Civil Design Philosophy

2018-03-12	2	Approved for Use	F Hugo	A Grobbelaar	D Stanger	T Atiba
2017-08-01	1	Approved for Use	F Hugo	A Grobbelaar	N Mason	M Weaver
2017-03-23	0	Approved for Use	F Hugo	A Grobbelaar	J Cleland	M Weaver
Date	**Rev.**	**Status**	**Prepared By**	**Checked By**	**Approved By**	**Approved By**
			HATCH			**Client**

Table of Contents

1. Introduction

This document establishes the Employers requirements for civil design and engineering for the Mary River Expansion Project.

This document is intended to address the key criteria required for the design of site infrastructure at Milne Inlet and the Mine Site.

2. Units and Coordinate System

2.1 The International System of Units (SI units and prefixes) shall be used for all design calculations and on all drawings.

2.2 The grid coordinates shall be based on: projection – Universal Transverse Mercator (UTM) Zone 17 and horizontal datum – NAD 83 Canadian Spatial Reference System (CSRS).

2.3 Vertical datum shall based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

3. References

3.1 Codes, Regulations and Standards

3.1.1 Unless specifically stated otherwise, civil design shall be based on the applicable sections of the latest revisions of the following codes, specifications, standards, regulations and other reference documents. In addition, the design must comply with all laws or regulations of federal and Nunavut territorial authorities.

3.2 General

3.2.1 All applicable federal, territorial (Nunavut) and local laws and regulations:

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch

3.3 Roads

- TAC Transportation Association of Canada – Geometric Design Guide for Canadian Roads
- AASHTO American Association of State Highway and Transportation Officials
- USBM Design of Surface Mine Haulage Roads – A Manual (US Department of the Interior, Bureau of Mines)
- MSHA Haul Road Inspection Handbook – MSHA Document Number PH99-I-4
- MTO Ministry of Transportation, Ontario – Ontario Traffic Manual.

3.4 Stormwater Management

- MOE Ministry of the Environment – Stormwater Management Planning and Design Manual
- MTO Ministry of Transportation, Ontario – Drainage Manual
- CDA Canadian Dam Association – Dam Safety Guidelines

3.5 Reference Documents

Reference will be made to/contents have been used as general guidance from the following documents, articulated during the previous phases of the project, during the development of these criteria:

- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds
- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management
- H337697-0000-15-124-0004: Geotechnical Data Report – Infrastructure
- Standard Specification S311213: Quarried Fill Materials
- Standard Specification S003120: Site Conditions
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012
- Updated Design Peak Flow Assessment. Knight Piesold, 2016
- BIM - Early Revenue Phase Tote Road Design Criteria
- H349000-1000-10-122-0001: Civil Design Criteria
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012
- Nunavut Impact Review Board (NIRB) Project Certificate (No.:005), December 28, 2012
- H349000-2133-10-220-0001: Runoff Coefficient for the Milne Port Ore Stockpile Pad, Project Memo
- H349000-1000-10-220-0001: Stormwater Sedimentation Pond Design Criteria, Project Memo

- E349000-1000-00-124-0005: Design Brief – Milne Inlet Landfarm, November 2012, EBA File E14101174.
- H353004-00000-228-066-0001: Mary River – Snowmelt + Rainfall Frequency Analysis. 2

4. Site Development

Site development refers to construction of civil infrastructure to support construction and operation of facilities. The following sections list the site development activities and establish criteria that shall be adhered to when carrying out site development design works.

All site development including toe lines of pads and roads shall be designed and positioned so that it is not closer than 31m from the edge of a stream or waterbody. The edge of a stream or water body shall be defined by using the existing surface obtained from the 1m density lidar survey (2016). 2

4.1 Site Preparation

4.1.1 Temporary drainage systems shall be provided at construction areas prior to construction activities taking place as required to control surface runoff.

4.1.2 During the summer months, wetlands or areas with standing water shall be drained and the drying of such shall be promoted prior to construction. Watercourses shall be re-routed with the use of cut-off ditches, or re-aligned engineered channels.

4.1.3 Waste material shall be stockpiled in designated areas with the appropriate erosion and sedimentation control measures in place.

4.2 Earthworks

4.2.1 Earthworks is defined as the activity of moving soil and/or rock. Earth-moving activities are required to obtain the required design elevations of the ground surface. Earthworks includes cut (if required) and fill for roads, buildings and equipment pads, utility berms, foundation excavation, and construction of ditches, diversion channels and berms, dikes, etc. Earthworks shall be carried out in accordance with the following general guidelines:

- Existing unsuitable soils shall be removed and replaced with suitable material to be decided by the Resident Engineer
- Fill materials shall be placed and roller compacted over the proof-rolled subgrade to achieve adequate bearing capacities, as required for specific construction activities
- Rocks/boulders and similar objects adjacent to areas which shall undergo excavation must be removed or secured, if they potentially endanger workers/machinery.

4.2.2 Table 4-1 provides the minimum slope ratios that shall be used in permanent cuts/excavations or fills/embankments. It must be noted that specific studies must be carried out by geotechnical engineers, if these slopes are to be modified with the aim of lowering costs of cut and/or fill.

Table 4-1: Minimum Slope Ratios

Type of Earthworks	Layer	Ratio H:V
Permanent unsupported cuts	Overburden (ice-rich)	2:1
	Overburden (non-ice-rich)	1.5:1
	Rock (less than 4m)	1:8
Permanent fills (on natural, firm ground)	Granular fill	1.5:1
	Base and Subbase	1.5:1
	Rock fill	1.5:1
	Frozen Permafrost (During winter)	1:8

Notes:
1. The maximum heights and ratios shall be determined considering slopes with typical geometry and no surcharge.
2. The above-listed parameters serve as minimum requirements, and shall be updated/modified based on confirmation/update of the site-specific conditions and/or geotechnical recommendations, or as per BIM's directions.
3. Any geometry and load condition not covered by the table above shall be reviewed by the geotechnical engineer.
4. The granular fill is assumed to be in a drained condition.
5. If the total fill height is greater than 2 m, geotechnical stability analysis and benching requirements shall be considered on a case-specific basis.
6. For overburden cut/fill heights of greater than 5 m, 1.5 m wide benching with minimum 2% cross slope shall be provided.
7. The absolute minimum fill slope for granular material is 1.5H:1V. However, the desirable slope is 2H:1V.
8. The absolute minimum fill slope for rock fill material is 1.25H:1V. However, the desirable slope is 1.5H:1V.
9. For the haul road, the fill side slopes shall be 2H:1V, depending on the site conditions and slope stability.
10. Stability assessments of some cut and fill slopes may be required.
11. For rock cut heights greater than 4 m, 1H:4V slope shall be used with 2 m wide benching and minimum 2% cross slope at every 6 m.

4.2.3 Pits, trenches and similar which will later be stabilized by backfill shall be excavated at a safe slope as determined by the field engineer. Slope ratios listed in Table 4-1 shall be used for planning purposes. Slope ratio of 1:8 shall be used for planning purposes for frozen permafrost ground excavated and backfilled during winter.

4.2.4 In general, cut activities in permafrost shall be avoided/minimized. However, cut may be required to reduce large fills and high embankments that may affect/endanger slope stability. In addition, within areas where the cut materials can be reused as fill, the suitability of performing cuts in the native soil shall be reviewed by BIM and the geotechnical engineer for requirements of soil treatment/improvement, including geogrids and geotextiles, prior to implementation into the final design.

4.3 Site Grading

4.3.1 If applicable, finish grade elevations for roads and yards shall be set a minimum of 100 mm below the finish floor elevation of buildings/sheltered areas, with local ramps provided at doorways, as required.

4.3.2 Finish grading and yard grading shall be set to slope away from planned structures at a minimum of 0.5% to 2%, and drain to a storm drainage collection system. For very long-run and localized areas, the slope shall be reduced or increased, depending on the existing ground slope and the grading around the buildings and facilities.

4.3.3 Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall adhere to the following:

- Final road and site grades shall ensure suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site
- Building floor elevations shall be established such that the ground floor of the buildings will not be subject to flooding in the event that the storm drainage system fails
- Elevations of buildings/sheltered areas shall be established to permit gravity connections into sanitary sewers if possible, to avoid the need for pumps.

4.4 Infrastructure Facilities, Pads and Laydown Areas

4.4.1 Temporary/permanent equipment and construction material laydown areas shall be provided as per the applicable Contract Drawings. The sizes of the footprints shall be optimized to keep disturbed areas to a minimum and still provide enough room for storage of material/equipment and circulation of mobile cranes/vehicles.

4.4.2 The subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. The following material shall be used:

- Type 12 (ROQ 600mm minus).

4.4.3 In general, following attainment of the subgrade, the pavement shall be laid on top, with the following minimum thicknesses/material types for infrastructure facility pads and other areas:

- 300 mm, Type 8 (150 mm minus) base △2
- 100 mm, Type 5 (32 mm minus) wearing surface course. △2

4.4.4 Temporary construction pads shall be constructed with:

- Minimum 300mm fill Type 8 for fill depth <600mm or Type 12 for fill depth>600mm
- 100 mm, Type 5 (32 mm minus).

4.4.5 Depending upon the area and specific requirements such as insulation for permafrost protection, the minimum pavement thicknesses and placement of wearing courses may differ from the above-listed.

4.4.6 Sub-grade insulation shall be installed under the footprint of all slab-on-grade and similar buildings to reduce heat transfer into the underlying permafrost. Sub-grade insulation shall comply with geotechnical recommendations. △2

4.4.7 Refer to Appendix A for typical layer works.

4.5 Milne Port Stockpile Area

4.5.1 The lump ore stockpile (Stockpile No. 2) shall be situated on an earthworks platform that shall be used as a laydown area before the stockpile becomes operational. The laydown area shall be designed to be a minimum of 300mm below the reclaim level. △2

4.5.2 The fine ore stockpile (Stockpile No. 1) shall be situated on the existing stockpile area. Additional earthworks will be constructed where required to ensure that there is sufficient area for the stockpile placement. △2

4.6 Milne Port Design High Tide

4.6.1 The design High Tide levels for the Project shall be as follows:

- The Higher High Water Level (HHWL) for large tides at the Milne Port is +2.3 m above Chart Datum (CD) which corresponds to +1.1 m above Mean Sea Level (MSL)
- The Highest Astronomical Tide (HAT) at the Milne Port is +2.4m above CD which corresponds to +1.2 m above MSL
- The Lower Low Water Level (LLWL) for large tides at the Milne Port is +0.0 m above CD which corresponds to -1.2 m below MSL.

4.7 Retaining Walls

4.7.1 Retaining walls and structures shall be designed based on site-specific conditions. Lateral pressure coefficients for design of retaining walls shall be as per the geotechnical recommendation.

4.7.2 Retaining walls shall be avoided to the greatest extent possible. Concrete, gabion walls, crib walls, reinforced earth and/or other systems of retaining structures shall be used, if required.

4.8 Erosion and Sediment Control

4.8.1 Erosion and sediment control measures shall be installed as required, in and around the project sites to minimize sediment transport off the site.

4.8.2 Control measures shall be designed to:

- Minimize the size of disturbed areas
- Remove sediments from on-site runoffs prior to the runoff leaving the sites
- Prevent sediments from off-site runoffs flowing across disturbed areas
- Reduce runoff velocity flowing across the site
- Meet local requirements for erosion and sediment control plans as defined in the FEIS.

4.8.3 A minimum set back of 31 m from fish-bearing streams and lakes or water bodies shall be provided. Any exception to this shall be consulted with and approved by the Project's environmental team. △2

4.9 Quarry Blasting

4.9.1 The minimum distance that dwelling units (living quarters) shall be positioned away from the quarry will be 600m. △2

4.9.2 The minimum distance that roads, rail lines and project working areas shall be positioned away from the quarry is 300m. △2

5. Road Design

5.1 General

5.1.1 The access roads at the two project sites may be temporary or permanent. An access road is defined as temporary if it will be used only during the construction period including site predevelopment or site capturing. Permanent roads are defined as roads that are requried for operarations. Permanant roads may be primary secondary or tertiary depending on frequency and type of traffic.

5.1.2 The design and construction of mine haul roads, access and internal site roads at the project sites shall provide a safe environment for construction, operations and maintenance personnel, and shall facilitate the mining operations, ore transport and port operations in an efficient manner. In addition, the design shall comply with the relevant standards, guidelines, acts, approvals, permits, and other contractual environmental requirements of Baffinland as defined in Section 3 of this document.

5.2 Road Category

5.2.1 For the purposes of this design criteria, the roads are classified in three categories:

- **Mine Haul Roads –** The purpose of this type of road is for the mining operation at the mine site – hauling of ore from the open pit to the crusher pad and for maintenance purposes, from the crusher pad to the maintenance building. The mine haul road shall be segregated from the other project roads for safety considerations, and shall comply with the applicable Nunavut MHSA.
- **Primary Roads –** These roads provide two-way access. Frequent traffic is expected.
- **Secondary Roads –** These roads provide two-way access to various facilities/areas within each site, where light vehicles will travel in both directions. They are expected to be used daily.
- **Tertiary Roads –** These roads are generally single lane width and are used in areas where traffic is infrequent / rare.
- **Temporary Roads –** These roads provide access for construction only and are not required for ongoing operation.

5.2.2 Special purpose roads, such as for module transport, may be required and will be determined on a case by case basis.

5.3 Design Vehicle

5.3.1 The following design vehicles shall be utilized for the design of the associated project roadways:

- CAT 793F Haul Truck for the Mine Haul Road
- Other types of design vehicles have been used for the remainder of the Project roadways and a fire truck has been considered as the minimum design vehicle for fire access routes.

△2

5.4 Geometric Design Criteria

5.4.1 All roads shall be designed as gravel roads and shall accommodate the design vehicle specified in Section 5.3 of this document. The roads' geometric design parameters are specified below:

Table 5-1: Road Geometric Design Criteria

Road Type	Mine Haul Road	Primary Road	Secondary Road	Tertiary & Temporary Roads
Number of Lanes	2	2	2	1
Design Speed (km/h)	50	60	40	40
Posted Speed (km/h)	40	50	30	30
Total Road Width (m)	25	10	6	4
Minimum Horizontal Curve C/L Radius (m)	100	35	35	35
Minimum Intersection Inner Radius (m)	30	15	15	15
Minimum Cross Slope (%)	3	2	2	2
Maximum Grade (%)	10	10	10	10
Minimum K Value (Vertical Sag Curve)	12	8	8	8
Minimum K Value (Vertical Crest Curve)	16	4	4	4
Maximum Super-elevation (%)	4	4	4	4
Minimum Vertical Clearance	9	7	5	5

Notes:
1. The road design parameters are based on the desirable design speeds. Specific parameters such as the minimum turn radii may be modified for some areas locally on a case-by-case basis, via adjustment of the design speeds.
2. The Haul Road width shall be based on the Nunavut Mine Health and Safety Act which requires a minimum travel width three times the width of the widest haulage vehicle for dual lane traffic and two times the width of the widest haulage vehicle for single lane traffic.
3. Shoulder barriers (safety berms or guardrails) for the Haul Road shall be based on the Nunavut Mine Health and Safety Act which requires shoulder barriers of at least ¾ the height of the largest tire of any vehicle using the road and shall be provided along the edge of the haul road wherever a drop-off greater than 3.0m exists. For CAT 777G, the shoulder barrier (safety berm or guardrail) height shall be 2.0 m based on standard tire 27.00 R49 (E4).
4. Total road width includes shoulder width and snow allowance but doesn't include the safety berm width for the haul road.
5. Widening shall be provided in roadway curves as necessary.
6. Need for geotextiles or geogrids shall be considered on a case-specific basis.
7. For the Tote Road design criteria, refer to H349000-3100-10-122-0001.
8. Provide safety stations, emergency ramps or escape lanes in accordance with the local and mine safety requirements. Hatch will only provide two escape ramps at the most critical locations as per BIM's instruction. Escape ramp design shall be carried out as per the USBM manual.
9. For cut/fill heights of greater than 5 m, provide 1.5 m wide benching with minimum 2% cross slope at every 5 m.
10. The ramp leading down to the sea lift from the laydown area at the Milne Port shall have a maximum grade of 8%.
11. The maximum grade for ramps to the buildings is 6%.
12. Fill toe key shall be provided in areas where the existing ground is steeper than 3H:1V away from the road.
13. Design speeds may be reduced locally if needed.

5.4.2 The following general rules shall apply to the geometric design of the project roads:

- Roadway grades shall not exceed the maximum grades specified in Table 5-1 except for short ramps which shall be considered on a case-specific basis
- Signage shall be provided for speed and caution at steep horizontal and/or vertical curves, and where the design criteria can't be met

- Traffic signs and shoulder barriers (safety berms or guardrails), shall be placed at the outer edges of the roads, as required.

5.5 Pavement Thickness

5.5.1 For the project internal site roads, the subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. Type 12 Run-of-Quarry and/or suitable earth fill material shall be used for subgrade where appropriate and approved by the Engineer. Otherwise type 8 (150mm minus) shall be used. The voids of each layer of Type 12 material shall be filled with rock fragments prior to placement of the next layer.

5.5.2 Pavement thickness for each road type shall comply with Table 5-2.

Table 5-2: Pavement Thickness

Road Type	Primary / Secondary Roads	Tertiary & Temporary Roads
Base (Type 8) note: refer to 5.5.4 below	300 mm	300 mm
Surface (Type 5)	100 mm	100 mm

5.5.3 Pavement details for mine haul road to be confirmed.

5.5.4 Sub-base fill shall be placed as required to achieve specified sub-base elevations with minimum thickness as specified and:

- For sub-base fill depth >600mm Type 12 shall be used. Where no base is placed over the Type 12 the top of Type 12 material shall be chinked with smaller rock fragments and compacted to minimize infiltration of Surface Type 5 material △2
- For sub-base fill depth <600mm Type 8 material shall be used. △2

5.5.5 Pavement thickness for special purpose roads shall be determined on a case by case basis.

5.5.6 Refer to Appendix A for typical layer works.

5.5.7 Design Vehicles, Traffic Volume and Load

5.5.7.1 Vehicle types have been selected for the project roads based on the expected usage and transportation requirements of the area (Section 5.3).

5.5.7.2 All pavement, slabs, bridges, trenches, trench covers and underground installations accessible to trucks shall be designed to withstand the load associated with an HS 20-44 wheel load or its equivalent, as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specification for highway bridges. However, within areas of special equipment operation, this shall be considered as per the actual vehicle loading.

5.6 Parking

5.6.1 Parking areas shall be designed to accommodate their intended use. In general, all parking areas shall be surfaced with granular materials.

5.6.2 Vehicle parking area design shall adhere to the following:

- The area shall be graded to direct stormwater away from the parking
- Alignment and gradients shall be coordinated with the grading plans to control drainage
- Walking distance from parking areas shall be kept to a minimum
- Barrier-free parking spaces as well as walkways shall be provided according to the applicable regulations
- Designated turnaround areas shall be provided at dead ends
- Parking lot design criteria shall be as shown in Table 5-3.

Table 5-3: Parking Lot Design Criteria

Topic	Criteria
Gradient	Maximum 5% Minimum 0.5% Optimum 2%
Cross Slope	Maximum 5% Minimum 2% Optimum 3%
Pavement Structure	300 mm Type 8 (150 mm minus) subbase 100 mm Type 5 (32 mm minus) base/wearing surface course
Parking Stall Dimensions	Driving Lane • Width 7.5 m Standard • Depth 6 m • Width 2.75 m Barrier-free • Depth 6 m • Width 3.5 m • Access Aisle Width 1.5 m

5.7 Signage

5.7.1 Traffic control signs and road edge markers shall be provided as required to ensure safe movement in and about the site.

5.7.2 Direction and information signs for both vehicle and pedestrian traffic shall be provided for parking areas, restricted areas, shipping and receiving.

5.7.3 Primary identification signs shall be free-standing and sited according to the applicable standards as listed in Section 3.3.

5.7.4 Other signs shall be free-standing, fence-mounted or wall-mounted.

5.7.5 Security signs shall be provided at the sites and along the site property boundaries.

5.7.6 Signs for the site access roads shall be compliant with the local traffic regulations.

5.7.7 Signs shall be lighted, if deemed necessary.

5.7.8 All signs and pavement markings (if applicable) shall be well maintained during the construction and operational periods.

5.8 Bollards

5.8.1 Concrete blocks and /or tires shall be provided where required to protect buildings and hazardous areas.

5.8.2 Where available, tires must be used. If tires are not available, concrete blocks must be placed be placed based on the engineer's recommendations.

5.9 Shoulder Barriers (Safety Berms/Guardrails)

5.9.1 Shoulder barriers (earth safety berms or guardrails) shall be provided in accordance with the Nunavut Mines Health and Safety Act.

5.9.2 Barriers shall be provided where a 3.0 m or more drop-off exists at the edge of vehicular areas including roads, pads, lay down areas and similar.

5.9.3 Height of barrier shall be minimum 0.75 times the maximum wheel diameter of traffic expected to operate in the area, including:

- For areas where heavy mining equipment travels barrier height shall be minimum 2.7m high (based on CAT793 F tire, 40.00R57)
- For general vehicular areas barrier height shall be minimum 1.0m high (based on typical transport, vac and tanker trucks used on site).

5.9.4 Safety berms side slopes shall be 1H:1V.

5.9.5 Discontinuous openings shall be provided in berms at maximum 25 m spacing for drainage and snow clearance, with openings smaller than half the blade width of vehicles constructing or maintaining the berms.

5.9.6 Runaway vehicle collision berms or escape lanes shall be provided in accordance with industry requirements as described in the Nunavut MHSA.

5.10 Utility Berms

5.10.1 Utility berms may travel along the project roadways to the greatest extent possible, shall be of trapezoidal cross-sections. Berms with power cables shall be minimum 0.6 m high from the road edge or the existing ground, and shall have maximum fill side slopes of 1.5H:1V, as validated by the geotechnical engineer. They shall be constructed with the use of 300 mm of granular Type 8 (150 mm minus) and 50 mm of granular Type 5 (32 mm minus) material. Berms for pipes may be level with adjacent roads or pipe may be placed directly on existing grade without berm construction where risk of damage is low.

The top width of utility berms will depend on the pipe and cable duct sizes. Utility berms shall cross roadway intersections through utility sleeves. After crossing the intersections, they shall resume the alignments within the utility berms.

6. Stormwater Management System

6.1 Allowance for Snow Melt Runoff Volume

2

An investigation into Snowmelt was done as per *H353004-00000-228-066-0001: Snowmelt+ Rainfall Frequency Analysis*. It was found that the combination of rainfall and snowmelt in the start of spring has a lower impact on the size of stormwater infrastructure than rainfall during the middle of the wet season (at higher intensities and total precipitation). For this reason, only the runoff methods as specified in the *Baseline Hydrology Report, January 4. North Bay, Ontario. Ref. No. NB102-181/30-7, Rev 1* and updated in *VA16-01950 on 13 December 2016* by Knight Piésold Consulting will be used for designing stormwater infrastructure.

6.2 Internal Surface Drainage

6.2.1 Internal surface drainage areas are defined as areas where the catchment consists out of areas where the natural surface has been disturbed through excavation, mining activity or bulk earthworks such as the construction of pads and roads. The general criteria for the site internal storm water management systems are described below.

2

- All interior site grading and roads shall be designed to provide continuous overland flow without erosion to a drainage ditch system
- All drainage ditches should be of trapezoidal cross sections, where possible
- Ditches shall be designed to convey a 1 in 25 year flood event
- Provision must be made to ensure that there is a safe flow path for events up to the 1 in 100 year event, such that the runoff will not flood key mining areas, cause significant erosion, pick up excessive contaminants or cause other significant problems
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-1
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch or 300mm freeboard, whichever is higher

  2

  Minimum set back distance of structures from top of drainage ditch slopes shall be 3 m
- Roof and yard drainage shall be collected in open ditches
- Appropriately sized rip rap shall be provided at locations throughout the stormwater drainage system which are susceptible to erosion, including ditch sections subject to high-velocities (greater than 1.5 m/s), sections of super critical flow, ditch outlets, storm sewers outfalls, and culverts inlets and outlets
- If the ditch is in rock, no rip rap is required
- Energy dissipaters shall be used where the flow velocities may reach values high enough to cause severe erosion or hydraulic jumps.

6.3 External Surface Drainage

External surface drainage areas are defined as areas where the catchment consists of undisturbed areas where the environment is mostly in its natural state. Criteria for drainage of the external areas are as follows: 2

- Runoff from undisturbed areas surrounding the mine site shall be collected in perimeter ditches and diverted around and/or through the site perimeter
- To the extent possible, these perimeter ditches shall be designed to discharge at locations that best retain the characteristics of the existing (i.e., pre-development) natural drainage patterns
- Diversion ditches shall be designed to convey the 1 in 100 year flood event 2
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 6-1
- For supercritical flow conditions, the ditches shall be designed to maintain the energy line within the ditch. 2

6.4 Peak Flow Estimation

For flow estimation refer to *NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012* and updated in *VA16-01950 on 13 December 2016.* 2

6.5 Rainfall Intensity

Rainfall intensities must be based on *NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012* and updated in *VA16-01950 on 13 December 2016.* 2

6.6 Sedimentation Ponds / Pollution Control Ponds

The design of the sedimentation ponds shall be based on the Civil Design Criteria Document No. H349000-1000-10-122-0001 (Appendix B) that was used for a previous phase of Mary River Mine with the following exception: 2

- Runoff coefficient to estimate runoff shall be 0.9. 2
- Ponds shall be operated as empty to ensure enough capacity is available to accommodate the design volumes. Failure to empty the ponds will result in overflow occurring and the prescribed TSS will not be achieved. 2
- All sedimentation ponds shall be lined with appropriate impermeable geomembrane material. Geomembrane material shall be exposed (not covered with granular material) except where the material will be anchored. 2
- It is assumed that all runoff captured by the sedimentation ponds are non-acid generating and can be discharged to the environment once the TSS levels are within the acceptable range. 2

6.7 Stockpile Footprint

The following sections will cover runoff that can be expected from the Stockpile No. 1 and No. 2 areas. 2

6.7.1 *Stockpile No.1 Runoff* 2

Runoff from Stockpile No.1 would drain towards the existing sedimentation pond to the North West of the stockpile. The existing pond size will be determined from survey information and evaluated to determine if it meets the required design criteria as stated in Section 6.6.

6.7.2 *Stockpile No.2 Runoff*

The entire stockpile area would be surrounded by adequately sized berms to prevent any water from discharging into the natural environment from the stockpiles. Water shall be tested for the required TSS before pumping into the natural environment. 2

6.8 Culverts, Roadside Ditches and Berms

6.8.1 Drainage ditches and culverts shall be designed for return periods as prescribed in Section 6.2 and Section 0 with peak flows calculated as per Section 6.4. such that the inlet headwater level does not exceed the bottom of the road subbase. Their analysis and design shall consider design flow, culvert size and material, entrance structure layout, outlet structure layout and erosion protection.

6.8.2 Drainage ditch design shall also be subject to the criteria stated in Table 6-1.

Table 6-1: Drainage Ditch and Culvert Design Criteria

Maximum permissible flow velocity in ditch without rip rap (m/s)		1.5
Minimum ditch and culvert slope (%)		0.2
Ditch side slopes (H: V)	Rock	1:4
	Soil	2:1
Minimum culvert diameter (mm)		600
Berm Side Slopes (H:V)		2:1
Berm Top Width (mm)		500
Ditch and Berm Freeboard Requirement of Sub-Critical Flow (mm)		300

6.8.3 Loading over culverts and pipes shall be in accordance with AASHTO HS 20-44, except for areas of special equipment operation, which shall consider actual vehicle loading. The minimum cover for culverts shall be 600 mm, or as required by the differing specific design vehicle.

6.8.4 Fish-bearing culverts shall be minimum 1,000 mm diameter and only one pipe shall be embedded by 10% of the pipe diameter.

6.8.5 All culverts shall be Corrugated Steel Pipe (CSP).

6.8.6 Apply Manning's n values as per the following:

- n = 0.025 for gravel ditches
- n = 0.040 for rip rap ditches
- n = 0.024 for all CSP pipe. 0.

6.9 Drainage Interceptor/Collector Berms

6.9.1 Drainage berms diverting overland flow from the waste rock drainage area to the sedimentation ponds shall detail as per Table 6-1 above and 0.5 m top width.

6.9.2 Rip rap and other energy dissipation measures shall be provided to protect against erosion.

Appendix A: Typical Layer Works

Item	Sub-Base	Base	Surface	Comments
Rail Embankment	Type 12	Type 22 (-50)	Ballast	Refer to rail design for additional details
	>550 mm	150 mm	*per rail detail*	
Construction Laydown Pad	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	
General Operations Areas and Pads for Equipment / Structures (unheated)	Type 12*	Type 8 (-150)	Type 5 (-32)	Pads constructed directly on excavated rock do not require sub-base fill
	-	300 mm	100 mm	
Slab-on-Grade Building on Permafrost	Type 12*	Type 8 (-150)	Type 5 (-32)	Styrofoam insulation installed in the Base fill (500mm below finished grade), total thickness with insulation 650mm.
	-	300 mm	500 mm	
Stacker/Reclaimer Berm	Type 8 (-150)	Type 22 (-50)	Ballast	To be confirmed by Geotechnical based on updated borehole data and final design for S/R equipment
	>1.85m	150 mm	*per S/R rail detail*	
Ore Stockpile Pads (where developed pad required)	Type 12*	-	Iron Ore **	Primary crusher feed area, rail loading stockpile area, fines intermediate pile, and fines stockpile area (existing SL pile)
	-	-	200 mm	
Road - Primary / Secondary	Type 12*	Type 8 (-150)	Type 5 (-32)	
	-	300 mm	100 mm	
Road - Tertiary / Temporary	Type 12*	-	Type 5 (-32)	
	>300 mm	-	100 mm	
HME Operating Roads / Areas	Type 12*	-	-	Sub-base and surface requirements for Mine Haul Road / HME operating areas to be confirmed
	-	-	-	
Heavy Module Transport Road	Type 12	Type 8 (-150)	Type 5 (-32)	Design and requirements to be confirmed based on final module transport equipment and loads
	>600 mm	300 mm	100 mm	
Mine Haul Road	Type 12	Type 8 (-150)	Type 5 (-32)	This pavement design is applicable to the CAT 793
	800 mm	600 mm	200 mm	

Notes:

1. Sub-Grad fill depth as required to achieve final grad. Use Type 8 instead of Type 12 for depth <600mm.

2. Iron ore used to surface stockpile pads may be on-spec or off-spec as supplied by BIM operations.
3. Material Types:
   a. Type 12 – ROQ nominally, <600mm (maximum permitted 1000mm)
   b. Type 8 – Jaw crushed or similar, <150mm
   c. Typed 5 – Crushed Aggregate, <32mm
   d. Type 22 – Rail sub-ballast, <50mm

Appendix B:
Document No. H349000-1000-10-122-0001
Civil Design Criteria

Civil

2013-08-28	1	Approved for Use	A. Mohebkhani	S. Hassan	S. Perry	D. Matthews
2013-03-20	0	Approved for Use	A. Mohebkhani	S. Hassan	S. Perry	D. Matthews
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**

Table of Contents

1. Introduction

- The Mary River project site is located in northern Baffin Island, in Nunavut Territory of the Canadian Arctic. The Project currently consists of activities which entail mining high grade iron ore, at a production rate of 3.5 million tonnes per annum, stockpiling it throughout the year at the Milne Port, and shipping the material during the summer months. Development of this Project includes the infrastructure construction and operational activities associated with the Milne Port and Mine Site areas along with upgrading the 100 km Tote Road connecting the two sites. All associated project infrastructure shall be based on a 5 year design life, with the exception of the laydown areas, for which a 1 year design life shall be considered. 1
- The purpose of this document is to provide the necessary information required for the design of infrastructure at the two project sites (Milne Port and Mine Site). The works covered by this criteria include earthworks, site grading, internal roads, stormwater drainage system and the earthworks for service utilities, to be implemented at the project sites. The design criteria proposed in this document shall be treated as minimum requirements for the intended infrastructure design. Refer to Section 2 of this document for a list of other design criteria and technical design documents from the pertinent disciplines. Where a conflict between the various design criteria occurs, the most stringent shall apply.
- This document is intended to address the key criteria required for the design of site infrastructure.

1.1 Safety

The consideration of personnel safety in all stages of the design, construction and operation is paramount. Prime consideration shall be given to safety and reliability to:

- Maximize health and safety for all personnel.
- Minimize environmental impacts.
- Maximize the security of equipment.

2. Other Project Design Criteria

2.1 This design criteria document shall be read in conjunction with other documents which may already exist or will be developed as the project proceeds. These documents include the following:

- Tote Road Design Criteria (H349000-3100-10-122-0001).
- Structural Design Criteria (H349000-1000-35-122-0001).
- ~~Foundation Design Criteria (H349000-1000-35-122-0002).~~ 1
- Aerodrome Design Criteria (H349000-1000-00-109-0001).
- Layout Design Criteria (H349000-1000-50-122-00030. 1
- Foundation Design Basis (H349000-1000-30-109-0001) – For Non-Process buildings. 1

3. Units and Coordinate System

3.1 The International System of Units (SI units and prefixes) shall be used for all design calculations and on all drawings.

3.2 The grid coordinates shall be based on: projection - Universal Transverse Mercator (UTM) Zone 17 and horizontal datum - NAD 83 Canadian Spatial Reference System (CSRS).

3.3 Vertical datum shall based on the Canadian Geodetic Vertical Datum of 1928 (CGVD28).

4. References

4.1 Codes, Regulations and Standards

4.1.1 Unless specifically stated otherwise, civil design shall be based on the applicable sections of the latest revisions of the following codes, specifications, standards, regulations and other reference documents. In addition, the design must comply with all laws or regulations of federal and Nunavut territorial authorities.

4.2 General

4.2.1 All applicable federal, territorial (Nunavut) and local laws and regulations.

- OHSA Occupational Health and Safety Act
- CSA Canadian Standards Association
- MHSA Mine Health and Safety Act (Nunavut – S.N.W.T. 1994)
- OHSR Occupational Health and Safety Regulations
- NBCC National Building Code of Canada (2010)
- ASTM American Society for Testing and Materials
- ASCE American Society of Civil Engineers
- NFPA National Fire Protection Association
- NRC Natural Resources Canada – Explosives Safety and Security Branch △1

4.3 Roads

- TAC Transportation Association of Canada – Geometric Design Guide for Canadian Roads
- AASHTO American Association of State Highway and Transportation Officials
- USBM Design of Surface Mine Haulage Roads – A Manual (US Department of the Interior, Bureau of Mines)
- MSHA Haul Road Inspection Handbook – MSHA Document Number PH99-I-4
- MTO Ministry of Transportation, Ontario – Ontario Traffic Manual △1

4.4 Stormwater Management

- MOE Ministry of the Environment - Stormwater Management Planning and Design Manual
- MTO Ministry of Transportation, Ontario – Drainage Manual
- CDA Canadian Dam Association – Dam Safety Guidelines 1

4.5 Reference Documents

Reference will be made to/contents have been used from the following documents, articulated during the previous phases of the project, during the development of these criteria:

- H337697-0000-10-122-0001: Stormwater Management and Drainage System Design.
- H337697-6170-10-122-0001: Milne Port Drainage System and Stormwater Management Ponds.
- H337697-6170-10-122-0002: Mine Site Drainage System, Stormwater and Sediment Management.
- H337697-0000-15-124-0004: Geotechnical Data Report – Infrastructure.
- Standard Specification S311213: Quarried Fill Materials.
- Standard Specification S003120: Site Conditions.
- NB 102-181/30-7: Baseline Hydrology Report, Knight Piesold, Jan 04, 2012.
- BIM - Early Revenue Phase Mine Haul Road Design Criteria.
- BIM - Early Revenue Phase Tote Road Design Criteria.
- H349000-3000-00-124-0001: NB102-00181 Bulk Sampling Program – Road Upgrade Design Summary.
- Final Environmental Impact Statement (FEIS), Mary River Project, February 2012.
- Nunavut Impact Review Board (NIRB) Project Certificate (No.:005), Dec 28, 2012.
- H349000-4221-10-220-0001: Number of Runaway Truck Arresting Provisions for the Mine Haul Road, Project Memo. 1
- H349000-2133-10-220-0001: Runoff Coefficient for the Milne Port Ore Stockpile Pad, Project Memo. 1
- H349000-1000-15-122-0001: Geotechnical Design Criteria 1
- H349000-1000-10-220-0001: Stormwater Sedimentation Pond Design Criteria, Project Memo. 1
- E349000-1000-00-124-0005: Design Brief – Milne Inlet Landfarm, November 2012, EBA File E14101174. 1

5. Site Development

Site development refers to construction of civil infrastructure to support construction and operation of facilities. The following sections list the site development activities and establish criteria that shall be adhered to when carrying out site development design works.

5.1 Site Preparation

5.1.1 Construction areas shall be cleared of vegetation, and temporary drainage systems shall be provided prior to construction activities taking place within the proposed areas for the new site facilities.

5.1.2 Topsoil and/or existing roots shall be removed to a minimum depth of 150 mm, if required, from all areas where buildings, roads, yards and services are to be constructed, and shall be stockpiled in designated areas. Disposal options shall include on-site reuse, development of a designated stockpile area for disposal, or removal by truck to off-site areas, as instructed by the Company.

5.1.3 During the summer months, wetlands or areas with standing water shall be drained and the drying of such shall be promoted prior to construction. Watercourses shall be re-routed with the use of cut-off ditches, or re-aligned engineered channels.

5.1.4 Waste material shall be stockpiled in designated areas with the appropriate erosion and sedimentation control measures in place. 1

5.2 Earthworks

5.2.1 Earthworks is defined as the activity of moving soil and/or rock. Earth-moving activities are required in order to obtain the required design elevations of the ground surface. Earthworks includes cut (if required) and fill for roads, buildings and equipment pads, utility berms, foundation excavation, and construction of ditches, diversion channels and berms, dikes, etc. Earthworks shall be carried out in accordance with the following general guidelines: 1

- Existing unsuitable soils shall be removed and replaced with suitable material.
- Fill materials shall be placed and compacted over the proof-rolled subgrade in order to achieve adequate bearing capacities, as required for specific construction activities.
- Rocks/boulders and similar objects adjacent to areas which shall undergo excavation must be removed or secured, if they potentially endanger workers/machinery.
- The following criteria shall be used to determine the suitability of the soil for fill:
  - Satisfactory soil: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and, SM, or a combination of these groups; non ice-rich, free of debris, waste, vegetation and other deleterious matter. 1
  - Unsatisfactory soil: According to ASTM D 2487 Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH and PT; according to AASHTO M145 Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6 and A-7 or a combination of these groups. Also, ice-rich soils or soils containing traces of contamination and/or organic materials. 1
  - Water shall be diverted away from excavations, so it does not saturate the side slopes.

- If pipes are located in the vicinity of the slopes, erosion control measures shall be in place as mitigation for eventual leaks.
- No loads, including excavated material, traffic of vehicles or heavy machinery shall be allowed near the crest of the slopes (at a distance equal to the height of the excavation) if the slope-support solutions did not take such loads into account.
- Dust control measures shall be in place.
- For delineation of the project development boundaries, the minimum setback from freshwater aquatic environments, including fish-bearing streams and water bodies shall be as per NIRB Project Certification No.005. In general, a minimum 5 m set back shall be provided for non fish-bearing water bodies and streams, due to the potential risks of erosion and slope stability.
- Culvert installation in fish-bearing streams shall follow DFO guidelines.

5.2.2 Table 5-1 provides the minimum slope ratios that shall be used in cuts/excavations or fills/embankments. It must be noted that specific studies must be carried out by geotechnical engineers, if these slopes are to be modified with the aim of lowering costs of cut and/or fill.

Table 5-1: Minimum Slope Ratios

Type of Earthworks	Layer	Ratio H:V
Permanent unsupported cuts	Overburden (ice-rich)	2:1
	Overburden (non ice-rich)	1.5:1
	Rock (less than 4m)	1:8
Permanent fills (on natural, firm ground)	Granular fill	1.5:1
	Base and Subbase	1.5:1
	Rock fill	1.5:1

Notes:
1. The maximum heights and ratios shall be determined considering slopes with typical geometry and no surcharge.
2. The above-listed parameters serve as minimum requirements, and shall be updated/modified based on confirmation/update of the site-specific conditions and/or geotechnical recommendations, or as per BIM's directions.
3. Any geometry and load condition not covered by the table above shall be reviewed by the geotechnical engineer.
4. The granular fill is assumed to be in a drained condition.
5. If the total fill height is greater than 2 m, geotechnical stability analysis and benching requirements shall be considered on a case-specific basis.
6. For overburden cut/fill heights of greater than 5 m, 1.5 m wide benching with minimum 2% cross slope shall be provided.
7. The absolute minimum fill slope for granular material is 1.5H:1V. However, the desirable slope is 2H:1V.
8. The absolute minimum fill slope for rock fill material is 1.25H:1V. However, the desirable slope is 1.5H:1V.
9. For the haul road, the fill side slopes shall be 2H:1V, depending on the site conditions and slope stability.
10. Stability assessments of some cut and fill slopes may be required.
11. For rock cut heights greater than 4 m, 1H:4V slope shall be used with 2 m wide benching and minimum 2% cross slope at every 6 m.

5.2.3 In general, cut activities in permafrost shall be avoided/minimized. However, cut may be required to reduce large fills and high embankments that may affect/endanger slope stability. In addition, within areas where the cut materials can be reused as fill, the suitability of performing cuts in the native soil shall be reviewed by BIM and the geotechnical engineer for requirements of soil treatment/improvement, including geogrids and geotextiles, prior to implementation into the final design.

5.3 Backfilling

5.3.1 The gradation of fill material shall be within the Type 5 (32 mm minus) gradation limit for finish grading, within the Type 8 (150 mm minus) and/or suitable earth fill material gradation limit for rough grading, and Type 12 (600 mm minus) and/or suitable earth fill material gradation limit for the rest of the mass backfill. The surface voids of each layer of Type 12 (i.e. Run-of-Quarry material) shall be filled with rock fragments prior to the next layer being placed. 1

5.4 Site Grading

5.4.1 If applicable, finish grade elevations for roads and yards shall be set a minimum of 100 mm below the finish floor elevation of buildings/sheltered areas, with local ramps provided at doorways, as required. 1

5.4.2 Finish grading and yard grading shall be set to slope away from planned structures at a minimum of 0.5% to 2%, and drain to a storm drainage collection system. For very long-run and localized areas, the slope shall be reduced or increased, depending on the existing ground slope and the grading around the buildings and facilities.

5.4.3 Site grading shall produce a useable and easily maintainable ground surface, not subject to flooding or erosion. The rough grades and finish grades shall adhere to the following:

- Final road and site grades shall ensure suitable pedestrian and vehicular access to buildings and facilitate adequate drainage of the site.
- Building floor elevations shall be established such that the ground floor of the buildings will not be subject to flooding in the event that the storm drainage system fails.
- Elevations of buildings/sheltered areas shall be established to permit gravity connections into sanitary sewers if possible, to avoid the need for pumps.

5.5 Infrastructure Facilities, Laydown and Ore Stockpile Areas

5.5.1 Temporary/permanent equipment and construction material laydown areas shall be provided as per the applicable Contract Drawings. The sizes of the footprints shall be optimized to keep disturbed areas to a minimum and still provide enough room for storage of material/equipment and circulation of mobile cranes/vehicles.

5.5.2 The subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) fill shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry (600 mm minus) and/or suitable earth fill material shall be used. The voids of each layer of Type 12 shall be filled with rock fragments prior to placement of the next layer. 1

5.5.3 In general, following attainment of the subgrade, the pavement shall be laid on top, with the following minimum thicknesses/material types for infrastructure facility pads and other areas:

- 300 mm, Type 8 (150 mm minus) subbase.
- 100 mm, Type 5 (32 mm minus) base/wearing surface course. 1

5.5.4 Depending upon the area and specific requirements such as insulation for permafrost protection, the minimum pavement thicknesses and placement of wearing courses may differ from the above-listed.

5.5.5 There shall be no insulation under “fold-away” and “fabric” buildings constructed on non-frost susceptible ground material (typical for Milne Port). 1

5.5.6 Insulation shall be provided under “fold-away” and “fabric” buildings constructed on frost susceptible ground material (typical for Mine Site). 1

5.5.7 Frost susceptible and ice-rich soils shall be excavated to the extent required and backfilled with Type 12 Run-of-Quarry (600 mm minus). Non-frost susceptible soils with no visible ice shall not be excavated. 1

5.6 Landfarm

~~5.6.1~~ ~~Both the Milne Port and Mine Site landfarms shall be designed as per the criteria listed in Section 3.2 of Annex 5 in the FEIS, Attachment 5: Waste Management Plan for Construction Operation, and Closure; Appendix 10D-4.~~ 1

~~5.6.2~~ ~~The overall geometry as well as the liner details shall be as per Figure 3, “Hydrocarbon Impacted Soils Storage and Landfarm Facility – Preliminary Design of Landfarm Facility” contained within Attachment 5.~~ 1

5.6.3 EBA Engineering Consultants Ltd. has already carried out the design for the Milne Port Landfarm. 1

5.6.4 Milne Port and Mine Site Hazardous Waste Containment designs shall be carried out as per environmental requirements. They shall be lined, and shall contain sumps. 1

5.7 Milne Port Design High Tide

5.7.1 The design High Tide levels for the Project shall be as follow: 1

- The Higher High Water Level (HHWL) for large tides at the Milne Port is +2.3 m above Chart Datum (CD) which corresponds to +1.1 m above Mean Sea Level (MSL). 1
- The Highest Astronomical Tide (HAT) at the Milne Port is +2.4m above CD which corresponds to +1.2 m above MSL. 1
- The Lower Low Water Level (LLWL) for large tides at the Milne Port is +0.0 m above CD which corresponds to -1.2 m below MSL. 1

5.7.2 The toe of ramp and earthworks pad leading down to the sea lift from the laydown area, including the designated turnaround area at the beach within the Milne Port shall have a design elevation greater than +1.2 m above MSL. 1

5.7.3 Landing pad elevation at the beach shall be minimum 7’ (2.15 m) above the average between the HHWL and LLWL (i.e. +3.3 m above CD which corresponds to +2.1 m above MSL). 1

5.8 Retaining Walls

5.8.1 Retaining walls and structures shall be designed based on site-specific conditions. Lateral pressure coefficients for design of retaining walls shall be as per the geotechnical recommendation.

5.8.2 Retailing walls shall be avoided to the greatest extent possible. Concrete, gabion walls, crib walls, reinforced earth and/or other systems of retaining structures shall be used, if required.

5.9 Erosion and Sediment Control

5.9.1 Erosion and sediment control measures shall be installed as required, in and around the project sites in order to minimize sediment transport off the site.

5.9.2 Control measures shall be designed to:

- Minimize the size of disturbed areas.
- Remove sediments from on-site runoffs prior to the runoff leaving the sites.
- Prevent sediments from off-site runoffs flowing across disturbed areas.
- Reduce runoff velocity flowing across the site.
- Meet local requirements for erosion and sediment control plans as defined in the FEIS.

5.9.3 A minimum set back of 30 m from fish-bearing streams and lakes or water bodies shall be provided. Any exception to this shall be consulted with and approved by the Project's environmental team. 1

5.10 Construction and Permanent Fencing

5.10.1 Chain link fence, where required, shall be galvanized, with a minimum height of 1.8 m.

5.10.2 Two strands of barbed wire shall be bracketed off the top of the fence for safety reasons, where required by the Company.

5.10.3 Fencing within the sites shall be provided as required and as directed by the Company.

5.11 Explosives Magazine Pads and Earth Barricades 1

5.11.1 Explosives magazine pads shall be designed as per the criteria in Section 5.5 of this document. 1

5.11.2 Geometry of the Explosives Magazine Earth Barricades shall be designed in accordance with the Quantity-Distance Principles Manual from the Natural Resources Canada, Explosives Safety and Security Branch. 1

6. Road Design

6.1 General

6.1.1 The access roads at the two project sites may be temporary or permanent. An access road is defined as temporary if it will be used only during the construction period, including site predevelopment or site capturing. If an access road will be used during the operational period as well, it is defined as permanent. A 100 km roadway provides access from the Mine Site to the Milne Port (Tote Road), the design criteria for which is included in a separate document. In addition, there is a mine haul road along with internal site roads at the Mine Site, and internal site roads only within the Milne Port, in order to accomodate the mining operations.

6.1.2 The design and construction of mine haul roads, access and internal site roads at the project sites shall provide a safe environment for construction, operations and maintenance personnel, and shall facilitate the mining operations, ore transport and port operations in an efficient manner. In addition, the design shall comply with the relevant standards, guidelines, acts, approvals, permits, and other contractual environmental requirements of Baffinland as defined in Section 2 of this document.

6.2 Road Category

6.2.1 For the purposes of this design criteria, the roads are classified in three categories:

- **Mine Haul Roads -** The purpose of this type of road is for the mining operation at the mine site - hauling of ore from the open pit to the crusher pad and for maintenance purposes, from the crusher pad to the maintenance building. The mine haul road shall be segregated from the other project roads for safety considerations, and shall comply with the applicable Nunavut MHSA.
- **Permanent Access and Internal Site Roads –** These roads provide two way access to and link the various facilities/areas within each site, where B-Trains will travel in both directions.
- **Facility Service Roads –** These roads provide two way access to various facilities/areas within each site, where light vehicles will travel in both directions.
- **Tote Road –** 100 km road providing access from the Mine Site to the Milne Port.

6.3 Design Vehicle

6.3.1 The following design vehicles shall be utilized for the design of the associated project roadways:

- CAT 777G Haul Truck for the Mine Haul Road.
- B-Train (12 axle) for Permanent Access Roads and Internal Plant Roads (150 metric tonnes payload) that need to be utilized by the Tote Road trucks. 1
- CAT 740B for Waste Rock Drainage Pond/Berm. 1
- Other types of design vehicles have been used for the remainder of the Project roadways and a fire truck has been considered as the minimum design vehicle for fire access routes. 1

6.4 Geometric Design Criteria

6.4.1 All roads shall be designed as gravel roads and shall accommodate the design vehicle specified in Section 6.3 of this document. The roads' geometric design parameters are specified below.

Table 6-1: Geometric Design Criteria

Road Type	Permanent Internal Plant Road	Infrastructure Facility Service Road	Haul Road – Open Pit to Crusher Pad	Waste Rock Dump Road	Haul Road Switchback	Truck Escape Ramps
Number of Lanes	2	2	2	1	2	1
Design Speed (km/h)	30	30	50	30	30	90
Posted Speed (km/h)	20	20	40	20	20	-
Total Road Width (m)	9.2	8 or 6	20	13	20	9
Minimum Horizontal Curve C/L Radius (m)	35	35	100	50	35	280
Minimum Intersection Inner Radius (m)	15	15	30	30	30	-
Minimum Cross Slope (%)	2	2	3	3	3	3
Maximum Grade (%)	10	10	10	10	8	20
Minimum K Value (Vertical Sag Curve)	8	8	12	8	8	3
Minimum K Value (Vertical Crest Curve)	4	4	16	4	4	-
Maximum Super-elevation (%)	4	4	4	4	4	6
Minimum Vertical Clearance	7	5	9	9	9	-

Notes:
1. The road design parameters are based on the desirable design speeds. Specific parameters such as the minimum turn radii may be modified for some areas locally on a case-by-case basis, via adjustment of the design speeds.
2. The Haul Road width shall be based on the Nunavut Mine Health and Safety Act which requires a minimum travel width three times the width of the widest haulage vehicle for dual lane traffic and two times the width of the widest haulage vehicle for single lane traffic.
3. Shoulder barriers (safety berms or guardrails) for the Haul Road shall be based on the Nunavut Mine Health and Safety Act which requires shoulder barriers of at least ¾ the height of the largest tire of any vehicle using the road and shall be provided along the edge of the haul road wherever a drop-off greater than 3.0m exists. For CAT 777G, the shoulder barrier (safety berm or guardrail) height shall be 2.0 m based on standard tire 27.00 R49 (E4).
4. Total road width includes shoulder width and snow allowance but doesn't include the safety berm width for the haul road.
5. ~~For the single lane Haul Road from the crusher pad to the maintenance building, pullouts shall be provided at every 100m.~~
6. Widening shall be provided in roadway curves as necessary.
7. Need for geotextiles or geogrids shall be considered on a case-specific basis.
8. For the Tote Road design criteria, refer to H349000-3100-10-122-0001.
9. Provide safety stations, emergency ramps or escape lanes in accordance with the local and mine safety requirements. Hatch will only provide two escape ramps at the most critical locations as per BIM's instruction. Escape ramp design shall be carried out as per the USBM manual.
10. For cut/fill heights of greater than 5 m, provide 1.5 m wide benching with minimum 2% cross slope at every 5 m.
11. The ramp leading down to the sea lift from the laydown area at the Milne Port shall have a maximum grade of 8%.
12. The maximum grade for ramps to the buildings is 6%.
13. Fill toe key shall be provided in areas where the existing ground is steeper than 3H:1V away from the road.
14. Design speeds may be reduced locally if needed.

6.4.2 The following general rules shall apply to the geometric design of the project roads:

- Roadway grades shall not exceed the maximum grades specified in Table 6-1, except for short ramps which shall be considered on a case-specific basis.
- Signage shall be provided for speed and caution at steep horizontal and/or vertical curves, and where the design criteria can't be met.
- Light poles, traffic signs and shoulder barriers (safety berms or guardrails), shall be placed at the outer edges of the roads, as required.

6.5 Pavement Design

6.5.1 The design of pavement structures requires information such as the expected pavement service life, design vehicle traffic volume, loads, and geotechnical information such as soil type and California Bearing Ratio (CBR).

6.6 Pavement Thickness

6.6.1 For the project internal site roads, the subgrades shall be prepared via cut/fill activities prior to pavement installation/placement. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) material shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry and/or suitable earth fill material shall be used. The voids of each layer of Type 12 material shall be filled with rock fragments prior to placement of the next layer. 1

6.6.2 The following minimum internal site road pavement thicknesses shall be used throughout the project:

- 300 mm, Type 8 (150 mm minus) subbase.
- 100 mm, Type 5 (32 mm minus) base/surface course for low speed light vehicle traffic roads and low speed B-Train traffic roads. 1
- 200 mm, Type 5 (32 mm minus) base/surface course for medium to high speed B-Train traffic roads. 1

6.6.3 The following minimum haul road pavement thicknesses shall be used throughout the project:

- 300 mm, Type 8 (150 mm minus) subbase.
- 300 mm, Type 8 (150 mm minus) base.
- 200 mm, Type 5 (32 mm minus) base/surface course. 1
- ~~900 mm, Type 12 Run-of-Mine structural subgrade (varies depending on the actual site conditions).~~ 1

6.6.4 The ramp and earthworks pad leading down to the sea lift from the laydown area, including the designated turnaround area at the beach within the Milne Port shall contain the following pavement thickness:

- 300 mm, Type 8 (150 mm minus) subbase.
- 200 mm, Type 5 (32 mm minus) base/surface course. 1
- ~~100 mm Type 3 (19 mm minus) wearing course.~~ 1

6.6.5 Pavement Service Life

6.6.5.1 The service life of the site pavements, prior to any structural rehabilitation work being required, shall be 5 years, unless noted otherwise for specific items.

6.6.6 Design Vehicles, Traffic Volume and Load

6.6.6.1 Vehicle types have been selected for the project roads based on the expected usage and transportation requirements of the area (Section 6.3).

6.6.6.2 All pavement, slabs, bridges, trenches, trench covers and underground installations accessible to trucks shall be designed to withstand the load associated with an HS 20-44 wheel load or its equivalent, as defined by the American Association of State Highway and Transportation Officials (AASHTO) under Standard Specification for highway bridges. However, within areas of special equipment operation, this shall be considered as per the actual vehicle loading.

6.7 Parking

6.7.1 Parking areas shall be designed to accommodate their intended use. In general, all parking areas shall be surfaced with granular materials.

6.7.2 Vehicle parking area design shall adhere to the following:

- The area shall be graded to direct stormwater away from the parking. 1
- Alignment and gradients shall be coordinated with the grading plans to control drainage.
- Walking distance from parking areas shall be kept to a minimum.
- Barrier-free parking spaces as well as walkways shall be provided according to the applicable regulations.
- Designated turnaround areas shall be provided at dead ends.
- Parking lot design criteria shall be as shown in Table 6-2.

Table 6-2: Parking Lot Design Criteria

Topic	Criteria
Gradient	Maximum 5% Minimum 0.5% Optimum 2%
Cross Slope	Maximum 5% Minimum 2% Optimum 3%
Pavement Structure	300 mm Type 8 (150 mm minus) subbase 1 100 mm Type 5 (32 mm minus) base/wearing surface course 1 ~~50mm wearing course~~
Parking Stall Dimensions	Driving Lane • Width 7.5 m Standard

Topic	Criteria
	• Depth 6 m • Width 2.75 m Barrier-free • Depth 6 m • Width 3.5 m • Access Aisle Width 1.5 m

6.8 Signage

6.8.1 Traffic control signs and road edge markers shall be provided as required to ensure safe movement in and about the site.

6.8.2 Direction and information signs for both vehicle and pedestrian traffic shall be provided for parking areas, restricted areas, shipping and receiving.

6.8.3 Primary identification signs shall be free-standing and sited according to the applicable standards as listed in Section 4.3.

6.8.4 Other signs shall be free-standing, fence-mounted or wall-mounted.

6.8.5 Security signs shall be provided at the sites and along the site property boundaries.

6.8.6 Signs for the site access roads shall be compliant with the local traffic regulations.

6.8.7 Signs shall be lighted, if deemed necessary.

6.8.8 All signs and pavement markings (if applicable) shall be well maintained during the construction and operational periods.

6.9 Bollards

6.9.1 Bollards, if required, shall be provided at building entrances and around hazardous areas such as tanks and transformers. Bollards shall be 1.2 m high, 150 mm diameter schedule 40 CS pipes. 1

6.9.2 Bollards shall be filled with concrete.

6.9.3 Bollards shall be painted and coated such that they provide clear reflection off of vehicle headlights.

6.10 Shoulder Barriers (Safety Berms/Guardrails)

6.10.1 Shoulder barriers (earth safety berms or guardrails) shall be provided where a 3.0 m or more drop-off exists at the edge of roads. 1

~~6.10.2~~ ~~Shoulder barriers shall be installed where the horizontal distance from the edge of a travelled lane to an obstruction is less than 1.0 m~~ 1

6.10.3 Earth/safety berms for the Mine Haul Road from the open pit to the crusher pad and from the crusher pad to the maintenance building shall have heights of 2.0 m, and side slopes of 1H:1V. 1

6.10.4 Safety berms for the internal roads shall have heights of 1.0 m and side slopes of 1H:1V. 1

6.10.5 Discontinuous openings shall be provided in berms at maximum 25 m spacing for drainage and snow clearance, with openings smaller than half the blade width of vehicles constructing or maintaining the berms. 1

6.10.6 Runaway vehicle collision berms or escape lanes shall be provided in accordance with industry requirements as described in the Nunavut MHSA.

6.11 Utility Berms

6.11.1 Utility Berms shall travel along the project roadways to the greatest extent possible, shall be of trapezoidal cross-sections, shall be minimum 0.6 m high from the road edge or the existing ground, and shall have maximum fill side slopes of 1.5H:1V, as validated by the geotechnical engineer. They shall be constructed with the use of 300 mm of granular Type 8 (150 mm minus) and 100 mm of granular Type 5 (32 mm minus) material. If the height of the subgrade fill is less than 600 mm, Type 8 (150 mm minus) fill shall be used. If the height of the subgrade fill is greater than 600 mm, Type 12 Run-of-Quarry and/or suitable earth fill material shall be used. The voids of each layer of Type 12 material shall be filled prior to placement of the next layer. The top width of utility berms will depend on the pipe and cable duct sizes. Utility berms shall cross roadway intersections through utility sleeves. After crossing the intersections, they shall resume the alignments within the utility berms. 1

7. Stormwater Management System

7.1 Internal Surface Drainage

7.1.1 The general criteria for the site internal stormwater management system are described below.

- All interior site grading and roads shall be designed to provide continuous overland flow without erosion to a drainage ditch system.
- All drainage ditches should be of trapezoidal cross sections, where possible. 1
- Ditches shall be designed to convey a 1 in 25 year flood event.
- Provision must be made to ensure that there is a safe flow path for events up to the 1 in 100 year event, such that the runoff will not flood key mining areas, cause significant erosion, pick up excessive contaminants or cause other significant problems.
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 7-2.
- Minimum set back distance of structures from top of drainage ditch slopes shall be 3 m.
- Roof and yard drainage shall be collected in open ditches.

- Rip rap shall be provided at locations throughout the storm drainage system which are susceptible to erosion, including ditch sections subject to high-velocities (greater than 1.5 m/s), sections of super critical flow, ditch outlets, storm sewers outfalls, and culverts inlets and outlets.
- If the ditch is in rock, no rip rap is required.
- Energy dissipaters shall be used where the flow velocities may reach values high enough to cause severe erosion or hydraulic jumps.

7.2 External Surface Drainage

Criteria for drainage of the external area are as follow:

- Runoff from undisturbed areas surrounding the mine site shall be collected in perimeter ditches and diverted around and/or through the site perimeter.
- To the extent possible, these perimeter ditches shall be designed to discharge at locations that best retain the characteristics of the existing (i.e. pre-development) natural drainage patterns.
- Diversion ditches shall be designed to convey the 1 in 100 year flood event.
- Ditch freeboard, minimum depth, minimum width, side slope, longitudinal slope and maximum permissible velocities shall be as per Table 7-2.

7.2.1 Peak Flow Estimation

- **For catchment areas greater than 0.5 km^2:** 1

Runoff peak flow estimation shall be based on the following equations developed by Knight Piésold Consulting:

$Q_2 = 1.1\ A^{0.79}$

$Q_5 = 1.7\ A^{0.77}$

$Q_{10} = 2.0\ A^{0.76}$

$Q_{25} = 2.6\ A^{0.75}$

$Q_{100} = 3.5\ A^{0.73}$

$Q_{200} = 3.9\ A^{0.73}$

Where:

Q=peak flow instantaneous flow in m^3/s

A = drainage area in km^2 (0.5 km^2 $\leq$ A $\leq$ 1000 km^2)

- **For catchment areas less than 0.5 km^2:** 1

The Rational Method shall be used for peak flow estimation, as follows:

Q = 0.28 CIA

Where:

Q = peak instantaneous flow in m^3/s

A = drainage area in km^2

C = runoff coefficient = 0.90 (for all drainage areas except the Milne Port Ore Stockpile footprint, for which C = 0.0, as per BIM's instructions). 1

I = rainfall intensity corresponding to the time of concentration (mm/hr), estimated using Table 7-1 below.

- Time of Concentration shall be computed with the modified Kirpich equation:

$T_c = 0.06628 (L^{0.77}/S^{0.385})$

Where:

T_c = time of concentration (hours)

L = main channel length (km)

S = main channel slope (m/m)

Minimum T_c = 10 min

7.3 Rainfall Intensity

7.3.1 Table 7-1 displays the Intensity-Duration-Frequency data which shall be used for peak flow runoff approximation, developed by Knight Piesold consulting:

Table 7-1: Rainfall Intensity (mm/h)

Duration	2 yrs	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	50 yrs	100 yrs	200 yrs
5 min	9.5	12.0	14.0	15.1	15.9	16.5	18.3	20.1	22.0
10 min	7.2	9.0	10.5	11.3	11.9	12.4	13.7	15.1	16.5
15 min	6.0	7.5	8.7	9.4	9.9	10.3	11.4	12.6	13.7
30 min	5.0	6.3	7.3	7.9	8.3	8.6	9.5	10.5	11.4
1 hr	4.0	5.2	6.1	6.6	7.0	7.3	8.1	9.0	9.9
2 hr	3.0	3.9	4.6	5.0	5.2	5.5	6.1	6.8	7.4
6 hr	2.0	2.7	3.3	3.6	3.9	4.0	4.6	5.1	5.7
12 hr	1.3	1.8	2.2	2.4	2.6	2.7	3.1	3.4	3.8
24 hr	1.0	1.4	1.7	1.9	2.0	2.1	2.4	2.7	3.0

7.3.2 Figure 7-1 displays the 200 year design storm distribution:

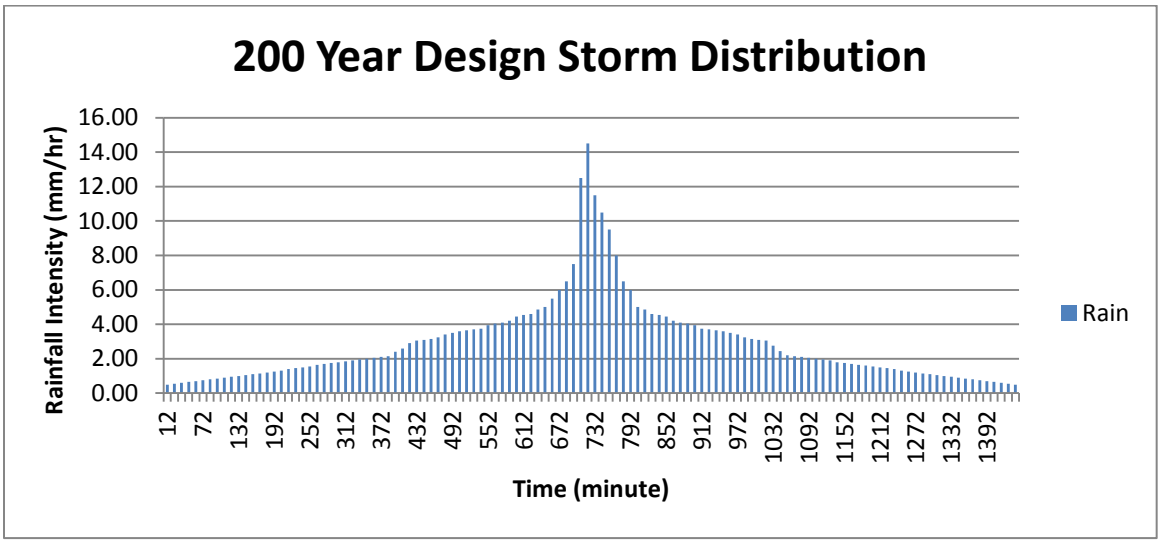

Figure 7-1: 200 Year Storm Distribution

7.3.3 The 200 year 24-hour balanced storm depth is 71 mm.

7.4 Sedimentation Ponds

7.4.1 Sedimentation ponds shall only be provided at the Milne Port Ore Stockpile area, Mine Site Crushing and Screening area and the Mine Site Waste Rock Drainage area. For all other areas, including infrastructure facility pads, laydown areas and roads, the water is considered to be clean and no sedimentation ponds shall be provided. 1

7.4.2 The general design criteria for the project sedimentation ponds are as follow:

- Ponds shall be sized based on 1 in 10 year, 24 hour design storm volumes. 1
- Runoff coefficient to estimate runoff shall be 0.9 for all drainage areas except the Milne Port Ore Stockpile footprint, for which the runoff coefficient shall be 0.0 as per BIM's instructions. 1
- Sedimentation shall be for Total Suspended Solids (TSS) ≤ 30 mg/l for a single sample and TSS ≤ 15 mg/l for the monthly average.
- Sedimentation ponds shall contain emergency overflow weirs of sufficient capacity to safely convey a 1 in 200 year return period storm event or the Probable Maximum Flood (PMF), maximum wind-induced waves, or unexpected operational difficulties. 1
- Emergency overflow weirs shall be designed to handle applicable design storms, such that the pond high water level does not increase past the set freeboard elevation. 1
- Emergency overflow weirs shall be designed as broad-crested weirs with rip rap. 1
- Gabion mattresses shall be provided at the downstream locations of emergency overflow weirs as energy dissipation measures to protect against erosion. 1
- The following broad-crested weir capacity flow equation shall be used for sizing the Project emergency overflow weirs:

$Q = CLH^{3/2}$ Where: 1

Q = Peak instantaneous flow (m^3/s)

C = Weir discharge coefficient

L = Width of weir (m)

H = Depth of flow (m), measured 2.5H upstream of the weir discharge point

- Deep sedimentation ponds shall be avoided as much as possible. Sedimentation pond depths shall be kept to less than 5 m, to avoid non-compliant TSS removal/efficiency and other safety concerns. 1
- Berm/embankment side slopes for the ponds shall be 3H:1V. 1
- Mine Site Ore Crushing and Screening and Waste Rock Drainage sedimentation ponds shall be lined and the discharge from the ponds shall be controlled. 1
- Milne Port Ore Stockpile pond(s) can be lined/unlined and depending on its impact to the environment and permafrost as well as geotechnical stability, the discharge from the pond(s) can be controlled/uncontrolled. 1
- Ponds with storage volumes greater than 30,000 m3 and heights exceeding 2.5 m shall be classified as dams and shall meet the dam safety requirements as per the Canadian Dam Association's Dam Safety Guidelines (CDA 2007). 1

7.5 Off-Spec and Treated Effluent Ponds

7.5.1 The off-spec effluent pond at the Milne Port shall be sized based on the storage requirements specified in the event that the sewage treatment plant does not meet effluent discharge criteria and/or the system halts operations due to technical difficulties. 1

7.5.2 The treated effluent pond at the Mine Site shall be sized based on the requirements for 10 months storage of treated sewage generated at the Mine Site during the period in which the body of water receiving the discharge (i.e. Mary River) is frozen. 1

7.5.3 The ponds shall have minimum freeboards of 0.3 m. 1

7.5.4 The ponds shall have side slopes of not steeper than 3H:1V.

7.5.5 The effluent ponds shall be lined.

7.6 Culverts and Roadside Ditches

7.6.1 Drainage ditches and culverts for all internal/access roadways and vehicle access points shall be designed to convey the runoff peak flow from a 1 in 25 year return period storm, such that the inlet headwater level does not exceed the bottom of the road subbase. Their analysis and design shall consider design flow, culvert size and material, entrance structure layout, outlet structure layout and erosion protection.

7.6.2 Drainage ditch design shall also be subject to the criteria stated in Table 7-2.

Table 7-2: Drainage Ditch and Culvert Design Criteria

Maximum permissible flow velocity in ditch without rip rap (m/s)		1.5
Minimum ditch and culvert slope (%)		0.3
Minimum freeboard for ditch (mm)		300
Minimum ditch depth for internal roads and other areas (mm)		300
Minimum ditch bottom width for internal roads and other areas (mm)		500
Minimum rock ditch depth for haul road (mm)		500
Minimum ditch bottom width for haul road (mm)		1000
Ditch side slopes (H:V)	Rock	1:4
	Soil	2:1
Minimum culvert diameter (mm)		500

~~7.6.3~~ ~~All culverts shall have 50 mm diameter steam pipes welded at the top inner sides for prevention of water from freezing.~~

7.6.4 Loading over culverts and pipes shall be in accordance with AASHTO HS 20-44, except for areas of special equipment operation, which shall consider actual vehicle loading. The minimum cover for culverts shall be 600 mm, or as required by the differing specific design vehicle.

7.6.5 Fish-bearing culverts shall be minimum 1,000 mm diameter and only one pipe shall be embedded by 10% of the pipe diameter.

7.6.6 All culverts shall be Corrugated Steel Pipe (CSP).

7.6.7 Apply Manning's n values as per the following:

- n = 0.025 for gravel ditches
- n = 0.040 for rip rap ditches
- n = 0.024 for all CSP pipe.

7.7 Drainage Interceptor/Collector Berms

7.7.1 Drainage berms diverting overland flow from the waste rock drainage area to the sedimentation ponds shall be a minimum of 1.0 m high with 1.5H:1V side slopes and 0.5 m top width.

7.7.2 Rip rap and other energy dissipation measures shall be provided to protect against erosion.