habitat and provision of culvert pools as required
Sediment effects and degradation of habitat	• Construction will follow practices outlined in the Project EMS

(water quality) due to sediment or other contaminants both at the crossing and downstream	• Timing of works in and adjacent to watercourses during winter window where possible to minimize effects
Damage to stream banks from construction equipment increases the potential for erosion	• Operate machinery on land (above the HWM) and in a manner that minimizes disturbance to the banks of the watercourse during open water season. • Install effective sediment and erosion control measures before starting work to prevent the entry of sediment into the watercourse. Inspect them regularly during the course of construction and make all necessary repairs if any damage occurs.
Removal of vegetation at crossing locations.	• This removal should be kept to a minimum and within the right-of-way. When practicable, prune or top the vegetation instead of uprooting. • Approaches will be designed and constructed so that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation. • Existing trails, roads, or cut lines will be used wherever possible to avoid disturbance to the riparian vegetation. • Any disturbed areas will be vegetated by planting and seeding native trees, shrubs or grasses and areas with be covered by mulch to prevent erosion and to help seeds germinate. The site will be maintained until site is stabilized by vegetation.
.	•
Potential for spills of fuel or other fluid from construction vehicles	• Adhere to contingency plans identified in the project EMS. •

Figure 1:
Water Crossing Details





Culvert Summary Table

Pipe Name	Size	Length	Slope	U/S-D/S Invert	Northing/Easting U/S	Northing/Easting D/S
Culvert A	1x3000mm	44.45	3.00%	U/S-26.905 D/S-25.574	N-7801073.6916 E-594432.8520	N-7801052.0642 E-594393.8234

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PROJECT PHASE	
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PROJECT NUMBER	07 – 36
PROJECT NO.	159952
ACTIVITY NO.	
PACKAGE CODE	
SCALE	AS SHOWN
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SUBJECT	ACCESS ROAD CONSTRUCTION CULVERT A PLAN AND PROFILE
DRAWING NO.	FIGURE 8
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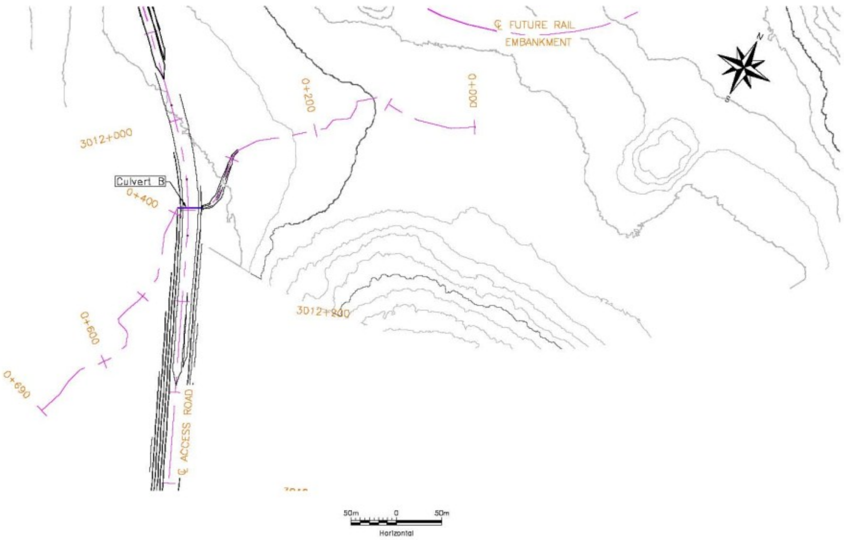

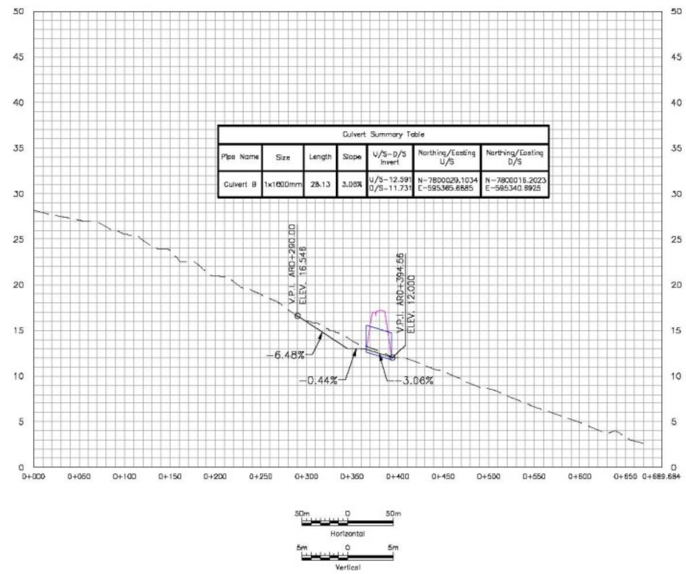

Culvert Summary Table

Pipe Name	Size	Length	Slope	U/S-D/S Invert	Northing/Easting U/S	Northing/Easting D/S
Culvert B	1x1600mm	28.13	3.06%	U/S-12.591 D/S-11.731	N-7800029.1034 E-595365.6885	N-7800015.2023 E-595340.8925

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PROJECT PHASE

Baffinland Iron Mines Corporation

AREA 5000

CANARAIL DILLON CONSULTING

PROJECT NUMBER 07 – 36

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159952		DSN		
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SUBJECT: ACCESS ROAD CONSTRUCTION
CULVERT B
PLAN AND PROFILE

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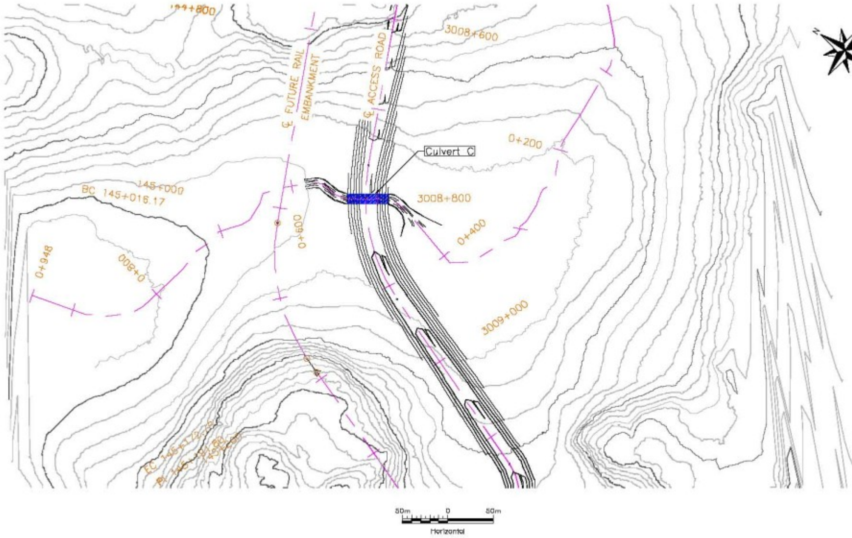

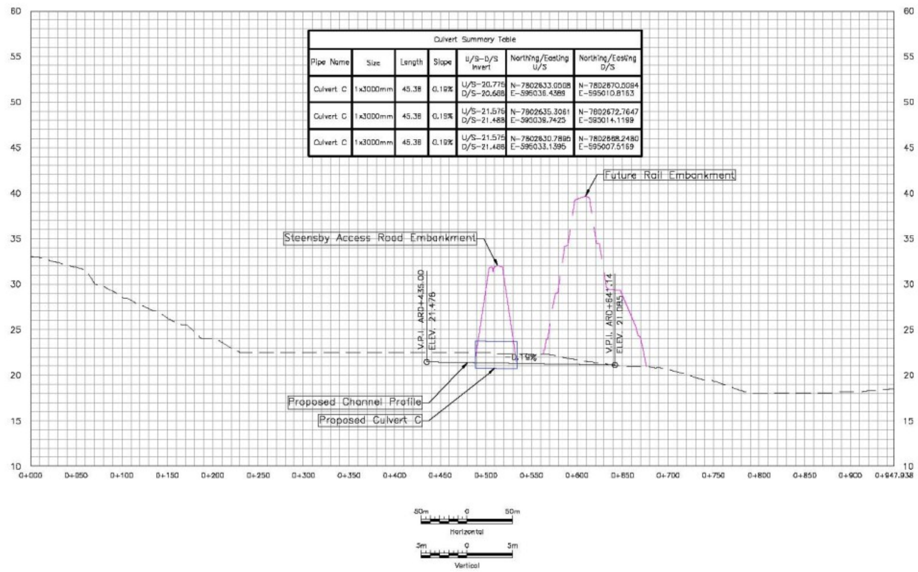

Culvert Summary Table

Pipe Name	Size	Length	Slope	U/S-D/S Invert	Northing/Easting U/S	Northing/Easting D/S
Culvert C	1x3000mm	45.38	0.19%	U/S-20.775 D/S-20.688	N-7802633.0508 E-595036.4389	N-7802670.5094 E-595010.8163
Culvert C	1x3000mm	45.38	0.19%	U/S-21.575 D/S-21.488	N-7802635.3061 E-595038.7425	N-7802672.7647 E-595014.1199
Culvert C	1x3000mm	45.38	0.19%	U/S-21.575 D/S-21.488	N-7802630.7895 E-595033.1395	N-7802668.2480 E-595007.5169

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PROJECT PHASE

Baffinland Iron Mines Corporation

AREA 5000

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PROJECT NO. 159952

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SUBJECT ACCESS ROAD CONSTRUCTION CULVERT C PLAN AND PROFILE

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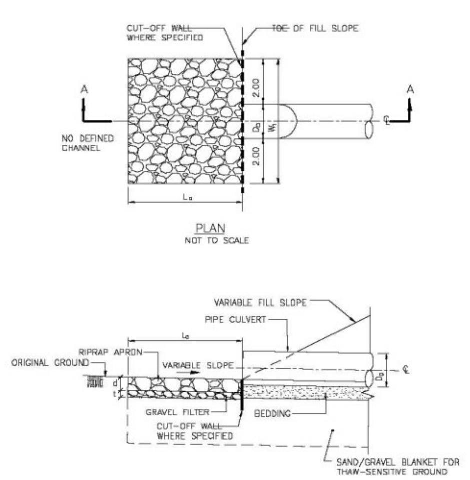


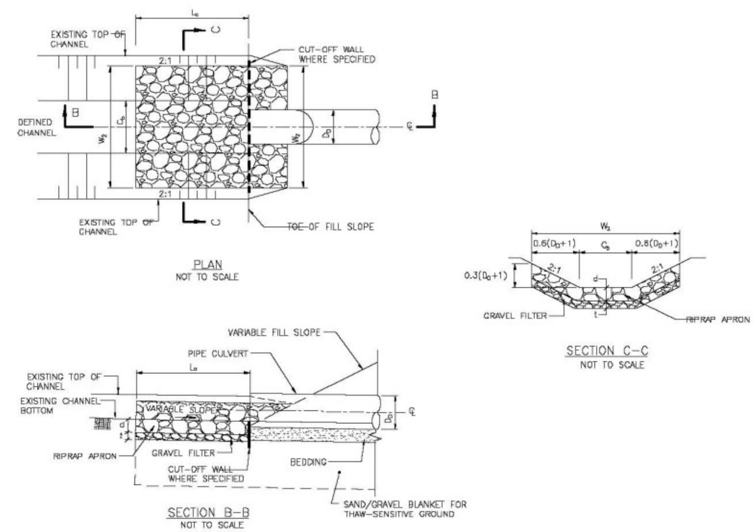
TYPE A RIPRAP APRON

(USED WHERE THERE IS NO DEFINED CHANNEL UPSTREAM OF CULVERT INLET)

CULVERT DIAMETER D_0 (m)	INLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH L_a (m)	APRON WIDTH W_1 (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)
1.60	0.0 – 3.0	A1	SEE NOTE 1	5.60	0.30	0.60	0.30
1.60	3.0 – 4.0	A2	SEE NOTE 1	5.60	0.60	1.20	0.30
1.60	4.0 – 5.0	A3	SEE NOTE 1	5.60	0.90	1.80	0.50
3.00	0.0 – 3.0	A4	SEE NOTE 1	7.00	0.30	0.60	0.30
3.00	3.0 – 4.0	A5	SEE NOTE 1	7.00	0.60	1.20	0.30
3.00	4.0 – 5.0	A6	SEE NOTE 1	7.00	0.90	1.80	0.50

NOTES:

1. INLET SCOUR PROTECTION LENGTH (La) IS BASED ON SITE SPECIFIC CONDITIONS INCLUDING FLOW RATE, FLOW VELOCITY AND GEOTECHNICAL CONDITIONS. (THE MINIMUM LENGTH IS 5M)



TYPE B RIPRAP APRON

(USED WHERE THERE IS DEFINED CHANNEL UPSTREAM OF INLET)

CULVERT DIAMETER D_0 (m)	INLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH L_a (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)	
1.60	0.0 – 3.0	B1	SEE NOTE 1	0.30	0.60	0.30	
1.60	3.0 – 4.0	B2	SEE NOTE 1	0.60	1.20	0.30	
1.60	4.0 – 5.0	B3	SEE NOTE 1	0.90	1.80	0.50	
3.00	0.0 – 3.0	B4	SEE NOTE 1	0.30	0.60	0.30	CULVERTS A & B
3.00	3.0 – 4.0	B5	SEE NOTE 1	0.60	1.20	0.30	
3.00	4.0 – 5.0	B6	SEE NOTE 1	0.90	1.80	0.50	

$W_2 = C_b + 1.2D_0 + 1.2$

WHERE C_b = WIDTH OF CHANNEL

NOTES:

1. INLET SCOUR PROTECTION LENGTH (La) IS BASED ON SITE SPECIFIC CONDITIONS INCLUDING FLOW RATE, FLOW VELOCITY AND GEOTECHNICAL CONDITIONS. (THE MINIMUM LENGTH IS 5M)

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PROJECT PHASE

Baffinland Iron Mines Corporation

AREA 5000 GENERAL

CANARAIL DILLON CONSULTING

PROJECT NUMBER 07 – 36

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SUBJECT: ACCESS ROAD CONSTRUCTION EROSION PROTECTION INLET RIPRAP APRON SINGLE CULVERTS

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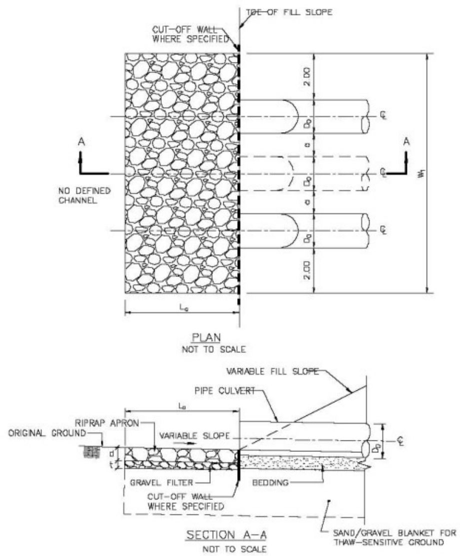


TYPE C RIPRAP APRON

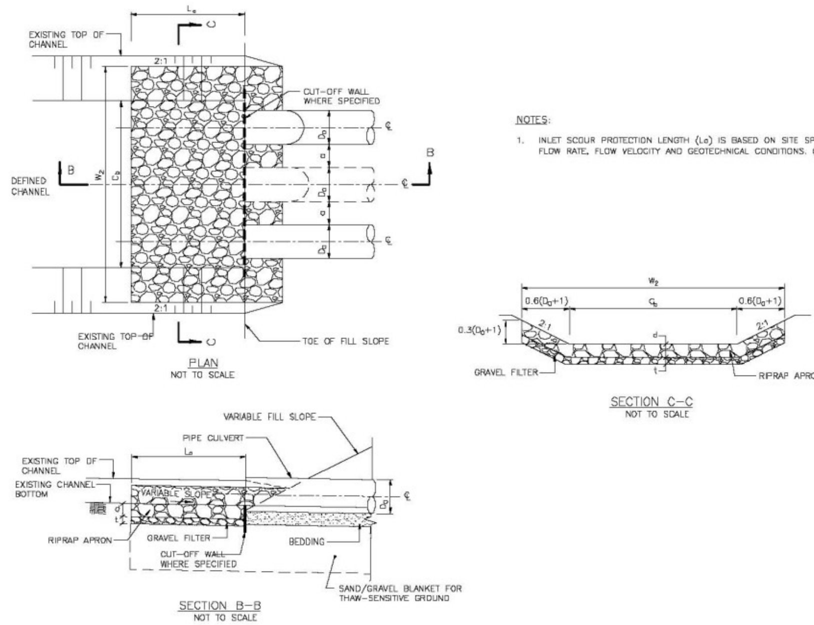
(USED WHERE THERE IS NO DEFINED CHANNEL UPSTREAM OF CULVERT INLET)

CULVERT DIAMETER D_0 (m)	DISTANCE BETWEEN CULVERT a (m)	INLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)
1.60	0.90	0.0 – 3.0	C1	SEE NOTE 1	0.30	0.60	0.30
1.60	0.90	3.0 – 4.0	C2	SEE NOTE 1	0.60	1.20	0.30
1.60	0.90	4.0 – 5.0	C3	SEE NOTE 1	0.90	1.80	0.50
3.00	0.90	0.0 – 3.0	C4	SEE NOTE 1	0.30	0.60	0.30
3.00	0.90	3.0 – 4.0	C5	SEE NOTE 1	0.60	1.20	0.30
3.00	0.90	4.0 – 5.0	C6	SEE NOTE 1	0.90	1.80	0.50

$W_1 = xD_0 + (x-1)a + 4.0$
WHERE C_b = WIDTH OF CHANNEL
x = NO. OF CULVERTS

NOTES:

1. INLET SCOUR PROTECTION LENGTH (La) IS BASED ON SITE SPECIFIC CONDITIONS INCLUDING FLOW RATE, FLOW VELOCITY AND GEOTECHNICAL CONDITIONS. (THE MINIMUM LENGTH IS 5M)



NOTES:

1. INLET SCOUR PROTECTION LENGTH (La) IS BASED ON SITE SPECIFIC CONDITIONS INCLUDING FLOW RATE, FLOW VELOCITY AND GEOTECHNICAL CONDITIONS. (THE MINIMUM LENGTH IS 5M)

TYPE D RIPRAP APRON

(USED WHERE THERE IS DEFINED CHANNEL UPSTREAM OF INLET)

CULVERT DIAMETER D_0 (m)	NO. OF CULVERT x	DISTANCE BETWEEN CULVERT a (m)	INTLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)	
1.60	2	0.90	0.0 – 3.0	D1	SEE NOTE 1	0.30	0.60	0.30	
1.60	2	0.90	3.0 – 4.0	D2	SEE NOTE 1	0.60	1.20	0.30	
1.60	2	0.90	4.0 – 5.0	D3	SEE NOTE 1	0.90	1.80	0.50	
3.00	2	0.90	0.0 – 3.0	D4	SEE NOTE 1	0.30	0.60	0.30	CULVERT C
3.00	2	0.90	3.0 – 4.0	D5	SEE NOTE 1	0.60	1.20	0.30	
3.00	2	0.90	4.0 – 5.0	D6	SEE NOTE 1	0.90	1.80	0.50	

$W_2 = C_b + 1.2D_0 + 1.2$
WHERE C_b = WIDTH OF CHANNEL

DEVELOPMENT OF THIS DRAWING IS BASED ON PRELIMINARY TOPOGRAPHICAL AND GEOTECHNICAL INFORMATION ADEQUATE FOR PRELIMINARY DESIGN ONLY. IT SHOULD NOT BE USED FOR CONSTRUCTION OR ANY OTHER PURPOSES.

Baffinland Iron Mines Corporation | CANARAIL | DILLON CONSULTING

PROJECT NO. 159952 | AREA 5000 GENERAL | PROJECT NUMBER 07 – 36

DSN ECQ | DRN ECQ | CHK BGH

SCALE: AS SHOWN

SUBJECT: ACCESS ROAD CONSTRUCTION
EROSION PROTECTION
INLET RIPRAP APRON
MULTIPLE CULVERTS

DRAWING NO. FIGURE 21

CAD FILE: C:\Sheets\A1-159952-5000-121-5025.dwg

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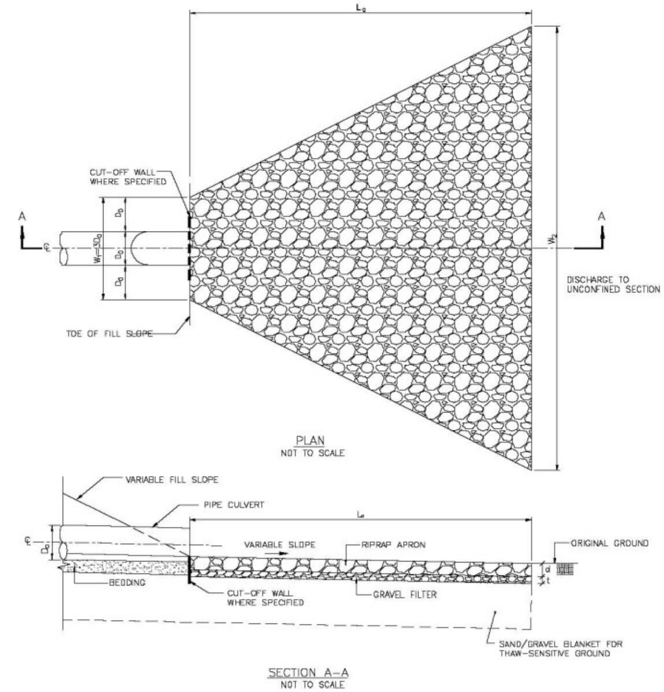
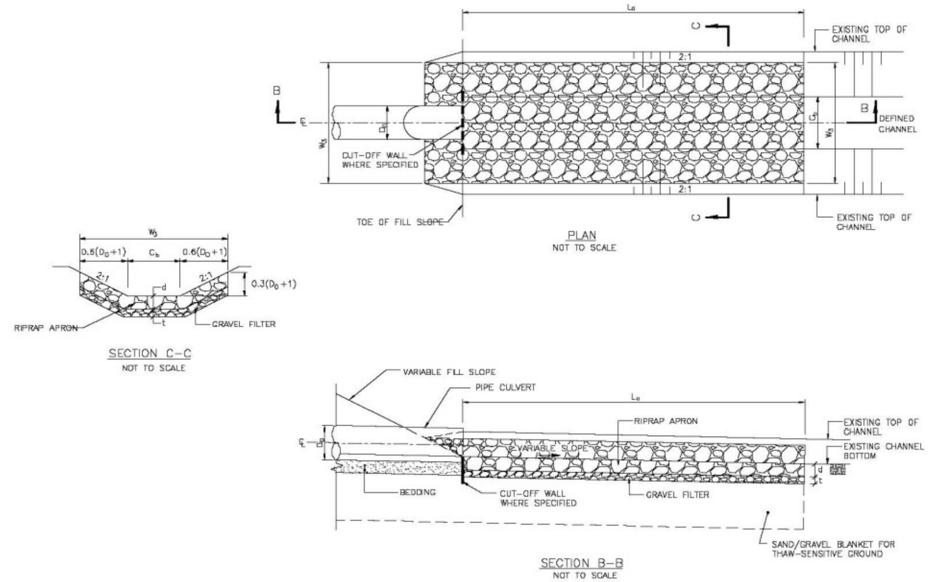


TYPE E RIPRAP APRON

(USED WHERE THERE IS NO DEFINED CHANNEL DOWNSTREAM OF OUTLET)

CULVERT DIAMETER D_0 (m)	OUTLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	APRON WIDTH W_1 (m)	APRON WIDTH W_2 (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)
1.60	0.0 – 3.0	E1	15	4.80	20	0.30	0.60	0.30
1.60	3.0 – 4.0	E2	15	4.80	20	0.60	1.20	0.30
3.00	0.0 – 3.0	E3	25	9.00	34	0.30	0.60	0.30
3.00	3.0 – 4.0	E4	25	9.00	34	0.60	1.20	0.30



TYPE F RIPRAP APRON

(USED WHERE THERE IS DEFINED CHANNEL DOWNSTREAM OF OUTLET)

CULVERT DIAMETER D_0 (m)	OUTLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)	
1.60	0.0 – 3.0	F1	15	0.30	0.60	0.30	
1.60	3.0 – 4.0	F2	15	0.60	1.20	0.30	
3.00	0.0 – 3.0	F3	25	0.30	0.60	0.30	
3.00	3.0 – 4.0	F4	25	0.60	1.20	0.30	CULVERTS A & B

W_3 – GREATER OF $\begin{cases} C_b + 1.2D_0 + 1.2 \\ 3D_0 \end{cases}$

WHERE C_b = WIDTH OF CHANNEL

DEVELOPMENT OF THIS DRAWING IS BASED ON PRELIMINARY TOPOGRAPHICAL AND GEOTECHNICAL INFORMATION ADEQUATE FOR PRELIMINARY DESIGN ONLY. IT SHOULD NOT BE USED FOR CONSTRUCTION OR ANY OTHER PURPOSES.

REV	DDMMMYY	REVISION	DR	CHK	APP	APP	APP	APP	ISS	DDMMMYY	APP	ISSUED FOR	REF	NUMBER	TITLE

REFERENCES

STAMP/SEAL

Baffinland Iron Mines Corporation — CANARAIL — DILLON CONSULTING

CLIENT PROJECT MGR.	DEPARTMENT MGR.	PROJECT MGR.			
PROJECT PHASE			AREA 5000	GENERAL	PROJECT NUMBER 07 – 36
PROJECT NO. 159952	ACTIVITY NO.	BY / DDMMMYY: DSN ECQ; DRN ECQ; CHK BGH; APP	SUBJECT	ACCESS ROAD CONSTRUCTION EROSION PROTECTION OUTLET RIPRAP APRON SINGLE CULVERTS	DRAWING NO. FIGURE 22 — REV. 1
SCALE AS SHOWN	PACKAGE CODE				

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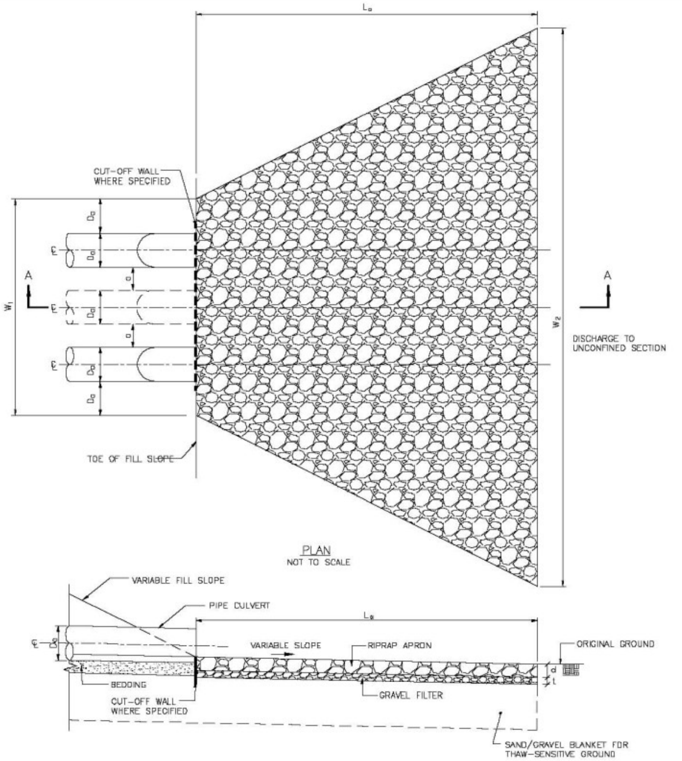
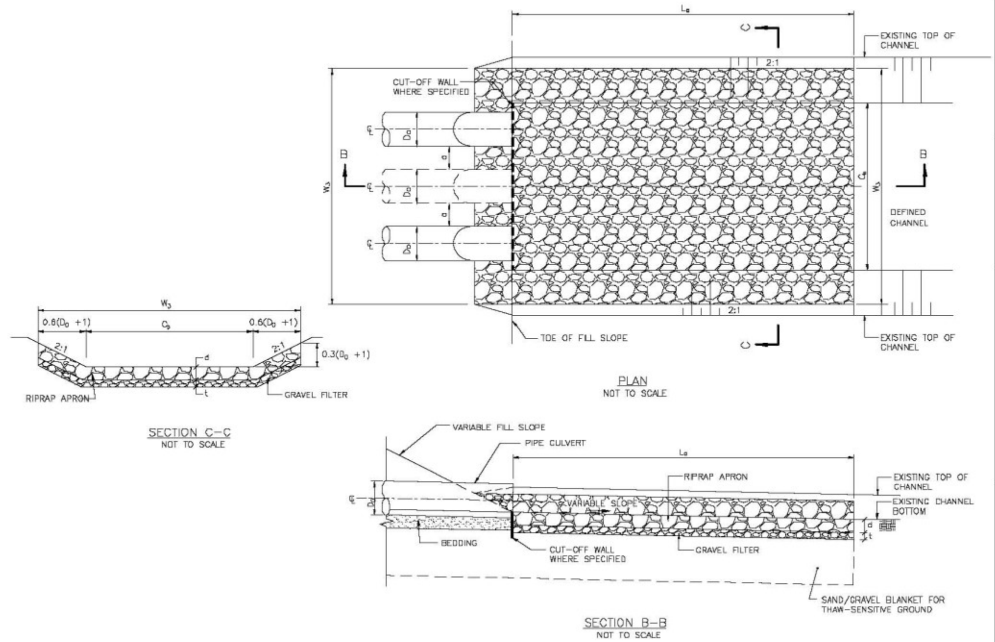


CULVERT DIAMETER D_0 (m)	No. OF CULVERT x	DISTANCE BETWEEN CULVERT a (m)	OUTLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)
1.60	2	0.90	0.0 – 3.0	G1	15	0.30	0.60	0.30
1.60	2	0.90	3.0 – 4.0	G2	15	0.60	1.20	0.30
3.00	2	0.90	0.0 – 3.0	G3	25	0.30	0.60	0.30
3.00	2	0.90	3.0 – 4.0	G4	25	0.60	1.20	0.30

W =D1 (x+2) + (x−1)a
W = W1 + a L



TYPE H RIPRAP APRON

(USED WHERE THERE IS DEFINED CHANNEL DOWNSTREAM OF OUTLET)

CULVERT DIAMETER D_0 (m)	DISTANCE BETWEEN CULVERT a (m)	INLET VELOCITY (m/s)	APRON TYPE	APRON LENGTH La (m)	AVERAGE STONE SIZE D_{50} (m)	APRON THICKNESS d (m)	GRAVEL FILTER THICKNESS t (m)	
1.60	0.90	0.0 – 3.0	H1	15	0.30	0.60	0.30	
1.60	0.90	3.0 – 4.0	H2	15	0.60	1.20	0.30	
3.00	0.90	0.0 – 3.0	H3	25	0.30	0.60	0.30	CULVERT C
3.00	0.90	3.0 – 4.0	H4	25	0.60	1.20	0.30	

W = Cb + 1.2D +1.2
WHERE C_b = WIDTH OF CHANNEL

DEVELOPMENT OF THIS DRAWING IS BASED ON PRELIMINARY TOPOGRAPHICAL AND GEOTECHNICAL INFORMATION ADEQUATE FOR PRELIMINARY DESIGN ONLY. IT SHOULD NOT BE USED FOR CONSTRUCTION OR ANY OTHER PURPOSES.

REV | DDMMYY | REVISION | DR | CHK | APP | APP | APP | APP | ISS | DDMMYY | APP | ISSUED FOR | REF | NUMBER | TITLE | REFERENCES

STAMP/SEAL

CLIENT PROJECT MGR. DEPARTMENT MGR. PROJECT MGR.
PROJECT PHASE
Baffinland Iron Mines Corporation
CANARAIL
DILLON CONSULTING
AREA 5000 GENERAL
PROJECT NUMBER 07 – 36
PROJECT NO. 159952
ACTIVITY NO.
DSN ECQ
DRN ECQ
CHK BGH
APP
SCALE AS SHOWN
PACKAGE CODE
SUBJECT: ACCESS ROAD CONSTRUCTION EROSION PROTECTION OUTLET RIPRAP APRON MULTIPLE CULVERTS
DRAWING NO. FIGURE 23
REV. 1

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