August 2, 2011

Project No. 09-1427-0006/5000
AECOM Doc. No. 317-Baker_Creek-11-LET-0004-Rev1_20110802
GAL Doc. No. 086

Robert Girvan
Public Works and Government Services Canada
PO Box 518
Yellowknife, NT
X1A 2N4

PRELIMINARY PROJECT SCOPE FOR JO-JO LAKE – REACH 6 BAKER CREEK POND GIANT MINE, YELLOWKNIFE

Dear Mr. Girvan,

1.0 INTRODUCTION

Baker Creek currently flows through the Giant Mine site to Yellowknife Bay from Little Martin Lake to the west of the mine site. On May 13, 2011, Baker Creek above the falls on upper Baker Creek was observed to have started to flow outside of the natural channel towards Baker Pond in the area of Jo-Jo Lake. The flows were conveyed towards Baker Pond along an old access road to Trapper Creek at the north end of Baker Pond. The flow did not follow the Trapper Creek channel to the main body of Baker Pond, but continued across the tailings that are in the upper portion of Baker Pond (Jo-Jo Lake area). The tailings were eroded by the flows and continued down Baker Creek to Yellowknife Bay. Further on May 30, high winds caused waves to re-mobilize some of the tailings and the creek currents carried the sediments downstream. The tailings in upper portion of Baker Pond are generally restricted to the original footprint of Jo-Jo Lake, which connects to Jo Lake (main portion of Baker Pond). Jo-Jo Lake is some 100 m by 150 m in plan area with an approximate area of some 14,000 m^2.

Upper Baker Creek was diverted back to the original creek channel by May 18 and further erosion of the tailings was minimized. It is now proposed to contain or remediate the tailings in the Jo-Jo Lake area of Baker Pond to minimize the potential for erosion of the tailings in the future. The plan to remediate the area in the next eight (8) months would be set out to be consistent with the plans presented in the Developer's Assessment Report.

Golder Associates Ltd.
500 - 4260 Still Creek Drive, Burnaby, British Columbia, Canada V5C 6C6
Tel: +1 (604) 296 4200 Fax: +1 (604) 298 5253 www.golder.com

Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

2.0 PROPOSED CLOSURE OPTIONS

Baker Pond is also referred to as Reach 6 in the Baker Creek system and contains tailings (Jo-Jo Lake portion) and submerged tailings and contaminated sediments at the north edge of Baker Pond (Jo Lake area). Recent studies have also shown that the pond is now a source of nutrients for Reach 4 and is important in attenuating high storm or flood flows to the lower reaches of Baker Creek. Thus, the plan to remediate the tailings in the pond and in the Jo-Jo Lake portion of the pond must consider this benefit and make all reasonable efforts to minimize any disturbance to the pond and the present conditions. There are 2 options which are recommended to remediate the tailings and the impacted pond area and these are:

a) Isolate the tailings and contaminated sediments in the north portion of Baker Pond (Jo-Jo Lake and north portion of Jo Lake) by capping the area and developing a wetland at the edge of the capped area. Trapper Creek on the west side of the capped area would be placed in an engineered channel to convey the creek flow in a controlled manner to the main portion of Baker Pond. The channel would also collect any over flow from upper Baker Creek that may flow down the slope above Trapper Creek; or

b) Remove the tailings in the Jo-Jo Lake portion of Baker Pond and in the north portion of the main Baker Pond area. Trapper Creek on the west side of the area would still be placed in an engineered channel to convey all flow to the main portion of Baker Pond. The tailings which would be exposed along the mine access road between the B1 pit area and the Northwest Tailings Facility would be protected by a 1.0 m thick layer of rip rap. This would prevent the tailings from being re-mobilized. The proposed dredging would remove the tailings to a depth of 1.5 m below the normal operating water level in Baker Pond and a layer of gravel 30 to 40 cm would be placed to prevent re-suspension of tailings due to ice or wind. The area could then be redeveloped as a wetland as part of final closure plans.

3.0 COMMENTS

The proposed remediation is to be completed by April 30, 2012 and will be managed to minimize disturbance to the current functions of the Baker Pond with regard to the overall Baker Creek water management system. This includes the important function for Reach 4 and the desire to minimize the potential for movement of sediments and tailings in the pond down to the lower reaches of the creek and Yellowknife Bay. The review of the two options notes that Option 2 will result in the potential to mobilize sediments downstream, even with best practices to manage and control the movement of sediment / tailings downstream. The capping option would result in less sediment being mobilized and reduce significantly the potential for movement of sediment or tailings downstream. Thus, we recommend that Option 1 be considered further as the preferred option to mitigate the tailings in Jo-Jo Lake.

4.0 RECOMMENDED CLOSURE OPTION

Option 1, the recommended option would involve placing a 0.5 to 0.6 m thick layer of gravel / coarse rock across Jo-Jo Lake tailings. The gravel would then be covered with a 0.3 to 0.5 m thick layer of fine sand with organics to allow development of a vegetative cover in 2012. The cap would be underlain by a geotextile with a high strength to minimize disturbance of the tailings as the cap was placed in a late summer / early fall time frame. The schedule is proposed to work in a period of low rainfall and before winter so that the material would be placed and spread easily with out causing additional disturbance to the tailings. The last of the work at the edge of the cover pad in the cooler weather would improve the accessibility of equipment to the north limit of Baker Pond (frozen ground would be easier to work on as south edge of pad is placed). The geotextile will

minimize the loss of the gravel cap material into the tailings. The extent of the cap would be some 5 m into the main portion of upper Baker Pond to a water depth of ~1.0 m of water at low water level. A zone of coarse 15 cm minus coarse gravel with no fine or small riprap would be placed along the south limit to protect the new cap from wave action in Baker Pond. A section through the cap at the south limit of the cap is shown on Figure 2. The coarse gravel would be from an off site source (local quarries used for construction projects in the City of Yellowknife) which would be checked to confirm the material is acceptable for instream work. The rip rap zone would extend across the south edge of the tailings area to be covered and at present, it is anticipated that some 1,800 m^2 (18 m by 100) of Baker Pond would be covered with rip rap and the zone on the west edge or wetland on the west edge of the cap area would be some 18 m by 20 m (~400 m^2). The southern extent of the cap would be inspected with DFO in early August to confirm the actual limit based on tailings in the area. A revised plan for the cap area would then be submitted before August 19 or at least 10 days before construction starts. An area of wetland at the southwest corner of the cap shown on the attached Figure 1 indicates that the cap may cover an area some 50 m by 50 m which may not be covered in tailings (southwest corner of cap). It is proposed to inspect this area before construction starts and if the tailings did not reach the area, the cap would stop short and not cover the wetland area.

The cap would start at the mine access road and move across this area to the west edge of the area. The west edge of the cap would define the east side or edge of the engineered channel which would be developed on the west side of the cap for Trapper Creek. The engineered channel would be placed against the west shoreline of Jo-Jo Lake. It would be practical to cover the tailings between the mine access road and the highway to further minimize the potential for tailings to be re-mobilized in the future. The small area would be developed to drain to a culvert under the mine access road and the drainage swale would also pick up any run-off flows from the new 450 mm culvert under Highway 4. The area between the two roads would add an area of 40 m by 80 m and require some 2,000 m^3 of gravel. The sandy cover layer could be delayed until final closure. The design for the preferred option would cover all of the exposed tailings in Jo-Jo Lake or an area of some 14,000 m^2 and require some 7,000 m^3 of coarse gravel and some 5,500 to 6,000 m^3 of the sandy cover layer.

The new channel for Trapper Creek would have a base width of 2 to 3 m, an invert at least 1 m below the normal water level in Baker Pond and side slopes of 3 horizontal to 1 vertical. The channel bottom would be lined with a 30 cm layer of 15 cm clean (coarse) gravel with some sand (less than 20 %). The channel would start as shown on the attached Figure 1 and extend along the west side of the cap and outlet into Baker Pond, just north of the current outlet point of Baker Creek. The maximum size of the base material would be determined based on the estimated design storm flows anticipated down Trapper Creek (from Trapper Lake). The channel will require an excavation of some 2,000 to 3,000 m^3 of material on the east side of Jo-Jo Lake, some 2,000 m^2 of geotextile to line the channel and some 1,000 m^3 of gravel. The material excavated from the new engineered channel would be placed in the Northwest TSF near Dam 21A or 21B.

The 50 to 60 m initial section of the channel from Vee Lake Rd is through a low wet area. The creek channel in this zone would be excavated in the winter to connect the outlet point of the creek to Jo-Jo Lake (the culvert) and the start of the engineered channel.

The final design effort will require survey data along the west side of the Jo-Jo Lake area to define the best location for the engineered channel. A survey would also be needed to establish the south edge of the tailings in the main portion of Baker Pond and to confirm a south limit for the cap. The survey will also be used to confirm quantities for the construction of the cap for construction management. The construction drawings will be developed for specific work plans to address procedures, contingency plans, and would address environmental monitoring tasks needed to manage the work. The construction specifications for the Earthworks materials (aggregate materials, geotextiles and geomembranes), Re-vegetation and Culverts / Ditch liners are attached in Appendix I.

Run-off and surface water will be managed on the tailings cap for positive drainage (to prevent ponding) and at low slopes (to reduce erosion potential). The capped area of approximately 1.4 ha will be graded to drain from the centre to the sides of the cap, keeping drainage areas small to again reduce erosion potential. Sediment control measures will be provided around the perimeter, including silt fence on land areas and floating silt curtain in lake areas. Additional information on water management and erosion and sediment control is provided in the attached Erosion and Sediment Control Plan in Appendix II. This plan builds on the current site sediment manage plan. It is anticipated the plan would be updated as work progresses and would be used as guidance by the successful contractor. A monitoring plan for the construction period and the next 2 years would be submitted by August 19, 2011.

The current plans anticipate the engineered channel would be excavated in September and the lining placed as the channel is developed. The main cap area would be developed in late September or early October, once the channel is opened. The cap would extend as far to the west as practical in early October, but may require the final sections at the edge or at the west limit to be developed in November as the ground 'firms up' (freezes) and allows access. The south limit of the cap and the coarse gravel wave protection material would be placed in November. The small drainage swale on the east of the cap would be lined with the same material as proposed for the main channel. An 'As-build' report documenting the work and the performance of the cap during the 2012 freshet would be submitted 60 days after completion of the work (April 30, 2012) or by July 1, 2012.

We trust this provides this provides the information you require and if you have any questions, please contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

John Hull, P.Eng. (BC, NWT/NU, YK)
Principal

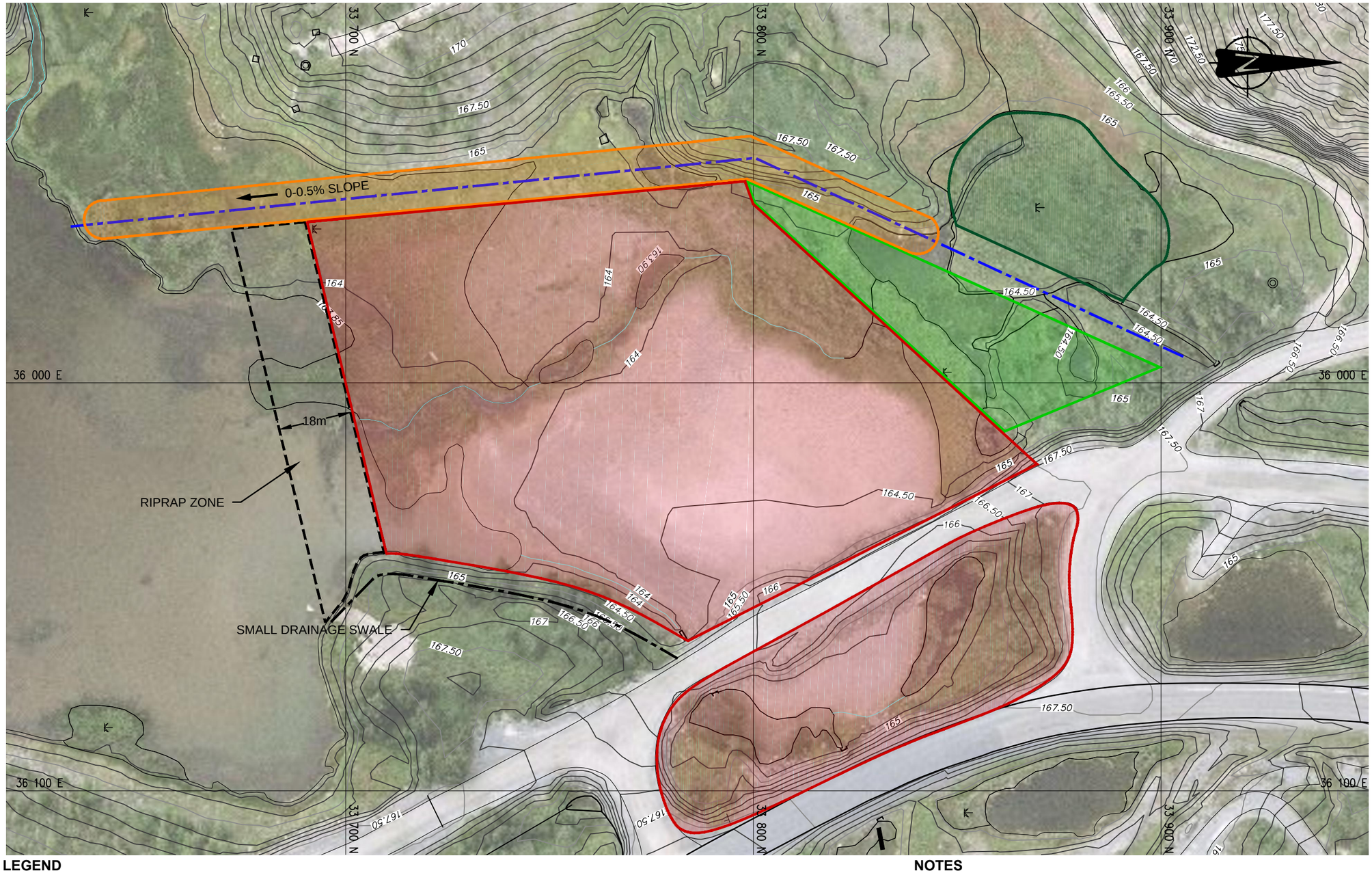
ORIGINAL SIGNED

Nathan Schmidt, Ph.D., P.Eng.
Principal, Senior Water Resources Engineer

CC: Lisa Dyer and David Abernethy, PWGSC

Attachments: Figures 1 and 2
Appendix I: Specifications
Appendix II: Erosion and Sediment Control Plan for Capping at Jo-Jo Lake
Technical Memorandum, August 2, 2011

\\bur1-s-filesrv2\final\2009\1427\09-1427-0006\3. correspondence\2 issued documents\word\phase 2\doc 086 let 0725_11\317-baker_creek-11-let-0004-rev1_20110802.doc



LEGEND

- LOW AREA OR WET LAND
- LOW AREA BESIDE CREEK
- ENGINEERED CHANNEL
- AREA OF TAILINGS TO BE COVERED
- APPROXIMATE CREEK AND CHANNEL CENTERLINE
- APPROXIMATE RIPRAP BOUNDARY
- SMALL DRAINAGE SWALE

DRAFT
For Discussion Purposes Only

0 10 20 30 40 50
SCALE IN METRES

NOTES

1. TOPOGRAPHIC CONTOURS SHOWN ARE IN METRES TO GMRP DATUM AT 0.5m INTERVALS.
2. COORDINATES SHOWN ARE IN METRES GMRP GRID.
3. FAULT TRACES AND GEOLOGICAL CONTACTS BASED ON REGIONAL GEOLOGY PLAN. LOCATIONS MAY NOT BE ACCURATE.

REFERENCES

1. PWGSC, TOPOGRAPHIC CONTOURS, CAD FILES: GM-CONTOURS-pt5m-GRP.DWG, DATED NOVEMBER 16TH, 2009.
2. PWGSC, AERIAL PHOTOGRAPH, IMAGE FILE: GIANTMINE_GRP.SID, DATED NOVEMBER 24TH 2009.
3. ROYAL OAK MINES, REGIONAL GEOLOGY PLAN, CAD FILE: GIANT MINESITE GEOLOGY AND TOPO.DWG, DATED 1995.

A0 – PWGSC – ANSI B–L1 – 11X17

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Revision/ Révision	Description/Description	Date/Date
0	ISSUED FOR REVIEW	

Client/client

PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet

GIANT MINE REMEDIATION PROJECT YELLOW KNIFE, N.W.T.

TAILINGS REHAB TASK NO. 7

Approved by/Approuvé par

Designed by/Concept par
W.D.

Drawn by/Dessiné par
D.T.

PWGSC Project Manager/Administrateur de Projets TPSGC
PWGSC

PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'ingénierie, TPSGC

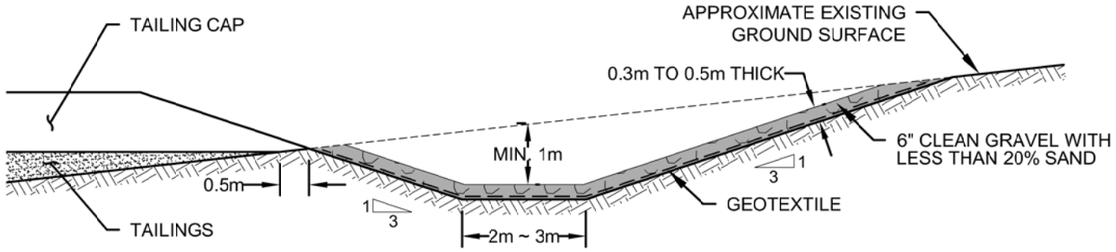
Client/client
PWGSC

Drawing title/Titre du dessin

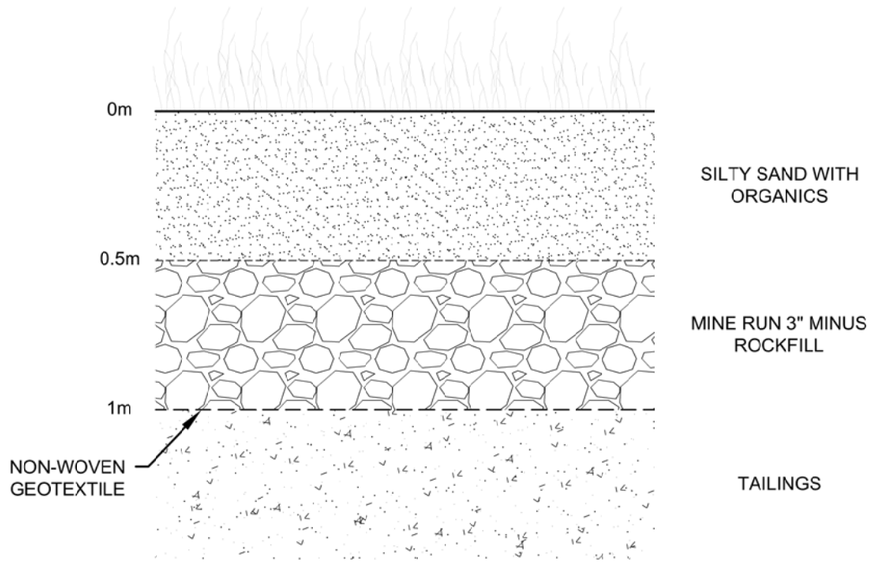
SITE PLAN

Project No./No. du projet	Sheet/Feuille	Revision no./ La Révision no.
R.014204.311	FIGURE 1 OF 2	0

0914270006_2000-01



1 DETAIL - CHANNEL DESIGN
SEE SCALEBAR A



2 DETAIL - TAILINGS COVER
SEE SCALEBAR B

DRAFT
For Discussion Purposes Only

0 0.5 1.0 1.5 2.0 2.5
SCALEBAR A (m)

0 0.2 0.4 0.6 0.8 1
SCALEBAR B (m)

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

0	ISSUED FOR REVIEW	
Revision/ Révision	Description/Description	Date/Date

Client/client

PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet

GIANT MINE REMEDIATION PROJECT YELLOW KNIFE, N.W.T.

TAILINGS REHAB TASK NO. 7

Approved by/Approuvé par

Designed by/Concept par
W.D.

Drawn by/Dessiné par
D.T.

PWGSC Project Manager/Administrateur de Projets TPSGC
PWGSC

PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'ingénierie, TPSGC

Client/client
PWGSC

Drawing title/Titre du dessin

TYPICAL DETAILS

Project No./No. du projet	Sheet/Feuille	Revision no./ La Révision no.
R.014204.311	FIGURE 2 OF 2	0

A0 – PWGSC – ANSI B–L1 – 11X17

0914270006_2000-02

APPENDIX I

Specifications:

- Aggregate Materials
- Grading
- Geotextiles
- Geomembranes
- Re-Vegetation
- Culverts and Ditch Liners

PART 1 GENERAL

1.1 Description

.1 This Section specifies general requirements for the purchase and/or processing of aggregates to be incorporated into the work.

.2 There is a requirement to select, blend, crush and/or screen granular materials to satisfy gradation specifications as indicated in this Section.

1.2 Source Approval

.1 Abide by conditions of the Authorities Having Jurisdiction (AHJ).

.2 Source of materials to be incorporated into work requires approval by Departmental Representative. Submit a request for source material to the Departmental Representative at least fifteen (15) days before source material is required.

.3 Use borrow areas identified within previously disturbed limits first.

.4 Indicated borrow areas and stockpiles are to be used. Approval to excavate borrow material from a new areas will be granted by Departmental Representative based on areas that do not require new access roads, areas that have minimal ice-rich permafrost and areas located away from water bodies.

.5 Advise Departmental Representative of proposed source of aggregates and provide access for sampling and testing at least seven (7) days prior to commencing production. Departmental Representative will conduct confirmatory testing of borrow material, if required, to determine if any contamination is present.

.6 If, in the opinion of Departmental Representative, materials from the proposed source do not meet, or cannot reasonably be processed to meet specified requirements, locate an alternative source or demonstrate that material from source in question can be processed to meet specified requirements.

.7 Should a change of material source be proposed during work, advise Departmental Representative one (1) week in advance of proposed change to allow sampling and testing.

.8 Acceptance of a material at source does not preclude future rejection if it is subsequently found to vary spatially, or if it fails to conform to requirements specified, or if its field performance is found to be unsatisfactory.

.9 Non-arsenic bearing / Non-PAG fill: Waste rock sources with a Neutralizing Potential to Acid Producing Potential ratio greater than 2.

1.3 Production Sampling

.1 Aggregate will be subject to continual sampling by Departmental Representative during production either at the stockpile or at the place of work. The aggregate is to meet the required specifications regardless of the place of sampling.

.2 Provide Departmental Representative with ready access to source and processed material for purpose of sampling and testing.

.3 Samples are to be obtained according to industry acceptable practices.

1.4 Measurement for Payment

.1 Location, access to and development of aggregate sources including stripping, scarifying, handling, stockpiling, replacement of organics, and any necessary restoration will be incidental to the work of Section 31 22 15 - Grading, and will not be measured separately.

.2 Processing of aggregate sources to meet project specifications, including selective excavation, blending, screening, crushing or any other method necessary to meet the required gradations and to produce non-PAG fill will be incidental to the work of this section and will not be measured separately.

.3 Work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section - 01 32 18 Construction Progress Schedules – Bar (GANTT).

PART 2 PRODUCTS

2.1 Materials

.1 There is a requirement to purchase, selectively excavate, blend or process aggregate materials to meet project specifications.

.2 Aggregate quality: sound, hard, durable material free from soft, thin, elongated or laminated particles, organic material or other deleterious substances.

.3 Flat and elongated particles are those whose greatest dimension exceeds five (5) times their least dimension.

.4 Waste rock sources used as fill will be reviewed by Departmental Representative prior to use as fill materials to assess the potential for acid generation.

.5 Fine aggregates satisfying requirements of applicable sections are to be one, or a blend of the following:

.1 Natural sand.
.2 Manufactured sand.

.6 Coarse aggregates satisfying requirements of applicable sections are to be one of following:

.1 Crushed rock.
.2 Gravel composed of naturally formed particles of stone.

.7 Type 1 Granular Fill:

.1 Type 1 Granular Fill is well graded cobbles and boulders with some gravel to be used for erosion protection, as indicated on the Drawings. The material is to be clean and well graded with a maximum size of 300 mm (nominal diameter) and no more than 10% passing the 20 mm sieve.

.2 Type 1 Granular Fill may be processed from natural sources or non PAG waste rock sources. There is a requirement to blend or screen material to meet the Type 1 gradation.

.8 Type 2 Granular Fill:

.1 Type 2 Granular Fill is selected material obtained from excavations or other sources approved by Departmental Representative, generally consisting of pit-run, screened gravel, gravel or sand in an unfrozen state and free from cobbles and boulders larger than 200 mm, waste or other deleterious material.

.2 Type 2 Granular Fill may be processed from natural sources or non PAG waste rock sources. There is a requirement to blend or screen material to meet the Type 2 gradation.

.3 Type 2 Granular Fill is used for construction of berms, landfill cover and regrading requirements.

.4 Gradations to be within the following limits when tested to ASTM C136 and ASTM C117, sieve sizes to CAN/CGSB-8.2:

Sieve Designation (mm)	% Passing by Weight
200	100
50	60 to 100
5	40 to 75
0.425	10 to 30
0.08	5 to 20

.9 Type 3 Granular Fill:

.1 Type 3 Granular Fill consists of granular pit-run material from identified borrow sources and is generally used for:
- .1 Regrading low areas as indicated;
- .2 Backfill for contaminated soil and landfill waste excavations;
- .3 General site grading requirements.

.2 Type 3 Granular Fill may be processed from natural sources or non PAG waste rock sources.

.3 Type 3 Granular Fill may be designated by Departmental Representative as a suitable alternative for other material types.

.4 Type 2 Granular Fill may be designated by Departmental Representative as a suitable alternative for Type 3 Granular Fill.

.10 Type 4 Granular Fill:

.1 Type 4 Fill consists of silty clay material, available on site from the C1 Pit Borrow Area indicated on the drawings and is generally used for cap material to support vegetation growth.

.11 Type 5 Granular Fill:

.1 Type 5 Granular Fill is to be used as an embedment material for geomembranes.

.2 Gradations to be within the following limits when tested to ASTM C136 and ASTM C117; sieve sizes to CAN/CGSB-8.2.

Sieve Designation (mm)	% Passing by Weight
25	100
12.5	75 to 100
5	50 to 100
2	30 to 60
0.425	10 to 40
0.08	0 to 8

.3 The material should be free from crushed or angular particles, waste or other deleterious materials.

.12 Type 6 Granular Fill:

.1 Type 6 Granular Fill is selected non-cohesive material from excavations or other sources approved by Departmental Representative, generally consisting of gravel or sand in an unfrozen state.
.2 Type 6 Granular Fill is generally used as an intermediate cover within landfills.
.3 The maximum particle size of the material is to be 150 mm with less than 20% of the material, by weight, passing the 0.08 mm sieve.
.4 When directed by Departmental Representative, contaminated soil may be used as Type 6 Intermediate Fill.

.13 Riprap:

.1 Riprap is rocks with a nominal diameter of 150 mm.
.2 The source and selection of rock to be used must be approved by Departmental Representative prior to placement.
.3 Riprap may be processed from natural sources or non PAG waste rock sources.
.4 Riprap gradations to be within the following limits:

	kg	mm
None greater than:	1,800	150
100% greater than:	200	50

.14 Boulders:

.1 Boulders are rocks with nominal diameter greater than 300 mm.

.15 Materials classified as unsuitable will include:

.1 Material of widely varying moisture density characteristics.
.2 Soils with moisture content exceeding optimum moisture by 5% or more.
.3 Soils containing organic material, snow, ice or other deleterious material.
.4 Potentially Acid Generating Rock.

PART 3 EXECUTION

3.1 Development of Aggregate Source

.1 Remove any debris (known or unknown) from the area prior to excavating borrow materials.

.2 Any significant deposits of organic material, as determined by Departmental Representative, are to be avoided and left undisturbed during development of an aggregate source.

.3 Strip an area ahead of excavating operation sufficient to prevent contamination of aggregate by deleterious materials.

.4 When excavation is completed, dress sides of excavation to achieve gentle slopes, maximum of 5H:1V, which fit local topography, and provide swales or ditches as required to prevent surface standing water.

.5 Trim off and dress slopes of waste material piles and leave site in neat condition.

.6 Trim, backblade and restore borrow areas as required by AHJ.

3.2 Processing

.1 Process aggregate using methods that prevent contamination, segregation and degradation.

.2 Blend aggregates if required to obtain gradation requirements specified. Use approved methods and equipment.

.3 Blending to decrease percentage of flat and elongated particles is permitted.

.4 When operating in stratified deposits use excavation equipment and methods that will produce uniform, homogeneous aggregate.

.5 Moisture condition aggregate, as required to achieve the specified density and/or degree of saturation.

.6 Dry aggregate, as required, to provide ease of handling during freezing temperatures or to place and compact according to this Specification.

3.3 Handling

.1 Handle and transport aggregates to avoid segregation, contamination and degradation.

3.4 Stockpiling

.1 If required, stockpile aggregates on site in locations indicated or designated by Departmental Representative. Stockpiles are to not be located on undisturbed areas.

.2 Stockpiling sites are to be level, well drained, and of adequate bearing capacity and stability to support stockpiled materials and handling equipment. Avoid areas with soft, fine-grained soils that may contaminate stockpiled materials.

.3 Separate aggregate stockpiles far enough apart to prevent intermixing.

.4 Reject intermixed or contaminated materials. Remove and dispose of rejected materials as directed by Departmental Representative within forty-eight (48) hours of rejection.

.5 Stockpile materials in uniform layers of one (1) metre maximum thickness.

.6 Complete each layer over the entire stockpile area before beginning next layer.

.7 Uniformly spot-dump aggregates delivered to stockpile in trucks and build up stockpile as specified.

.8 Coning of piles or spilling of material over edges of pile will not be permitted.

.9 During snowy conditions, prevent ice and snow from becoming mixed into stockpile.

.10 When work is complete remove excess stockpiled material to original borrow source or dispose of as indicated by Departmental Representative.

END OF SECTION

PART 1 GENERAL

1.1 Description

.1 This Section specifies requirements for:

.1 The grading of designated areas including existing landfills, granular borrow areas, site debris areas, depressions created by the removal of debris and contaminated soil, drainage modifications, wetland modifications and general site areas requiring regrading and reshaping;

.2 The supply and placement of fill materials as indicated.

.2 Requirements for maintenance and upgrades to site roads.

1.2 Definitions

.1 Reshaping: The levelling and grading, to a maximum depth of 600 mm, including the movement of boulders, of designated areas to blend in with the natural terrain and provide positive drainage. Reshaping does not require the supply and placement of additional granular fill material. Excavation of the terrain to a depth greater than 600 mm during reshaping operations will be considered as common excavation.

.2 Scarifying: The disturbance or loosening of a soil to a minimum depth of 300 mm to allow for compaction or aeration.

.3 Stripping: The removal of vegetation and topsoil to a minimum depth of 300 mm, and stockpiling that material on-site.

.4 Regrading: The supply and placement of granular fill in designated areas to blend in with the natural terrain and provide positive drainage.

.5 Common Excavation: Excavation of materials of whatever nature encountered in the work to the lines and grades indicated.

.6 Coarse-Grained Materials: Type 1, Type 2, and Type 5 material as specified in Section 31 05 17 – Aggregate Materials and native material with less than 20% of material passing the 80 micron sieve by weight.

.7 Fine-Grained Materials: Type 3 and Type 4 material as specified in Section 31 05 17 – Aggregate Materials and native material with more than 20% of material passing the 80 micron sieve by weight.

.8 General Fill: Type 3 Granular fill used for regrading low areas and general backfilling.

.9 Erosion Protection: Type 1 or Riprap Rock used for erosion protection.

.10 Unsuitable Material: Excavated material unsuitable for use in work or surplus to requirements.

.11 Borrow Material: Material obtained from approved areas and required for regrading requirements.

.12 Specific classifications of granular materials are described in Section 31 05 17 – Aggregate Materials.

.13 Maximum Dry Density is determined by the Standard Proctor Method in accordance with ASTM D698. It is applicable if less than 30% of the material is retained on the ASTM 19 mm sieve.

.14 Corrected maximum dry density is applicable if more than 30% of the material is retained on the ASTM 19 mm sieve. It is defined as:

.1 $$D = \frac{D1 \times D2}{(F1)(D2) + (F2)(D1)}$$

.2 Where:

D = corrected maximum dry density kg/m³
F1 = fraction (decimal) of total field sample passing ASTM 19.0 mm sieve
F2 = fraction (decimal) of total field sample retained on ASTM 19.0 mm sieve (equal to 1.00 - F1)
D1 = maximum dry density, kg/m³ of material passing ASTM 19.0 mm sieve determined in accordance with Method C of ASTM D698 or latest edition thereof.
D2 = bulk density, kg/m³ of material retained on ASTM 19.0 mm sieve, equal to 1000 G where G is bulk specific gravity (dry basis) of material when tested to ASTM C127-84, or latest edition thereof.

.15 Access Roads: Roads constructed or upgraded from existing access routes for the purpose of hauling material or equipment to complete the Work.

1.3 Site Conditions

.1 Suspend operations whenever climatic conditions are unsatisfactory for grading to conform with this Specification.

.2 Do not operate equipment in work areas until the material has dried sufficiently to prevent excessive rutting.

.3 Areas to be graded are to be free from debris and excessive snow, ice or standing water.

.4 Contractor is advised that soft ground conditions may be prevalent at the site during periods of maximum thaw of the permafrost. Schedule and carry out work to minimize disturbance to permafrost soils.

1.4 Protection

.1 Prevent damage to benchmarks, existing buildings, surface or underground service or utility lines which are to be used to support ongoing construction activities. Immediately repair any damage to the above or replace the above in the event of damage, at no cost to Departmental Representative.

.2 Protect and do not disturb spawning beds and breeding grounds as identified or required by the Authorities Having Jurisdiction (AHJ) during construction.

.3 Environmental protection measures are to be in accordance with the Erosion, Sediment and Drainage Control Plan and Section 01 35 43 - Environmental Procedures.

1.5 Samples

.1 Inform Departmental Representative of proposed source of fill materials and provide access for sampling in accordance with Section 31 05 17 – Aggregate Materials.

1.6 Measurement for Payment

.1 For items to be measured for payment by survey, survey the area to receive fill either by cross section or by grid, following removal/stripping (if required) of surface material. Survey significant breaks in the original ground surface grade, incorporating at minimum the cross section locations indicated on the Drawings. The maximum distance between cross sections or grid points is to not exceed 5 metres unless otherwise indicated by Departmental Representative. Survey measurements are to be to the nearest 0.01 metre. Following placement of granular fill material to specified thickness, Contractor is to resurvey the cross-sections or grid points. The volume measurement of granular material for payment will be determined by digital terrain model or average end area method, as Departmental Representative deems appropriate for the survey information provided. Preference is to be for quantity determination by digital terrain model.

.2 For items to be measured for payment by truck box measurement, Departmental Representative will measure the capacity of the hauling vehicles. The measurements will be to the nearest 0.1 m^3 capacity, and the capacity of the vehicle once measured is to not be changed without the consent of Departmental Representative. The granular material is to be levelled, using a strike-off method, by Contractor before measurement. No heaping or mounding of the load above the top of the box level will be allowed. Once the capacities of the truck boxes have been established, Departmental Representative may, at his own discretion, determine the granular material volume without enforcing the strike-off method. Truck boxes used in the haul of granular material are to be thoroughly cleaned when unloading. The following Bulking Factors will be applied to truck box measurements:

Material	Bulking Factor
Coarse-Grained Materials	15%
Fine-Grained Materials	20%
Debris	50%

.3 The unit of measurement for reshaping and stripping within designated areas indicated and to limits authorized by Departmental Representative will be by the square metre as measured by survey. Reshaping and stripping associated with earthworks, including, but not limited to, placement of fill materials, regrading or levelling of areas prior to construction, is not to be measured as part of reshaping, but is to be considered incidental to the unit price bid for such earthworks. Areas on the drawings requiring levelling prior to construction will not be considered for payment under reshaping, unless explicitly noted on the Drawings, or authorized by the Departmental Representative. Reshaping and stripping will be paid under Item 4 of the Basis of Payment Schedule.

.4 The excavation and backfilling of test pits, including restoration of original ground, as directed by Departmental Representative, using adequate mechanical excavating equipment, to a maximum depth of 3.0 metres will be measured for payment by the operating hours for the excavating equipment utilized, and paid under unit cost items for labour and equipment Item 5 of the Basis of Payment Schedule.

.5 The unit price for the excavation equipment is to include all ownership, operating and supervisory costs including costs for the equipment operator, lubricants, labour, and parts necessary to maintain the equipment.

.6 The supply, placement and compaction of Type 1, Type 2, Type 3, Type 4, Type 5, Type 6 Fill and Riprap Rock for site areas will be measured for payment by the cubic metre as determined by survey methods. Type 1, Type 2, Type 3, Type 4, Type 5, Type 6 Fill and Riprap Rock for site areas will be paid under Items 6 through 12 in the Basis of Payment Schedule. Payment Items 6 through 12 include, but are not limited to, fill associated with the following items:

.1 Ditches
.2 Berms
.3 Covers
.4 Caps

.7 Excavation required for the following work items will be measured for payment by the cubic metre as determined by survey measurement, and paid under Item 13 Common Excavation in the Basis of Payment Schedule:

.1 Excavation of the terrain to a depth greater than 600 mm during reshaping operations.
.2 Excavation as specifically indicated on the Drawings or as directed by Departmental Representative.

.8 The following work items will be incidental to the work described in this Section, and will not be measured separately:

.1 Stripping, stockpiling and replacement or placement to a new location of organic material from the borrow areas as directed by Departmental Representative, and where required from construction areas upon where material is to be placed.
.2 Disposal of unsuitable material from the borrow areas.
.3 Removal of surficial boulders over 300 mm in diameter from construction areas.
.4 Mining, separating, processing, screening, and stockpiling of borrow materials.
.5 Grading of borrow areas to approximate the before-construction condition upon completion.
.6 Loading, hauling and haul road construction, maintenance and rehabilitation.
.7 Water for moisture conditioning, compaction and dust control.
.8 All construction surveying, including layout of facilities, slope staking, and supply and installation of witness grade stakes to monitor the depth of granular material placement.
.9 Surveying and calculation of granular material quantities for progress payment purposes.
.10 Reshaping and regrading of Contractor’s laydown areas including the supply, placement and compaction of granular material.
.11 Draining of wet areas prior to regrading operations.
.12 Removal and disposal or burial in accordance with Section 02 41 16 –

Structure Demolition of abandoned utility lines exposed by Contractor during the excavation or granular materials.

.9 Grading materials required for the installation of culverts and ditch liners are not included for payment under this section, but are included in Section 33 42 13 – Culverts and Ditch Liners.

.10 Grading materials required for the installation of the stilling basin are not included for payment under this section, but are included in Section 33 42 13 – Culverts and Ditch Liners.

.11 No measurement for payment will be made for:

.1 Rejected material.
.2 Surplus material.
.3 Excavation, and stripping and replacement of organic material beyond specified limits.
.4 Excavation to prove borrow sources.
.5 Placement of granular fill beyond the limits and depths specified, unless specifically authorized by Departmental Representative.

.12 Except as indicated above, work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section 01 32 18 Construction Progress Schedules – Bar (GANTT).

PART 2 PRODUCTS

2.1 Materials

.1 Fill materials in accordance with Section 31 05 17 – Aggregate Materials

.2 Fill materials require the approval of Departmental Representative.

.3 There is a requirement to selectively acquire, blend and/or screen granular materials to satisfy gradation specifications as indicated in Section 31 05 17 – Aggregate Materials.

PART 3 EXECUTION

3.1 Site Preparation

.1 Unless specifically indicated, do not remove existing topsoil or organic materials from fill placement areas.

.2 Borrow Excavation:

.1 Obtain from potential borrow areas as indicated, or provide from own sources, all required fill material.
.2 The existing operational pads and roadways at the site are not to be used as granular material borrow sources unless specifically authorized by Departmental Representative.
.3 Advise Departmental Representative of selected borrow areas seven days in advance of excavation operations for appropriate testing to be performed.

.4 Notify Departmental Representative whenever unsuitable materials are encountered in borrow areas.

.5 Stripping, stockpiling and replacement or placement to a new location of organic material and stripping and disposal of unsuitable material found when excavating existing granular fills to be as directed by Departmental Representative.

.6 Final grading of borrow area upon completion to be tidy, in a well drained condition, free of standing water to the satisfaction of Departmental Representative.

.7 Upon completion of final grading, leave all slopes in a stable condition and spread all stripped organics.

.8 Transport aggregate from borrow areas to the work areas via existing access routes where available. Maintain and provide for dust control on the access route between the borrow area and the work areas.

3.2 Placement, Moisture Conditioning, and Compaction of Granular Fill Material

.1 Set grades and lay out work in detail from control points in areas of granular fill placement. Verify the original ground topography by survey.

.2 Haul granular fill material from borrow sites to designated areas.

.3 Place granular fill material to the lines, grades, elevations and dimensions indicated, or agreed to with Departmental Representative.

.4 Do not place granular fill on snow or surface ice.

.5 Maintain natural drainage patterns, unless otherwise directed, and fill depressions to avoid any ponding of water adjacent to embankments.

.6 All fill material are to be placed in an unfrozen state. Fill material to be free from debris, snow and ice. Do not place granular fill if the outside air temperature is below 0°C, unless otherwise directed by Departmental Representative.

.7 Maintain a crowned surface during construction to ensure ready runoff of surface water. Do not place material in free standing water. Drain low areas, before placing material.

.8 Do not dump fill material over the side slopes of berms.

.9 Place and compact fill material in horizontal lifts.

.10 Cease construction at any sign of movement or bulging in the embankments to allow assessment by Departmental Representative.

.11 For fill depths greater than 500 mm, place granular material in lifts not exceeding 250 mm in loose thickness. For fill depths greater than 200 mm and less than 500 mm, place material in two lifts of equal depth. For fill depths less than 200 mm, place material in one lift.

.12 Moisture condition granular fill as required to meet compaction requirements. Provide a water truck capable of efficiently placing water on granular fill. If material is excessively moist, aerate by scarifying with suitable equipment until moisture content is corrected.

.13 Compact Type 2 and Type 4 Granular Fill material to a minimum of 95 percent or as shown of Maximum Dry Density determined in accordance with ASTM D698.

.14 Compact Type 3 Granular Fill material such that a loaded truck with a rear axle load of 10,000 kg minimum, does not deflect the compacted material more than 30 mm.

.15 If granular fill has dried out prematurely due to weather conditions, scarify surface, adjust moisture condition and recompact at Departmental Representative's discretion. No extra payment will be made for extra costs incurred as a result of any extra work.

.16 Compaction equipment must be capable of obtaining required densities uniformly in materials on project. Hand equipment must be available for compaction in areas where large equipment can not access and around instrumentation. Tracked or tired equipment may be substituted for dedicated compaction equipment, provided it can demonstrate satisfactory compactive effort as specified in this section.

.17 Following compaction of Type 2, Type 3 and Type 4 material placed on slopes, travel in a direction parallel to the slope direction with tracked equipment to create small ridges in the slope. In soft ground, travel in a direction parallel to the toe of the slope with tracked equipment.

.18 Shape finished surface to required cross-section and grade, or as directed by Departmental Representative.

3.3 Regrading

.1 Supply, compact, place, blade and trim Type 2, Type 4 or Type 3 Granular Fill material to elevation, grades, and cross-section dimensions indicated or directed by Departmental Representative.

.2 Supply and install witness grade stakes in areas to be regraded to monitor the depth of granular material. The grade stakes are to be placed on a grid spacing acceptable to Departmental Representative for each specific regrade area. Immediately replace all grade stakes that are damaged or displaced by Contractor operations.

3.4 Reshaping

.1 Obtain authorization from Departmental Representative prior to beginning reshaping operations.

.2 Blade and trim material to elevation, grades, and cross-section dimensions indicated or directed by Departmental Representative. Obtain Departmental Representative's approval before reshaping any area.

.3 Make use of material within the area designated for reshaping to provide a surface that is smooth and compact with stable slopes.

.4 Blend the final reshaped surface with the natural terrain and provide positive drainage.

3.5 Site Access and Haul Roads

.1 Construct access roads, haul roads. airstrips and barge landings as required to complete the Work to applicable regulations including, but not limited to, the NWT mine Health and Safety Act,

.2 Haul Roads

.1 Construct two-way haul roads to a minimum of two times the width of the largest hauling equipment.
.2 Construct one-way haul roads with distance/location markers between segments where the road is wide enough to allow vehicle meeting.
.3 Construct turn-outs as required
.4 Construct shoulder berms where shoulder drops exceed three (3) metres.
.5 Post speed limits where required as specified in Section 01 35 32 – Site Specific Health and Safety Plan.

3.6 Excavating

.1 Lay out work in detail from control points in areas of excavation. Verify the original ground topography by survey.

.2 Excavate to lines, grades, elevations and dimensions as indicated on the Drawings or designated by Departmental Representative.

.3 Keep excavations free of water while work is in progress. Protect open excavations against flooding and damage due to surface run-off. Dispose of water in a manner not detrimental to work completed or under construction. Provide treatment and discharge all water resulting from the dewatering of open excavations as described in Section 01 35 15 – Special Project Procedures for Contaminated Sites.

.4 Dispose of excavated material at approved locations. Do not obstruct flow of surface drainage or natural watercourses.

.5 Where required due to unauthorized over-excavation, fill areas with Type 3 granular material, as directed by Departmental Representative, compacted to a minimum 95 percent of Maximum Dry Density in accordance with ASTM D698.

3.7 Backfilling

.1 For backfilling operations, use compaction equipment capable of obtaining required densities in materials on project.

.2 Do not proceed with backfilling operations until Departmental Representative has inspected and approved excavation.

.3 Areas to be backfilled are to be free from debris, snow, ice and water.

.4 Commence backfilling of excavated soil areas within 1 day of receipt of confirmatory sampling results indicating no further excavation in the area is required. Costs for any extra work caused as a result of leaving excavations open longer will be the responsibility of Contractor.

.5 Place specified backfill material in uniform horizontal layers in depths to grades indicated. Compact each layer before placing succeeding layer.

.6 No trenches or excavations are to be left open during the winter.

3.8 Trenching

.1 Excavations in excess of the maximum allowable unprotected height of slopes indentified in applicable regulations, Section 01 41 00 – Regulatory Requirements, are

to be shored, cut back or protected by temporary protective structure.

.2 Trenching activities to be in compliance with applicable safety regulations and requirements specified in Section 01 35 32 – Site Specific Health and Safety Plan.

.3 Trenching activities to be completed in compliance with all other excavation requirements, specified in this section.

3.9 Testing

.1 Testing of fill material and compaction testing will be carried out and paid for by Departmental Representative.

.2 Frequency and method of testing will be determined by Departmental Representative.

3.10 Finishing and Tolerances

.1 All areas to be covered with granular material are to be uniform without projections or depressions exceeding 100 mm in 3 m.

.2 Granular fill surfaces to be within 100 mm of design elevations but not uniformly high or low.

.3 Finished surfaces are to be graded to promote positive drainage and minimize standing water.

3.11 Maintenance

.1 Maintain finished surfaces in a condition in accordance with this Section until succeeding material is applied or until demobilization.

END OF SECTION

PART 1 GENERAL

1.1 Description

.1 This section specifies the requirements for the supply and installation of non-woven geotextiles for the site.

1.2 Supply of Geotextile

.1 Geotextile is supplied to the contractor and is available on site at the Tailings Reprocessing Plant (TRP) warehouse, as shown on the drawings.

.2 Be responsible for loading, on-site transportation, off-loading, placement and installation.

1.3 Measurement for Payment

.1 The loading, on-site transportation, off loading, placement and installation of Geotextile to the lines and dimensions indicated, including all labour, additional materials, tools, supervision, and on-site transport will be measured for payment by the square metre of geotextile installed. No extra payment is to be made for material overlap requirements or for patches over damaged material. The installation of Geotextile will be paid under Item 14 of the Basis of Payment Schedule.

.2 Geotextile required for the installation of culverts and ditch liners are not included for payment under this section, but are included under Section 33 42 13 – Culverts and Ditch Liners.

.2 Excavating and backfilling necessary to install and anchor the geotextile beneath the original ground surface will be included in Section 31 22 15 - Grading.

.3 Upon completion of the project, bear all costs for the transport and stockpile of unused geotextile at the Tailings Reprocessing Plant (TRP) warehouse, as shown on the drawings.

.4 Except as indicated above, work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section 01 32 18 Construction Progress Schedules – Bar (GANTT).

PART 2 PRODUCTS

2.1 Materials

.1 Geotextile is supplied as stated in this section and is a non-woven geotextile 60 mil thick.

2.2 Storage

.1 During storage, protect geotextiles from excessive heat, mud, dirt, dust, debris, rodents and water.

PART 3 EXECUTION

3.1 Quality Assurance

.1 All materials, procedures, operations, and methods are to be in strict conformance with the Drawings and Specifications and are to be subjected to strict quality assurance monitoring as detailed herein. The installed systems are to conform to the Drawings and Specifications, except as otherwise authorized in writing by Departmental Representative.

3.2 Underlying Surface Preparation

.1 Ensure that the surface underlying the geotextile is graded smooth and is free from angular rocks, debris and protrusions. Remove all particles greater than 75 mm in diameter.

3.3 Deployment

.1 Do not begin installation of geotextile until the base has been approved by Departmental Representative.

.2 Deploy the geotextile by unrolling onto the prepared surface in orientation, manner and locations indicated.

.3 Place geotextile material smooth and free of tension stress, folds, wrinkles and creases.

.4 Place geotextile material on sloping surfaces in one continuous length from toe of slope to upper extent of geotextile, perpendicular to the slope direction.

.5 Overlap adjacent geotextile panels in accordance with manufacturer's recommendations.

.6 Employ sufficient temporary anchorage to hold geotextile in place during backfilling.

.7 Protect installed geotextile material from displacement and damage until, during and after placement of additional material layers.

.8 Repair rips or tears with a patch to cover a minimum of 1 metre on each side of the rip or tear.

3.4 Anchorage

.1 Anchor and backfill the geotextile as shown. Temporary anchorage can be provided by sandbags. Compact backfill in such a manner as to not damage the geotextile.

3.5 Protection

.1 Do not permit passage of any vehicle directly on geotextile at any time.

END OF SECTION

PART 1 GENERAL

1.1 Scope

.1 This section covers the supply, installation and quality assurance of geocomposite liner (GCL) and high-density polyethylene (HDPE).

1.2 Supply of GCL and HDPE

.1 GCL and HDPE is supplied to the Contractor and is available on site at the Tailings Reprocessing Plant (TRP) warehouse, as shown on the drawings.

.2 Be responsible for loading, on-site transportation, off-loading, placement and installation.

1.2 Measurement For Payment

.1 The loading, on-site transportation, off-loading, placement and installation of GCL to the lines and dimensions indicated, including all labour, additional material, tools, supervision, and on-site transport will be measured for payment by the square metre of GCL installed. No extra payment is to be made for material overlap requirements or for patches over damaged material. The installation of HDPE will be paid under Item 15 of the Basis of Payment Schedule.

.2 The loading, on-site transportation, off-loading, placement and installation of HDPE to the lines and dimensions indicated, including all labour, additional material, tools, supervision, and on-site transport will be measured for payment by the square metre of HDPE installed. No extra payment is to be made for material overlap requirements or for patches over damaged material. The installation of HDPE will be paid under Item 16 of the Basis of Payment Schedule.

.2 Excavating and backfilling necessary to install and anchor the geomembranes beneath in anchor trenches or as indicated is included in Section 31 22 15 - Grading.

.3 Upon completion of the project, bear all costs for the transport and stockpile of unused geotextile at the Tailings Reprocessing Plant (TRP) warehouse, as shown on the drawings.

.4 Except as indicated above, work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. . Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section 01 32 18 Construction Progress Schedules - Bar (GANTT).

PART 2 PRODUCTS

2.1 Geosynthetic Clay Liners

.1 Geosynthic Clay Liner (GCL) is supplied as stated in this section.

2.2 High-density Polyethylene (HDPE) Liner

.1 The high-density polyethylene (HDPE) is a nominal gauge of 60 mil. HDPE is supplied as stated in this section. Each roll supplied has HDPE liner 158.6 meters long and 6.8 meters wide.

2.1 Protective Layers

.1 Sand used for bedding and protection of the geomembrane is to meet the Type 5 gradation as specified in Section 31 05 17 – Aggregate Materials.

.2 Geotextile used for protection of the geomembrane is to be as per Section 31 32 21 – Geotextiles.

PART 3 EXECUTION

3.1 General

.1 The Installation (Sub)contractor is to be trained and licensed to install the geomembrane. Installation will be performed under the constant direction of a single field Installation Supervisor supplied by the Installation (Sub)contractor who will remain on site and be in charge throughout the liner installation for liner activities by the installer.

.2 Actual seaming is to be performed under the direction of a Master Seamer who has seamed a minimum of 100,000 square metres of geomembrane, using the same type of seaming apparatus specified in Section 3.5.3. The Master Seamer, who may also be the Installation Supervisor, will be present whenever seaming is performed.

3.2 On-Site Storage

.1 The geomembrane is to be stored so as to be protected from puncture, dirt, grease, mud, mechanical abrasions, excessive heat or other damage.

.2 The geomembrane is to be handled with equipment which does not contact the geomembrane itself or with clean fabric.

.3 The rolls are to be stored on a prepared surface (not wooden pallets) and should not be stacked more than two rolls high.

3.3 Earthwork

.1 Excavate the subgrade to line and grade as shown prior to liner system placement.

.2 In conjunction with the Departmental Representative, on a daily basis, inspect the subgrade preparation and inspect the adequacy of the subgrade for purposes of the warranty. Removed and replaced with properly compacted fill weak or compressible areas which cannot be satisfactorily. All surfaces to be lined will be smooth, free of all foreign and organic material, sharp objects, or debris of any kind. These surfaces will provide a firm, unyielding foundation with no sharp changes or abrupt breaks in grade. Standing water or excessive moisture will not be allowed.

.3 The Installer, on a daily basis, will inspect and certify that the surface on which the geomembrane will be installed is acceptable. After the supporting soil surface has been accepted, it will be the Installer's responsibility to indicate to the Departmental Representative any change to its condition due to natural causes or occurrences that may require repair work. Proceeding with the installation of the liner will be deemed to be acceptance of the subgrade and soil surface for purposes of the warranty.

.4 Anchor Trench

.1 The anchor trench will be excavated to the line, grade and width shown prior to liner system placement.

.2 Slightly rounded corners will be provided in the trench where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane.

3.4 Deployment of GCL and HDPE

.1 Deploy the GCL in such a manner to prevent any damage to the materials.

.2 Keep rolls dry at all times, particularly during transit, handling or storage of the GCL. Rolls may be marshalled in various location so as to facilitate deployment and minimize the transit distance during deployment, provided that the handling and storage requirements, outlined in Clause 3.2 of this Section are satisfied.

.3 Cut GCL material only using approved cutters, and take care to ensure that materials underlying the liner are not damaged during cutting.

.4 Keep the GCL materials clean and dry at all times up to and including the time of placement of the next layer of material covering them.

3.5 GCL and HDPE Overlapping and Joining

.1 Join panels of GCL such that adjacent panels are overlapped a minimum of 500 mm.

.2 Prepare seams of the overlapped panels in accordance with the manufacturer’s recommendations. In addition, follow any other recommendations by the GCL manufacturer for mechanical bonding or other provisions for all onsite lapping and/or joining operations.

3.6 Type 5 Granular Fill Installation

.1 Equipment used to spread the Type 5 granular fill must not exceed a mass more than 8,500 kg or produce a ground pressure greater than 30 KPa, with a minimum thickness of 150 mm of Type 5 granular fill below the tracks. The equipment will not push a pile such that the wheels or tracks spin. No sharp turns will be allowed. Larger equipment may be used at the discretion of Departmental Representative and a minimum of 500 mm of sand has been placed in the areas of additional load. Any damage to the geosynthetic liner or geotextiles by equipment will be repaired at Contractor’s expense.

.2 No wheeled vehicles allowed over the Geomembrane without approval of Departmental Representative. Any damage to the geosynthetic liner or geotextiles by equipment will be repaired at Contractor’s expense.

.3 The material will be placed to lines and grades as shown on the construction drawings, within ±50 mm in the vertical direction and ±100 mm in the horizontal direction.

END OF SECTION

PART 1 GENERAL

1.1 Description

.1 This Section specifies requirements for:

.1 The re-vegetation at of the Jo-Jo Lake Cap and the Reach 4 Backfill areas.

1.2 Definitions

.1 Imported native species: Plants of species native to the area that are transported to site from an approved source such as a plant nursery.

.2 Native seed mix: Seed mix which complies with all standard of Authorities Having Jurisdiction (AHJ) and is considered native to the Yellowknife, NT area.

.3 Erosion Matting: erosion matting is supplied to the contractor and is available onsite at the Tailings Reprocessing Plant.

.4 Weeds: Includes, but not limited to, dandelions, jimsonweed, quackgrass, horsetail, morning glory, rush grass, mustard, lambsquarter, chickweed, crabgrass, Canadian thistle, tansy, ragwort, Bermuda grass bindweed, bent grass, perennial sorrel, brome grass, red root, pigweed, buckweed, scentless chamomile, toadflax, foxtail and perennial sow thistle.

1.3 Supply of Erosion Matting

.1 Erosion mat is supplied to the contractor and is available on site at the Tailings Reprocessing Plant (TRP) warehouse, as shown on the drawings.

.2 Be responsible for loading, on-site transportation, off-loading, placement and installation.

1.4 Site Conditions

.1 Suspend operations whenever climatic conditions are unsatisfactory for grading to conform with this Specification.

.2 Do not operate equipment in work areas until the material has dried sufficiently to prevent excessive rutting.

.3 Areas to be graded are to be free from debris and excessive snow, ice or standing water.

.4 Contractor is advised that soft ground conditions may be prevalent at the site during periods of maximum thaw of the permafrost. Schedule and carry out work to minimize disturbance to permafrost soils.

1.5 Protection

.1 Protect and do not disturb spawning beds and breeding grounds during construction. Immediately report to Departmental Representative sighting of any fish, spawning beds and breeding grounds encountered in Baker Pond during construction.

.2 Environmental protection measures are to be in accordance with the requirements

specified in Section 01 35 43 - Environmental Procedures. Follow the approved Erosion, Sediment and Drainage Control Plan submitted in accordance with Section 01 35 43 - Environmental Procedures.

1.6 Product Delivery, Storage and Handling

.1 Delivery grass seed in the original containers, tagged with identification as to the analysis of seed mixture, percentages of seed, year of seed production, net weight and date.

.2 Deliver seed to site only when required.

1.7 Measurement for Payment

.1 The seeding at the Jo-Jo Lake Cap and Reach 4 Backfill areas will be measured for payment by the square metre as determined by the survey method as per Section 31 22 15 – Grading. Seeding will be paid under Item 17 in the Combined Price Form.

.2 The scope of work for Item 17 includes, but is not limited to:

.1 Supply, transportation and planting of seeds including all materials, labour, inspection, equipment and documentation necessary to complete the work specified.

.3 Placement of erosion matting, as indicated on the drawings, will be measured for payment by square metre as determined by survey method as per Section 31 22 15 – Grading. Erosion matting will be paid under Item 18 in the Combined Price Form.

.4 The scope of work for Item 18 includes, but is not limited to:

.1 Loading, on-site transportation, off-loading and installation including all labour, inspection, equipment and documentation necessary to complete the work specified.

.5 Except as indicated above, work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section 01 32 18 Construction Progress Schedules – Bar (GANTT).

1.8 Inspection

.1 Give timely notice, in writing, to Departmental Representative when such materials are available for inspections. Departmental Representative may inspect material at his/her discretion.

PART 2 PRODUCTS

2.1 Seed Mix

.1 Supply a seed mix which complies with all standard of Authorities Having Jurisdiction (AHJ) and is considered native to the Yellowknife, NT area.

.2 Submit to the Departmental representative the proposed seed mixture prior to the start of seeding.

.3 Seed mix it to be free of disease, weed seeds or foreign matter, minimum germination of 75%, minimum purity of 97% and conforming to the seed mix supplied by the Contractor. All seed must be from a recognized seed firm, meeting the requirements for the Seeds Act for Canada No. 1 Seed. Seed shall be certified No. 1 grade. A germination test and/or weed seed analysis may be requested and all lawn seed must comply with federal and provincial seed laws.

2.2 Equipment

.1 Cultivators: capable of scarifying, discing or harrowing.

.2 Dry Seeders: of the “Brillion” type, capable of rolling and covering the seed with 3 mm to 6 mm of soil; or of the cyclone type, with flexible wire mat drag.

.3 Hydro Seeders: capable of thoroughly mixing water, seed, fertilizer and pulverized wood fibre and of uniformly spraying the mix at designated rate.

.4 Rollers: of suitable size and mass.

PART 3 EXECUTION

3.1 Planting Season

.1 Plant vegetation only during months of June and July to allow plants sufficient time to establish prior to onset of winter season.

3.2 Site Preparation

.1 Sequence work to minimize erosion and minimize disturbances to surrounding area during site preparation.

.2 Remove weeds and debris from topsoil already in place.

.3 Examine the site, verify the grades and check that the topsoil has been placed as specified.

.4 The work shall be done in calm weather, during the normal planting season for the type of seed mixture supplied.

.5 Notify the Departmental Representative prior to the start of the seeding operations.

.6 Cultivate existing Type 4 material and apply additional Type 4 as required to obtain minimum required depths. Additional Type 4 shall be spread evenly and lightly compacted.

.7 Float and level out the finished topsoil surface.

3.3 Protection of Existing Vegetation

.1 Protect existing vegetation as specified in Section 01 35 43 – Environmental Procedures.

3.4 Mechanical Seeding

.1 Do not seed when prepared topsoil is covered with frost, snow or standing water. Proceed with seeding operations only during favourable weather conditions in accordance with sound horticultural practices.

.2 Slopes flatter than 3 horizontal to 1 vertical: apply seed by mechanical dry spread (Brillion or Cyclone type) at a rate of 24 kg/1,000 m². Apply in two passes, each pass at a rate of 12 kg/1,000 m² at 90 degrees to each other. Lightly roll seeded area.

.3 Hand broadcast seeding is unacceptable under any conditions except for site specific repair work and pre-approved work in naturalization areas.

.4 Sow the seed at a rate specified for the seed type, in two directions, 50% in one direction and remaining 50% of seed at right angles to first seeding pattern.

3.5 Hydro Seeding

.1 Use a hydro seeder to seed with approved seed mix.

.2 Mix seed with water, mulch and fertilizer in the following suggested quantities to cover 4,000 m²:

.1	Grass Seed: 80 kgs	Mulch:	640 kgs
.2	Water:6,400 litres	Fertilizer:	140 kgs

.3 Hydro seeding should not be carried out in wind velocities which cause seed mix to be blown.

.4 Measure quantities of materials to be fed into the seeder, either by weight or by using another approved system.

.5 Application rates:

.1 Grass seeds 2.0 kg per 100 m² or as specified for the seed type.
.2 Water 106 L/100 m².
.3 Mulch 16 kg/100 m² or sufficient to apply the specified amount of seed and fertilizer per 100 m².

.6 Thoroughly mix seed, fertilizer, mulch, binder (if specified) and water in a slurry and uniformly apply in one operation. Apply seed and fertilizer mixture than cover with an approved mulch.

3.6 Seed Germination, Dry Seed and Hydro Seed Applications

.1 If seed fails to germinate within four growing months, re-cultivate and re-seed until germination takes place.

.2 Approximately six weeks after germination apply supplementary fertilizer 27-14-0, at a rate determined by topsoil analysis or such other fertilizer as may be deemed appropriate by the Departmental Representative.

3.7 Warranty

.1 All grass shall have a one year warranty period from issuance of the Construction

Completion Certificate.

.2 Areas showing deterioration, bare spots or thin areas shall be re-seeded at the Contractor's expense.

.3 Departmental Representative will hold back 20% of lump sum amount of Seeding as indicated on Schedule A and release it after issuance of the Final Acceptance Certificate.

3.8 Maintenance

.1 Maintenance shall include all measures necessary to establish and maintain seeded areas in an acceptable, vigorous and healthy growing condition for a period of one year from the issuance of a Construction Completion Certificate and until the issuance of the Final Acceptance Certificate. Maintenance shall include:

.1 Replacing areas that show root growth failure, deterioration, bare or thin spots or which have been damaged by any means.
.2 Top dressing and rolling to repair ruts or erosion.

.2 The Departmental Representative may review the use of herbicides for weed control. They shall be applied in accordance with the manufacturer's recommendations by a licensed applicator. Damage resulting from the Contractor's improper use of herbicides shall be remedied at the Contractor's own expense.

3.9 Final Inspection

.1 Final inspection of seeded areas will be made prior to the end of the warranty period.

.2 At the time of inspection all the areas shall be alive and in a healthy satisfactory growing condition, free from weeds.

3.10 Clean-up

.1 Clean roadway, walkway and surrounding areas of soil, seed and other debris resulting from work done under this section at the end of each working day or as reviewed by the Departmental Representative.

3.11 Maintenance

.1 Carry out all measures necessary to establish and maintain all water sedge plants and live stakes in an acceptable and healthy growing condition.

.2 Maintenance includes supply, loading, hauling and distributing water for maintenance purposes, as well as supply of equipment.

3.12 Application of Erosion Matting

.1 Place erosion mats at the surface of the Jo-Jo Lake Cap, secure the edges with additional Type 4 material or by other means.

.2 Overlap erosion mats by 100 mm.

END OF SECTION

PART 1 GENERAL

1.1 MEASUREMENT FOR PAYMENT

.1 The installation of culverts to the lines and dimensions indicated will be measured for payment by the lineal meter of culvert installed. The installation of culverts will be paid under Item 19 of the Combined Price Form.

.2 Item 19, Culverts, includes, but is not limited to, the following:

- All material and labour and equipment necessary to complete the work as specified and as shown on the construction drawings,
- Trenching, excavation and grading for placing and bedding of the culvert,
- Culvert bedding as specified in the drawings,
- Supply and installation of culvert and all necessary couplings and bolts,
- Supply and installation of riprap and geotextile as specified and detailed,
- All incidental work for which payment is not specified elsewhere.

.3 The installation of semi-circular ditch liners to the lines and dimensions indicated will be measured for payment by the lineal meter of ditch liners installed. The installation will be paid under Item 20 of the Combined Price Form.

.4 Item 20, Semi-Circular Ditch Liners, includes, but is not limited to, the following:

- All material and labour and equipment necessary to complete the work as specified and as shown on the construction drawings,
- Trenching, excavation and grading for placing and bedding of the culvert,
- Culvert bedding as specified and detailed,
- Supply and installation of culvert and all necessary couplings and bolts,
- Supply and installation of riprap and geotextile as specified and detailed,
- All incidental work for which payment is not specified elsewhere.

.5 Include all direct costs for the construction of the stilling basins, including supply, aggregate materials, transportation, installation and placement, are to be included in the lump sum price for Stilling Basins, Item 21, as indicated in the Combined Price Form.

.6 Except as indicated above, work under this section will not be measured. Include all costs in Lump Sum Amount in the Combined Price Form. Indicate cost of the Work of this section as a separate line item in the Contract Work Breakdown Structure (CWBS) specified in Section 01 32 18 Construction Progress Schedules – Bar (GANTT).

PART 2 PRODUCTS

2.1 CULVERT - CORRUGATED STEEL PIPE

.1 Culverts shall be corrugated steel pipe, manufactured in accordance with CAN3-G401 and shall be zinc coated by a hot dip galvanizing process. The wall thickness shall be 2.0 mm in the 900 mm culvert size, and the corrugation pattern shall be 68 mm pitch and 13 mm depth. The pipe sections shall be connected with corrugated band couplings, also conforming to CAN3-G401. Ends shall be cut square or bevelled as indicated.

2.2 DITCH LINER - CORRUGATED STEEL PIPE

.1 Ditch Liners shall be corrugated steel pipe with a wall thickness of 20 mm in the 900 mm diameter size, and the corrugation pattern shall be 68 mm pitch and 13 mm depth. Ends shall be cut square or bevelled as indicated.

2.3 GRANULAR BEDDING

.1 Material for granular bedding shall be a mixture of clean sand and gravel, free from frozen lumps, topsoil, stumps, trees or other deleterious materials and shall not contain stones of a diameter larger than 70 mm. The granular bedding material shall be supplied by the Contractor and shall be subject to the approval of the Departmental Representative prior to being placed in the work.

2.4 BACKFILL

.1 Material for culvert backfill shall be a mixture of the excavated material obtained from the excavations on the road alignments. Use of random culvert backfill shall be subject to the approval of the Departmental Representative.

2.5 DITCH LINER – ANCHOR

.1 Construct anchors of non-contaminated timber.

2.6 STILLING BASIN

.1 Material for the stilling basin shall be rip rap, as defined in Section 31 05 17 – Aggregate Materials and indicated on the drawings.

PART 3 EXECUTION

3.1 TRENCHING AND EXCAVATION

.1 The excavation for the culvert base shall be carried to a depth of not less than 150 mm below the invert grade, as established by the Departmental Representative and shall be of sufficient width to permit pipe assembly and to accommodate operation of compaction equipment on either side of the culvert.

3.2 CULVERT BEDDING

.1 Place minimum 150 mm thick layer of compacted granular material on bottom of excavation. Place material in uniform layers not exceeding 150 mm thickness, and compact each layer to at least 95% Standard Proctor Density before placing succeeding layer. Any soft and yielding or other unsuitable material below this level shall be removed to the depth required by the Departmental Representative and backfilled with approved granular material compacted to a uniform density of 95% of Standard Proctor Density throughout the entire length of the culvert.

.2 The base for culverts installed along main water courses or through yielding areas shall consist of gravel bedding compacted to the excavated depth and extending over a width of three (3) times the diameter of the pipe. The depth of this base shall be not less than 300 mm. An impervious compacted bedding material shall be provided for a minimum length of 3 m or three (3) times the diameter of the pipe, whichever is greater, at the inlet end of the culvert to achieve a seal against seepage.

.3 Trench line and grade requires the Departmental Representative 's review prior to placing bedding material or pipe.

.4 Do not backfill until pipe grade and alignment are checked and accepted by the Departmental Representative.

3.3 LAYING CORRUGATED STEEL PIPE CULVERTS

.1 Commence pipe placing at downstream end on the prepared granular bedding with separated sections securely joined together by means of a coupling band.

.2 Do not allow water to flow through pipes during construction except as permitted by the Departmental Representative .

.3 All culverts shall be laid so that the horizontal seams fall at the sides of the culverts.

.4 The pipe shall be laid true to line and grade as established by the Departmental Representative and the pipe shall be carefully handled to prevent damage to the galvanized coating. Damaged pipe sections shall be immediately reported to the Departmental Representative and repaired and replaced according to his direction.

.5 Centreline of culvert shall not vary from the designated horizontal alignment by more than 75 mm. Invert grade shall not vary from the designated invert grade elevation by more than 12 mm provided positive flow is maintained.

3.4 CULVERT BACKFILL

.1 After assembly of the culvert on the bedding, the culvert shall be backfilled with approved granular and random backfill. Backfill shall be brought up on both sides of the culvert simultaneously and shall be compacted with a method approved by the Departmental Representative to a minimum density of 95% Standard Proctor.

.2 The backfill shall be spread and compacted in 150 mm layers and special care shall be taken to ensure proper filling and compacting under the haunches and within the culvert corrugations. Heavy equipment shall not be allowed over the culvert until a minimum of 0.5 m of fill is obtained above the crown of the pipe.

3.5 DITCH LINER ANCHORS

.1 Support the edge of the ditch liner. Bolt the flanged section to timber runners, as indicated.

3.6 STILLING BASIN

.1 Construct the stilling basin as indicated on the drawings and as directed by the Departmental Representative.

.2 Construct the stilling basin to drain into the ditch liner.

END OF SECTION

APPENDIX II

Erosion and Sediment Control Plan for Capping at Jo-Jo Lake
Technical Memorandum, August 2, 2011

TECHNICAL MEMORANDUM

DATE August 2, 2011

TO Robert Girvan
PWGSC

PROJECT No. 09-1427-0006/20000

AECOM DOC. No. 317-Baker_Creek-11-MEM-0004-Rev1_20110802

GAL DOC. No. 098

FROM Nathan Schmidt and John Hull

EMAIL nschmidt@golder.com; jhull@golder.com

EROSION & SEDIMENT CONTROL PLAN FOR TAILINGS CAPPING AT JO-JO LAKE, GIANT MINE SITE, YELLOWKNIFE, NT

1.0 INTRODUCTION AND DESCRIPTION OF WORK

This Erosion and Sediment Control Plan (ESCP) is prepared in part to support a submission in response to Indian and Northern Affairs Canada (INAC) Directive for NT Spill 11-159, dated 30 May 2011, requiring permanent mitigation of a historical tailings deposit in Jo-Jo Lake, at the north end of Baker Pond at the Giant Mine Site near Yellowknife, NT. The Directive requires that a plan be developed and implemented to permanently remove the potential of these tailings from coming in contact with the receiving environment.

The preliminary plan for permanent mitigation is presented in a letter to PWGSC dated 29 July 2011, to which this ESCP is attached. The plan includes the following activities:

- Placing a 0.5 to 0.6 m thick layer of gravel/coarse rock over the tailings deposit, and covering that layer with a 0.3 to 0.5 m thick layer of fine sand and organics to facilitate vegetation growth; and
- Constructing an engineered channel to convey Trapper Creek flows around the tailings cap.

Specifically, construction activities include capping the tailings area of approximately 14,000 m^2 with approximately 7,000 m^3 of coarse gravel/cobble and 5,500 to 6,000 m^3 of sandy cover layer. The channelization at Trapper Creek will involve approximately 2,000 to 3,000 m^3 of excavation, placement of 2,000 m^2 of geotextile and 1,000 m^3 of gravel.

The work will be completed between September and November 2011, commencing with channel construction, followed by capping of the areas closest to the land and finishing with capping of the areas furthest from the land.

2.0 REGULATORY REQUIREMENTS

Discussions with the INAC Water Resource Officer, subsequent to the Directive being issued, indicate that an ESCP is required as part of the plan to be submitted by August 1, 2011. In addition to this, the primary regulatory compliance requirement is that of the Canada *Fisheries Act*, Section 36(3), which is a general prohibition of the release of deleterious substances into water frequented by fish.

3.0 OBJECTIVES OF THE PLAN

The objectives of the ESCP are to provide guidance to:

a) Comply with the Directive requirements and federal regulations against deposition of deleterious substances in water bodies frequented by fish; and

b) Maintain the area during construction and after completion of the works in a condition that will not result in erosion or sediment deposition into Trapper Creek or Baker Pond.

4.0 RISK ASSESSMENT

Planned activities with a potential for surface disturbance include heavy equipment access, excavation, transport, stockpiling and placement of granular and organic materials, and surface clean-up. Planned excavation and material placement will occur “in the wet” in some areas.

The planned activities involve a surface disturbance of approximately 14,000 m^2. Land surface gradients in the construction area are low, and with the exception of Trapper Creek, concentrations of flowing water are not anticipated on disturbed surfaces. However, exposed soils will be fine-grained (high erodibility) and potential flow path lengths are greater than 70 m, indicating high erosion potential. The site is located in, and immediately adjacent to, fish-bearing water bodies (Trapper Creek and Baker Pond), meaning that the consequences of erosion and sedimentation are rated High by TAC (2005) criteria. This indicates the need to apply procedural BMPs, to develop a formal ESC Plan (this document) and consider applying structural BMPs for erosion and sediment control. Water quality monitoring may be required.

5.0 REQUIRED BMPS

A generic ESCP for the Giant Mine Site was developed for PWGSC and presented in a technical memorandum dated July 8, 2011. That document should be kept available at the construction site and is a supporting document for this site-specific ESCP. Site-specific aspects of the ESCP are referenced to the attached Figure 1.

Required Best Management Practices (BMPs) that shall be implemented during the planned activities include:

- Procedural BMPs:
  - Spill Prevention;
  - Surface Disturbance Prevention; and
  - Material Stockpiling.

- Structural BMPs (including Water Management):
  - Water Management BMPs;
  - Sediment Control BMPs; and
  - Erosion Control BMPs.
- Monitoring and Reporting.

BMPs applicable to each of these activities are described below.

5.1 Construction Sequencing

Construction sequencing is specified to minimize water management requirements, to reduce risks of erosion and sedimentation and to enhance constructability. Construction will commence with Trapper Creek channel construction. When that is complete, the inner portion of the tailings will be capped, moving outwards to meet the open water at Baker Pond. ESC BMPs will be applied as follows:

1) Throughout construction:
   a) Procedural BMPs will be applied.
2) Trapper Creek channel construction:
   a) The construction area will be isolated during construction to prevent sediment discharge. A gravel berm will be placed a the upper and lower ends of the channel to prevent inflow and outflow;
   b) Trapper Creek will flow along its existing alignment through the tailings area;
   c) The excavation area may require dewatering during construction. If so, water will be pumped to a settling tank before discharge to the upstream wetland area, rather than directly to Baker Pond; and
   d) At the completion of the Trapper Creek diversion phase, the inlet berm will be breached to allow the channel to fill, and left for a period of time to allow sediments to settle. Then, the outlet berm will be breached to allow flow to Baker Pond.
3) Jo-Jo Lake tailings cap construction:
   a) Highway drainage at the east side of the site will be managed by first inspecting, and if necessary, replacing the existing culverts under Highway 4 and the adjacent mine road. A small drainage swale will be constructed to convey drainage around the tailings area. This task may be done before, or during, the Trapper Creek channel work;
   b) Floating silt curtain will be installed in Baker Pond adjacent to the south boundary of the work area to isolate the in-water work area from the remainder of Baker Pond;
   c) Silt fence will be installed along the toe of the planned tailings cap on the east, west and northwest boundaries, to prevent runoff from conveying sediment into adjacent natural areas; and
   e) The silt fence and silt curtain will remain in place over winter to handle runoff during freshet.

4) Tailings area adjacent to Highway 4:

   a) The isolated tailings area to the west of Highway 4 and east of Jo-Jo Lake will be capped but no sand/organics layer will be placed;

   b) Culvert invert elevations in this area may need to be adjusted to provide positive drainage;

   c) The northern portion of this area will be isolated from the main east-to-west flow path by a silt fence, during construction; and

   d) The main east-to-west flow path will be armoured with a heavier gravel-cobble mix to provide additional erosion protection.

5.2 Procedural BMPs

5.2.1 Spill Prevention

1) Machinery shall arrive on site in a clean condition and is to be maintained free of fluid leaks.

2) Machinery shall be washed, refueled and serviced and fuel and other materials stored at least 100 m away from the water to prevent deleterious substances from entering the water body.

3) An emergency spill kit shall be kept on Site in case of fluid leaks or spills from machinery.

5.2.2 Surface Disturbance Prevention

1) Avoid removal of riparian and aquatic vegetation. Where removal is required, minimize removal and complete by hand, is if possible.

2) Avoid removal of terrestrial vegetation except where necessary to complete the activity.

3) Access the area only by existing paths. Surficial soils shall only be removed within the immediate excavation area. No surface disturbance is planned at material stockpile locations.

5.2.3 Material Handling, Stockpiling and Disposal

1) Care should be taken to keep equipment clean to prevent sediment from being carried off-site and deposited on roadways. Haul trucks shall be covered when operating on public roadways.

2) Material stockpiles will be placed inside work areas or at existing disturbed areas to protect land surfaces.

3) Material stockpiles will be placed so that sediment-laden runoff is subject to BMPs.

5.3 Structural BMPs (including Water Management)

5.3.1 Water Management

1) Construction sequencing means that Trapper Creek will not need to be diverted during construction. The new channel will be constructed while isolated, and flow diverted through the new channel when complete to allow the tailings cap to be constructed.

2) Water removed from the Trapper Creek diversion excavation will be pumped to a sedimentation tank or pond prior to release to the Trapper Creek wetland. Water shall not be pumped directly to Baker Pond.

3) Material stockpiles will be sited to avoid blocking overland flow paths, and/or bermed to convey flow around their perimeters and downstream, without bringing off-site water into the stockpiles.

5.3.2 Sediment Control

1) Sediment will be controlled at stockpile areas by berms and/or silt fences as described in Section 5.2.3.

2) Sediment mobilized in dewatering water will be managed as described in Section 5.3.1.

3) Sediment will be controlled at the capping area on land, by placing silt fence. Guidelines on proper use of silt fences are provided in the attached Factsheet 23.

4) Sediment will be controlled at the capping area in water, by placing a silt curtain. These shall be anchored to the shore and bed to prevent movement by wave or currents, and include a floating boom on top and shall be weighted to the bottom to prevent release of sediment.

5.3.3 Erosion Control - Surface Disturbance Restoration

1) The Trapper Creek diversion will be appropriately armoured to prevent erosion.

2) The tailings cap will be covered with a sandy organic mix to encourage revegetation. Surface gradients and runoff areas will be limited to reduce runoff velocities.

3) Seeding may be considered in 2012.

5.4 ESCP Monitoring and Reporting

1) Site inspections are planned on a weekly basis during remediation activities. These will include a visual inspection of disturbed and adjacent areas and observations of BMP performance.

2) Site inspections will include digital photography to establish a record of site conditions, completion of a site-specific inspection form and feedback to site personnel on required corrective actions, if any.

3) Site inspection reports will be compiled into a brief summary report at the completion of remediation activities.

6.0 REVIEW AND ACCOUNTABILITY

This ESCP was prepared to support regulatory applications and may be modified in response to approval requirements or to changing site conditions, to meet its stated objectives and to comply with applicable regulations.

Implementation of this ESCP is the responsibility of PWGSC, with the expectation that all Consultant (AECOM / Golder) and Contractor personnel will contribute to ESCP implementation and regulatory compliance. The ESCP shall be reviewed and signed off on by representatives of PWGSC, the Consultant and the Contractor prior to the commencement of site activities.

GOLDER ASSOCIATES LTD.

PWGSC Representative:	**Consultant Representative:**	**Contractor Representative:**
Name	Name	Name
Signature	Signature	Signature
Date	Date	Date

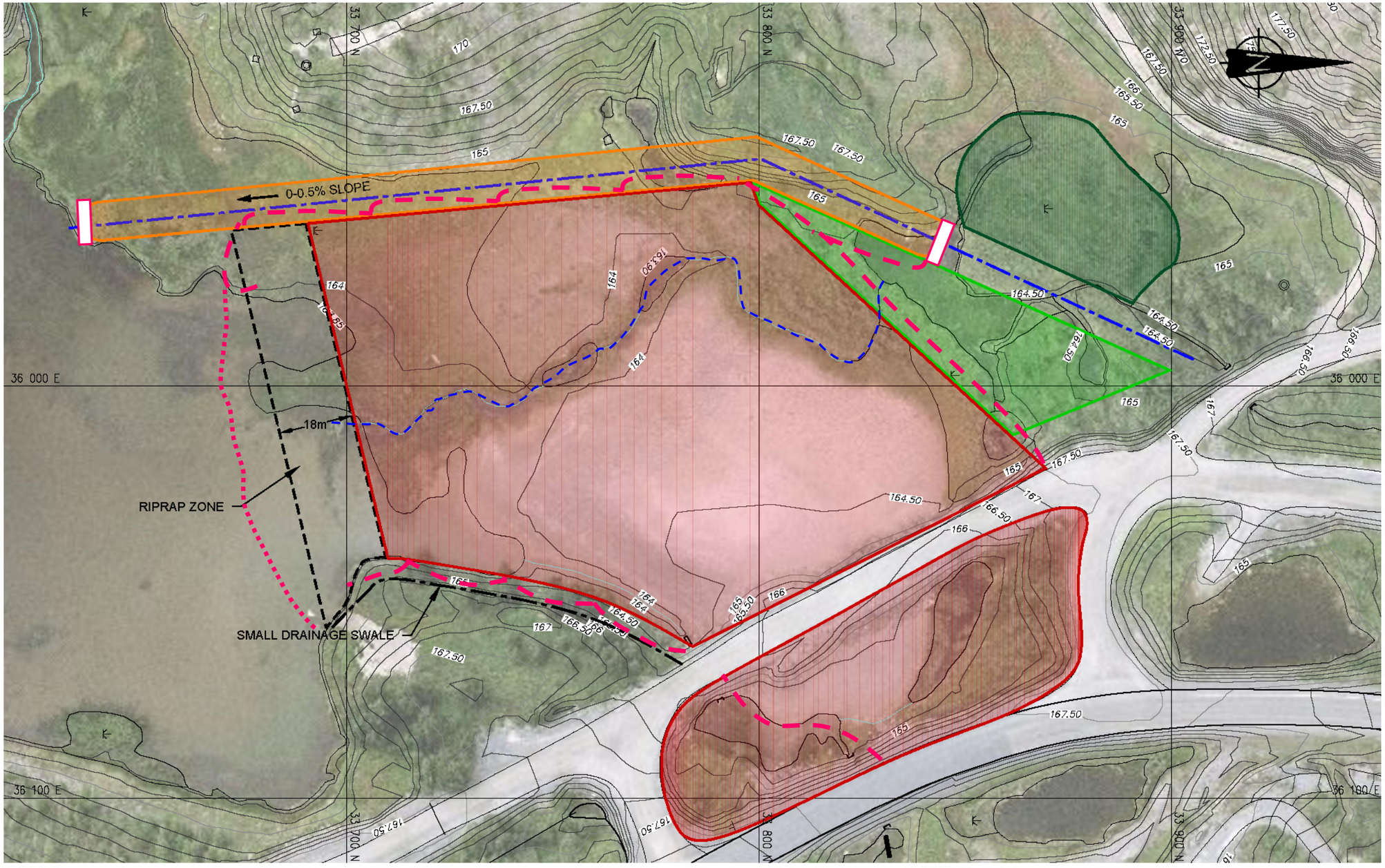
NS/JAH/rs

Attachments: Attachment 1: Erosion & Sediment Control Plan BMP Layout Drawing
Attachment 2: Giant Mine – Erosion and Sediment Control Guidelines (including BMP Factsheets) Technical Memorandum, July 8, 2011

\\bur1-s-filesrv2\final\2009\1427\09-1427-0006\3. correspondence\2 issued documents\word\phase 2\doc 098 mem 0728_11\317-baker_creek-11-mem-0004-rev1_20110802.doc

ATTACHMENT 1

Erosion & Sediment Control Plan
BMP Layout Drawing



LEGEND

- LOW AREA OR WET LAND
- LOW AREA BESIDE CREEK
- ENGINEERED CHANNEL
- AREA OF TAILINGS TO BE COVERED
- APPROXIMATE CREEK AND CHANNEL CENTERLINE
- APPROXIMATE RIPRAP BOUNDARY
- SMALL DRAINAGE SWALE
- SILT FENCE
- SILT CURTAIN
- TEMPORARY DITCH PLUG
- EXISTING TRAPPER CREEK

DRAFT
For Discussion Purposes Only

0 10 20 30 40 50
SCALE IN METRES

NOTES

1. TOPOGRAPHIC CONTOURS SHOWN ARE IN METRES TO GMRP DATUM AT 0.5m INTERVALS.
2. COORDINATES SHOWN ARE IN METRES GMRP GRID.
3. FAULT TRACES AND GEOLOGICAL CONTACTS BASED ON REGIONAL GEOLOGY PLAN. LOCATIONS MAY NOT BE ACCURATE.

REFERENCES

1. PWGSC, TOPOGRAPHIC CONTOURS, CAD FILES: GM-CONTOURS-pt5m-GRP.DWG, DATED NOVEMBER 16TH, 2009.
2. PWGSC, AERIAL PHOTOGRAPH, IMAGE FILE: GIANTMINE_GRP.SID, DATED NOVEMBER 24TH 2009.
3. ROYAL OAK MINES, REGIONAL GEOLOGY PLAN, CAD FILE: GIANT MINESITE GEOLOGY AND TOPO.DWG, DATED 1995.

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

REAL PROPERTY SERVICES
Western Region
SERVICES IMMOBILIERS
Région de l'ouest

PRELIMINARY
NOT FOR CONSTRUCTION

Revision/Revision	Description/Description	Date/Date
0	ISSUED FOR REVIEW	

Client/client

PUBLIC WORKS GOVERNMENT SERVICES CANADA

Project title/Titre du projet
GIANT MINE
REMEDIATION PROJECT
YELLOW KNIFE, N.W.T.

DRAWING MARK-UP

Approved by/Approuvé par

Designed by/Conçu par
W.D.

Drawn by/Dessiné par
D.T.

PWGSC Project Manager/Administrateur de Projets TPSGC
PWGSC

PWGSC, Architectural and Engineering Resources Manager/ Ressources Architectural et de Directeur d'ingénierie, TPSGC

Client/client
PWGSC

Drawing title/Titre du dessin

Erosion & Sediment Control Plan

BMP Layout Drawing

Project No./No. du projet	Sheet/Feuille	Revision no./ La révision no.
R.014204.311	FIGURE 1 OF 2	0

A0 – PWGSC – ANSI B–L1 – 11X17

0914270006_2000-01

ATTACHMENT 2

Giant Mine – Erosion and Sediment Control Guidelines (including BMP Factsheets)
Technical Memorandum, July 8, 2011

TECHNICAL MEMORANDUM

DATE	July 8, 2011	**PROJECT No.**	09-1427-0006/1500
TO	Robert Girvan PWGSC	**AECOM DOC. No**.	302-A1 Pit-6-MEM-0002-Rev1_20110708
CC	John Hull	**GAL DOC. No.**	057
FROM	Nathan Schmidt	**EMAIL**	nschmidt@golder.com

GIANT MINE – EROSION AND SEDIMENT CONTROL GUIDELINES

1.0 INTRODUCTION

This document is intended to provide guidance regarding design and application of 'Erosion and Sediment Control' (ESC) measures at the Giant Mine near Yellowknife, NT. It addresses:

- Relevant regulatory information;
- Physical fundamentals and how they should define ESC approaches;
- Selection and design of Best Management Practices (BMPs); and
- Implementation, monitoring and decommissioning.

This document is to provide guidance on developing plans for work with surface water features. It is recommended that plans for individual projects (*i.e.,* new ditches, etc.) consult this document to develop project specific 'Work Plans'. This is an overview document and it is not intended to be a comprehensive reference document. For a more detailed discussion of the concepts and methods discussed here, the reader should consult more detailed references such as those published by the Transportation Association of Canada (TAC 2005) or Alberta Transportation (AT 2003).

2.0 REGULATORY BACKGROUND

The primary piece of legislation applicable to ESC in Canada is the *Fisheries Act*. The *Act* addresses the deposition of deleterious substances into fish bearing waters. At the Giant Mine, the primary concern is with deposition of sediment into Great Slave Lake, Baker Creek, Baker Pond and non-fish bearing tributaries that may convey sediment to these waters. Specifically:

- Section 36(3) prohibits deposition of deleterious substances in waters frequented by fish;
- Section 38(4) establishes a requirement to report actual or imminent deposition of deleterious substances to federal authorities;

- Section 38(5) establishes a requirement to take measures to prevent or mitigate the adverse effects of deposition of deleterious substances;
- Section 38(6) grants Fisheries and Oceans Canada (DFO) and Environment Canada inspectors the authority to issue directives pertaining to deposition of deleterious substances. In the event of imminent or actual deposition, inspectors may order immediate actions to prevent, mitigate, counteract or remedy adverse effects; and
- Violations of Section 36 of the *Act* may result in fines of up to $1,000,000 or imprisonment of up to 6 months. Violations of Section 38 of the *Act* may result in fines of up to $200,000 or imprisonment of up to 3 months.

Runoff containing sediment is generally only permitted to be discharged to fish-bearing waters if concentrations are below background levels in the receiving stream, though some permits may allow modest exceedences of background levels.

The only defence against charges under the *Fisheries Act*, should an inadvertent release occur, is to establish that you took ***reasonable care*** to prevent such an occurrence (*i.e.,* you did everything a reasonable person should have done to prevent sediment release). Proving this requires documentation of your ESC approach, design, construction, monitoring and maintenance activities.

3.0 PHYSICAL FUNDAMENTALS

BMP approaches and designs must manage water, erosion and sedimentation to prevent off-site release of sediment.

Water erosion may occur on a range of scales:

- Splash erosion – occurs when raindrops detach particles from bare soil;
- Sheet erosion – occurs when particles detach from bare soil during uniform flow across a surface;
- Rill erosion – when sheet flow concentrates into preferential flow paths, the increased flow depth and velocity causes increased shear stresses, which detach soil particles and creates channels up to a few centimetres deep; and
- Gully erosion – when rills combine, increased flow rates and shear stresses can erode deeper and wider channels. Gullies were observed upstream of the A1 Pit during spring runoff in 2010, when sediment was deposited in Baker Creek.

Selected BMPs for erosion control are discussed in Section 4.0 and Appendix A.

Sedimentation occurs when flow velocity and turbulence fall below the threshold required to hold sediment in suspension or to move it along a channel bed. Sedimentation may occur:

- In receiving waterbodies – in slow-flowing or still areas, including lakes, ponds and pools upstream of riffles. Sediment may harm fish by abrading gills while it is in suspension, or by smothering spawning areas when it settles;

- In ponds, traps or basins – BMPs that are intended to manage sedimentation from relatively large areas include sediment ponds (custom-sized based on design hydrology), sediment basins (drainage areas of 2 to 40 ha) and sediment traps (drainage areas less than 2 ha); or
- In local BMPs – sedimentation from relatively small areas (up to 0.4 to 4 ha) can be managed using local BMPs, including vegetated or riparian zones, fibre rolls, silt fences, check dams.

Selected BMPs for sediment control are discussed in Section 4.0 and Appendix A.

Erosion potential can be described by the Revised Universal Soil Loss Equation (RUSLE), which incorporates the variables that govern the annual rate of soil loss from a given parcel of land. The RUSLE equation (Renard et al. 1996) is:

$$Average\ Annual\ Soil\ Loss = R \times K \times LS \times C \times P$$

Where:	R = Rainfall-runoff erosivity factor	K = Soil erodibility factor
	L = Slope length factor	S = Slope gradient factor
	C = Cover management factor	P = Erosion control practice factor

This equation is shown here only to illustrate the factors that we can, and cannot, control to manage erosion:

- R-factor values is defined by climate and cannot be changed;
- K-factor values is defined by soil type (see below), and can only be changed by placing or exposing surface soils;
- LS-factor values can be manipulated by managing topography (slope lengths and gradients);
- C-factor values can be manipulated by changing soil covers; and
- P-factor values can be manipulated by changing drainage patterns or runoff velocity, concentration or shear stresses.

RUSLE shows that erosion potential for a specific site can be accomplished most effectively by modifying topography (LS-factor), soil cover (C-factor) or runoff characteristics (P-factor).

The LS-factor can be modified by grading, but this must be compatible with mine planning constraints. The C- and P-factors are those that are most effectively modified by application of water management, erosion and sediment control BMPs (refer to Section 5).

Soil erodibility depends on particle size and cohesion. Larger particles (*e.g.,* gravel and sand) require higher energy flows for detachment and transport than smaller particles (*e.g.,* silt and loam). Clays have cohesive properties and may be more difficult to detach, though they are slower to settle out (flocculants may be required) once they are suspended in a flow. A hierarchy of soil erodibility is shown in Table 1.

Table 1: Heirarchy of Soil Erodibility (TAC 2005)

USDA Soil Texture (USCS Code)	Soil Erodibility Rating	Erodibility Classification	Soil Erodibility Rating	USDA Soil Texture (USCS Code)
Silt (SM, ML)	High	MOST	Low	Sandy Clay (SC)
Silty Loam (SM, ML)	High		Low	Clay (CI-CH)
Loam (OL)	High		Low	Heavy Clay (CH)
Silty Sand (SM)	High		Low	Loamy Sand (SC)
Sandy Loam (SM-SC)	Medium		Low	Sand (SW, SP)
Silty Clay Loam (CL)	Medium		Low	Poorly Graded Gravel (GP)
Sandy Clay Loam (CH)	Medium	LEAST	Low	Well-Graded Gravel (GW)
Silty Clay (CI, CL-CI)	Medium			

Surface soils at the Giant Mine vary from bedrock outcrops to the fine silts present in the overburden pile north of the A1 Pit. These fine silts take a very long time to settle out of suspension without flocculation, reinforcing the goal of preventing erosion in the first place, rather than managing sediment once it is present in runoff water.

4.0 FUNDAMENTAL APPROACHES

An effective ESC Plan should incorporate the following approaches:

- ***Keep the Clean Water Clean:*** Conveying upstream runoff around a disturbed area is the best way to reduce the amount of sediment-laden water that must be managed. Allowing upstream runoff into a disturbed area will increase the erosion potential as well as the amount of "dirty" water that must be managed. Upstream runoff may be conveyed around or through the site using natural or engineered channels;
- ***Erosion Control is Job #1:*** Preventing soil particles from being detached will reduce erosion, reduce quantities of sediment that will need to be managed by sediment control BMPs, and limit the risk of sediment release off-site;
- ***Sediment Control is Job #2:*** Sediment control is a second line of defence that is intended to manage any sediment that is mobilized despite upstream applications of erosion control measures. It is much more difficult to manage suspended sediment than to prevent erosion;
- ***Erosion & Sediment Control BMPs are most effective when applied closer to the source:*** Many BMPs can only be applied to runoff from small drainage areas. Particularly for sediment control BMPs, exceeding design flows can cause failures. When sediment is trapped closer to the source, it is trapped further from off-site waterbodies; and
- ***Procedural BMPs Apply to Virtually ALL Activities:*** Procedural BMPs or "Good Housekeeping" practices should be considered for almost all activities. These are non-physical measures or approaches that can reduce risks of off-site sediment release.

5.0 BEST MANAGEMENT PRACTICES

5.1 BMP Alternatives

TAC (2005) discusses a range of procedural, water management, erosion control and sediment control BMPs. Selected BMPs that may be appropriate for use at the Giant Mine are excerpted in the following tables, and fact sheets describing the erosion and sediment control BMPs in more detail are provided as an attachment.

Table 2: Procedural BMPs for ESC at Giant Mine (TAC 2005)

Name		Applicability							Comments		
		Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent
Site Management	Design and Implement ESCP	✓	✓	✓	✓	✓	✓	✓	It is essential to properly design and implement a site-specific ESCP to reduce erosion and ensure that sediment is not released from the construction site. This includes monitoring, maintenance and decommissioning.		✓
	Minimize Exposed Soils	✓	✓	✓	✓	✓	✓		By minimizing the total disturbed soil area and the disturbed soil area at any time, the erosion potential is reduced and the quantity of sediment control measures is reduced. Stripping of new areas should be delayed as long as possible and restoration of constructed areas should be done as soon as possible.	✓	
	Site Access Management	✓				✓		✓	The site should be accessible from a limited number of points. Frequently-used access roads should be paved or graveled to minimize the tracking of material off site. Vehicle washing on stabilized worksite entrances will minimize off-site sediment tracking.	✓	
	Stockpile Management						✓		Stockpiles should not be located near watercourses, adjacent developed areas or environmentally sensitive areas. Stockpiles should be protected against erosion by water and wind immediately after they are established. This can be done by seeding, hydroseeding or applying a synthetic cover.	✓	
	Dust Management	✓				✓	✓		Wind-blown dust from disturbed soil and roadway surfaces can be minimized by: ■ Seeding or mulching areas that will not be traveled on; ■ Constructing wind breaks or screens; ■ Enforcing reduced vehicle speeds on unpaved roads; and ■ Using water or chemicals for dust control. Note that care must be taken to prevent mud tracking if this is done.	✓	✓

Name		Applicability							Comments		
		Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent
Scheduling	Maximize Favorable Weather	✓	✓	✓	✓	✓	✓	✓	Erosion potential is reduced by working during relatively dry conditions. This includes consideration of the season of construction and may require a larger number of resources to complete the project in a shorter time.	✓	
	Prepare for Shutdowns	✓	✓	✓	✓	✓	✓	✓	Be prepared for planned or unplanned work stoppages, including winter shutdowns.	✓	
	Install BMPs Early	✓	✓	✓	✓	✓	✓	✓	Erosion potential can be minimized by installing ESC BMPs as soon as possible. Soil should never be exposed before developing an ESCP and ESC measures should be installed as early as is practical. Early installation may require site access or traffic control considerations.	✓	
	Restore Early	✓	✓	✓	✓	✓			Erosion potential can be minimized by restoring or reclaiming constructed areas as soon as possible by topsoiling and seeding. Temporary works (*i.e.,* detention ponds, sediment controls) should be removed as soon as practical when they are no longer needed.	✓	

Table 3: Surface Water Management BMPs for ESC at Giant Mine (TAC 2005)

Name	Applicability							Comments		
	Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent
Divert Clean Water Around the Site	✓	✓	✓	✓	✓	✓	✓	Clean water drainage from upstream areas should be diverted around the construction site wherever practical, to reduce the quantity of water that must be managed on site. This can be done using ditches, berms, pipes or culverts as appropriate.	✓	
Keep Clean Water on the Site Clean	✓	✓	✓	✓	✓	✓		Clean water drainage from undisturbed areas within the construction site should be collected and allowed to discharge to receiving streams without being mixed with runoff from disturbed areas.	✓	
Use Existing Drainage		✓	✓	✓				Existing watercourses tend to be well-vegetated and have natural rates of erosion. Discharges from the construction site containing natural levels of sediment should be conveyed to existing, undisturbed watercourses. Care should be taken to ensure that peak flows in the existing watercourse should not be increased significantly (*i.e.,* more than 30% increase in the 10-year flood event).	✓	
Integrate New Drainage into the Project Design		✓	✓	✓				If it is necessary to construct new ditches, pipes or culverts for on-site surface water management, integrating these with the project design will prevent future disturbance due to removal of temporary measures.	✓	✓
Keep Drainage Areas Small	✓	✓	✓	✓	✓	✓		Smaller drainage areas generally require less complex erosion control BMP arrangements and smaller drainage channels, so they are preferred if local topography permits. By discharging from a number of small discharge points rather than a few large ones, the size of sediment control measures is reduced and the magnitude of effects from a potential failure is reduced.	✓	✓
Design Drainage Channels Appropriately		✓	✓					Drainage channels should be designed with appropriate depths, slopes, cross-sections and linings (armored or vegetated). Natural channel design is recommended for watercourse diversions.	✓	✓
Manage Shallow Groundwater	✓					✓		Slopes, excavations and areas around retaining walls may be sensitive to piping failure or erosion due to high pore water pressures. These can be managed by temporary dewatering or by incorporating permanent drains to reduce pore water pressures. Aggregate or rock covers (refer to erosion control BMPs) can also be installed to protect the ground surface. Dewatering wells, if properly screened, may produce clean water and be suitable for direct discharge to receiving streams.	✓	✓

Table 4: Erosion Control BMPs (Exposed Surface Protection) for ESC at Giant Mine (TAC 2005)

Name			Applicability							Comments			BMP
			Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent	
Exposed Surface Protection	Vegetated	Topsoiling	✓		✓		✓	✓	✓	Topsoil absorbs energy from rain splash and provides water storage and an essential medium to support vegetation. It must be applied with seed or sod and soil moisture must be managed. Topsoil should not be applied to slopes steeper than a target maximum of 3H:1V with an absolute maximum of 2.5H:1V to 2H:1V, depending on the region.		✓	1
		Seeding	✓		✓		✓	✓	✓	Applying seed during restoration allows control over vegetation that will develop. Seeded areas are susceptible to erosion until leaf and root masses are developed, so monitoring is required. Contouring and reseeding will be required if erosion occurs.	✓	✓	2
		Mulching	✓		✓		✓	✓	✓	Mulching is effective at protecting exposed areas from rain splash erosion for short periods. It preserves soil moisture and protects germinating seeds to promote revegetation. Mulching on steep slopes may not be effective.	✓	✓	3
		Hydro-Seeding or Hydro-Mulching	✓		✓		✓	✓	✓	Seeding with mulch is an effective way of achieving higher germination rates and reducing erosion potential before substantial revegetation. Tackifier applied during hydro-seeding or hydro-mulching can provide immediate protection during germination and revegetation and is more effective on steep slopes.	✓	✓	4
		Riparian Zone Preservation		✓						Watercourse erosion potential is significantly reduced by preserving natural vegetation, to reduce runoff velocity and enhance infiltration.		✓	7

Name			Applicability							Comments			BMP
			Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent	
	Non-Vegetated	Riprap / Gabions	✓	✓	✓	✓				Riprap and gabions provide a flexible channel lining for protection against flowing water and can be used to construct drop structures and energy dissipation structures. Rock structure construction is relatively expensive and labor-intensive.		✓	8 / 9
		Aggregate or Rock Cover	✓	✓	✓	✓				Gravel and rock blankets can stabilize soil surfaces including areas with seepage piping erosion. Rock revetments are increasingly used to restore slumping areas in high precipitation regions. Aggregate and rock covers should be designed by a qualified engineer.		✓	10
		Stabilized Worksite Entrances							✓	Gravel pads located at site entrances can reduce the amount of sediment carried off construction sites by vehicles, by collecting sediment from vehicle washing. They should include a water supply to wash off excess soil from vehicles prior to leaving the site.	✓		11
		Rolled Erosion Control Products	✓		✓			✓		Rolled Erosion Control Products (RECP) provide a high degree of uniform and long-lasting erosion protection. Care should be taken to ensure that the product is suitable for the intended application and that it is applied in accord with the manufacturer's specifications. Permeable RECPs are used in conjunction with vegetation. Impermeable RECPs may be used for protection of stockpiles and if used as such, it may be necessary to protect areas where runoff is concentrated.	✓	✓	12

A recently-developed BMP for exposed surface protection is the Verdyol Biotic Earth application, which has been applied with success to northern locations (http://www.bioticearth.com/). It may be worthwhile to examine the economics and efficacy of this product at the Giant Mine, particularly for areas with highly erodible soils.

Table 5: Erosion Control BMPs (Runoff Control) for ESC at Giant Mine (TAC 2005)

Name		Applicability							Comments			BMP
		Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent	
Runoff Control	Slope Texturing / Grading	✓				✓	✓	✓	Slopes or flat surfaces may be textured using tracked equipment or a sheepsfoot packer. A rough slope retains more water, sediment and seed. This method is most suitable for application to clayey soils. Where possible, slopes can be graded and shaped to divert flows away from sensitive areas. Flatter slopes have less erosion potential. Where steep slopes are unavoidable, interceptor ditches can be effective in reducing effective slope lengths.	✓	✓	15
	Slope Drains	✓			✓				Slope drains convey surface water downslope through a pipe rather than over erodible soils. Pipes must be sized appropriately, anchored to the slope and provided with inlet and outlet erosion protection.	✓	✓	16
	Synthetic Permeable Barriers	✓							Synthetic permeable barriers reduce runoff velocities and are partially effective in retaining sediments. They can be moved and reused and are typically used as grade breaks on steep grades, in conjunction with drop structures. Synthetic barriers are easily damaged by construction or off-road traffic and become brittle in cold temperatures.	✓		18
	Fibre Rolls and Wattles	✓							Fibre rolls and wattles slow runoff and trap silt and can be effective on steep slopes. They function well in freeze-thaw conditions and are biodegradable. They are labor-intensive to install and are applicable to short slope lengths at a maximum slope of 1H:1V.	✓		19
	Check Dams			✓					Check dams can be constructed of rock, aggregate-filled sandbags, straw bales or logs to reduce flow velocities in drainage channels. Regular inspection and maintenance of such structures is essential to their effective operation.	✓	✓	20
	Diversion Ditch / Berm	✓		✓		✓	✓	✓	Diversion ditches, often combined with berms above steep slopes, can be used to collect runoff at the top of a slope and convey it around exposed areas. Berms on steep slopes should never be built without drainage ditches.		✓	21
	Energy Dissipator	✓		✓	✓				Rock riprap, gabions or sandbags can be installed at areas such as culvert outlets or drop structures to reduce flow velocities and protect against erosion. Dissipators with high flow rates should be designed by a qualified professional.		✓	22

Table 6: Sediment Control BMPs for ESC at Giant Mine (TAC 2005)

Name		Applicability							Comments			BMP
		Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent	
Infiltration-Trapping	Vegetated Buffer Strip or Sod Strip	✓	✓	✓	✓			✓	Vegetated buffer strips slow runoff velocities on slopes and encourage infiltration to trap sediment and reduce runoff volumes. Sod filters slow runoff velocities on slopes and encourage infiltration to trap sediment and reduce runoff volumes. They provide immediate protection to vegetated watercourses and entrances of drain inlets.		✓	5
	Riparian Zone Preservation		✓						Natural vegetation can slow runoff through surface vegetation and trap it by infiltration or by settling as the flow velocity reduces within the vegetation. Freshly planted riparian vegetation is not as effective as that in well-established areas.		✓	7
	Silt Fence	✓			✓		✓	✓	Silt fences create ponding to allow silt and larger sediment fractions to settle out. They are applicable to sheet flow sediment control only and require space to allow ponds to form upstream. Failure of the fence may create flow concentrations and cause erosion. Silt fences have a service life of approximately one year, must have sediment removed frequently. They are susceptible to damage during sediment removal.	✓		23
	Brush or Rock Berm	✓	✓					✓	Timber and granular material salvaged during clearing and grubbing can be wrapped with geotextile to construct an effective berm. Brush or rock filters tend to be more expensive than silt fence, do not divert runoff and are expensive to remove. They should not be used in channels or ditches with high flows.	✓		24

Name	Applicability							Comments			BMP
	Slopes	Natural Channels	Drainage Channels	Pipes and Culverts	Large Flat Surface	Borrow / Stockpile	Adjacent Properties		Temporary	Permanent	
Earth Dyke Barrier	✓		✓					Earth dyke barriers are constructed of compacted soil and are installed on contour to intercept and create ponding of sheet or overland flow.	✓	✓	27
Check Dams			✓					Check dams may be constructed of rock, aggregate-filled sand bags, straw bales or logs. These reduce upstream flow velocities to control channel erosion and encourage settlement of coarse sediments. Check dam installation is labor-intensive and they are susceptible to failure if they are undermined or outflanked.	✓	✓	20
Sediment Basin or Trap			✓					Sediment basins and traps reduce flow velocities and encourage sediment deposition. Sediment basins and traps can occupy large areas of land, require maintenance to remove sediment and must be designed by qualified personnel.		✓	28

5.2 BMP Selection and Design

The tables in Section 5.1 provide a list of BMPs that can be considered for managing erosion and sedimentation at the Giant Mine. Applications of specific BMPs will depend on topography, soil type, drainage area and whether the application is permanent or temporary.

A generic strategy for selection and design includes the following steps:

1) Specify applicable procedural BMPs for the planned activity in a project specific ESC work plan. It may be practical to develop a generic template for activities that require a formal ESC Plan that includes procedural BMPs and other documentation as discussed in Section 6.0.

2) Define drainage areas and flow paths. Where possible, divert upstream water around areas with exposed soils. Consider BMPs presented in Table 3.

3) Specify erosion control measures, including those for exposed surface protection (Table 4) and runoff control (Table 5). It is important to consult the fact sheets provided in Appendix A to ensure that application of any specific BMP is appropriate for the location to satisfy the objective. *Remember that erosion control is Job #1!*

4) Specify sediment control measures. For small drainage areas, it may be possible to manage sediment using local BMPs (silt fence, check dams), while for larger areas, sediment basins may be required. At the Giant Mine, it may be possible (or necessary) to convey runoff to mine water sumps or to the underground until upstream surfaces are stabilized.

5) Specify monitoring and maintenance requirements and develop inspection checklists. Implement the ESC Plan.

6.0 DOCUMENTATION, MONITORING AND MAINTENANCE

As noted in Section 2, if a potential *Fisheries Act* violation occurs, your best legal defence is to establish that you acted with ***reasonable care***. To demonstrate this, it is generally not sufficient to just install some BMPs – it is important to document the plan, its implementation and any monitoring and maintenance activities that are undertaken. An ESC Plan should include:

- Assignment of responsibilities for development and implementation of the Plan;
- Description of the project site or work area, including soils, terrain, runoff characteristics and planned activities;
- Evaluation of the risks of erosion and sedimentation at the specific site, to prioritize actions and define an appropriate level of effort;
- Specification and design of specific BMPs. It is often convenient to overlay the BMP layout on a plan view design drawing or aerial photograph;
- Details of project schedule, monitoring, maintenance, contingency, temporary shut-down decommissioning plans and procedure to report events to project managers and if needed to DFO; and
- Ongoing records of monitoring and maintenance.

A copy of the ESC Plan for each project should be kept on-site and should be treated as a “living document” until the project is accepted as complete. Project phasing or progress may require Plan revisions or updates.

Monitoring and maintenance records should include photographs and inspection notes. It is recommended that ESC inspections occur on a weekly basis during unfrozen conditions (open water), as well as after significant (greater than 25 mm water depth) runoff events until the project is marked as ‘complete’.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Nathan Schmidt, Ph.D., P.Eng.
Principal, Senior Water Resources Engineer

ORIGINAL SIGNED

John Hull, P.Eng.
Principal, Senior Geotechnical Engineer

NS/JAH/rs

Attachments: Appendix A: BMP Fact Sheets

\\bur1-s-filesrv2\final\2009\1427\09-1427-0006\3. correspondence\2 issued documents\word\phase 2\doc 057 tm 0503_11\302-a1 pit-6-mem-0002-rev1_20110708.doc

REFERENCES

AT (Alberta Transportation). 2003. Design Guidelines for Erosion and Sediment Control for Highways. March 2003 (Revised May 2003). http://www.transportation.alberta.ca/1812.htm.

Renard, K.G., G.R. Foster, G.A. Wessies, D.K. McCool, D.C. Yoder, Coordinators. 1996. Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation (RUSLE). US Department of Agriculture, Agriculture Handbook No. 703.

TAC (Transportation Association of Canada). 2005. National Guide to Erosion and Sediment Control on Roadway Projects. May 2005. https://vws3.primus.ca/www.tac-atc.ca/english/bookstore/products.cfm?catid=18&subcatid=29&prodid=165.

APPENDIX A
BMP Fact Sheets

The attached BMP fact sheets are excerpted from TAC (2005). They were adapted from those presented by Alberta Transportation (2003), with the original source freely available from the Alberta Transportation web site. This does not represent an exhaustive list of available BMPs and is not intended to exclude others that may be considered for application at the Giant Mine.

Erosion Control and Sediment Control BMPs Considered for Application at Giant Mine

BMP	Description	Erosion Control		Sediment Control	BMP	Description	Erosion Control		Sediment Control
		Exposed Surface Protection	Runoff Control				Exposed Surface Protection	Runoff Control	
1	Topsoiling	✓			15	Slope Texturing/Grading		✓	
2	Seeding	✓			16	Slope Drains		✓	
3	Mulching	✓			18	Synthetic Permeable Barrier		✓	✓
4	Hydroseeding-Hydromulching	✓			19	Fibre Rolls and Wattles		✓	✓
5	Sodding	✓		✓	20	Check Dam		✓	✓
7	Riparian Zone Preservation	✓		✓	21	Diversion Ditch		✓	
8	Riprap Armouring	✓			22	Energy Dissipators		✓	
9	Gabions	✓			23	Silt Fence			✓
10	Aggregate Cover	✓			24	Brush or Rock Berm			✓
11	Stabilized Worksite Entrance	✓			27	Earth Dyke Barrier			✓
12	Rolled Erosion Control Products (RECP)	✓			28	Sediment Traps and Basins			✓

Topsoiling

Erosion Control:
Exposed Surface Protection – Vegetated

BMP1

Description and Purpose

- The covering of exposed mineral soils with soils of high organic content to minimize raindrop erosion potential
- Provides a medium for vegetation to grow

Applications

- Permanent measure
- May be used to provide a bedding medium for seed germination and a cover to exposed soil that is not suitable to promote vegetation growth
- May be used on slopes with a maximum gradient of 2H:1V
- Normally topsoil is placed prior to seeding, mulching, hydroseeding-hydromulching, seeding and installing rolled erosion control products (RECP), or planting of trees/shrubs

Advantages

- Placing topsoil provides enriched organic medium for vegetation root structure to grow
- Topsoil organic content provides nutrients to promote plant growth
- Absorbs raindrop energy to reduce erosion

Limitations

- Not appropriate for slopes steeper than 2H:1V
- Dry topsoil may be removed by blowing wind
- Topsoil may not be readily available in some areas

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Prepare ground surface to final grade by removing large rocks or other deleterious materials
- Apply topsoil with dozer or light track equipment to design thickness
- Track walk upslope or downslope (do not overcompact topsoil by heavy equipment; only track walk one pass) to provide a contour of roughness of topsoil to further minimize erosion

Topsoiling

Erosion Control:
Exposed Surface Protection – Vegetated

BMP1

Construction Considerations

- Topsoil should be free of weeds which may inhibit re-vegetation of desirable plants
- Subgrade should be roughened by track walking up/down the slope prior to topsoiling to promote adhering of topsoil to subgrade (surface roughening of subgrade is especially required if topsoiling is not scheduled immediately after completion of the grade)
- Topsoil should be moistened regularly during periods of hot dry weather to minimize wind erosion
- Hydroseeding-hydromulching topsoil will minimize wind erosion of topsoil
- All available topsoil stripped for construction should be stockpiled and reused
- Seeding should follow as soon as possible after the topsoil has been placed, to reduce the possibility of it being eroded away by water or wind

Inspection and Maintenance

- Inspect topsoiled areas at least once per month after initial application or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rilling should be regraded and re-topsoiled immediately

Similar Measures

- Hydroseeding-hydromulching
- Mulching
- Rolled erosion control products (RECP)

Seeding

Erosion Control:
Exposed Surface Protection – Vegetated

BMP2

Description and Purpose

- The planting or placing seed into soils of cut slope or fill embankment slopes after a layer of organic topsoil is spread over the slope
- Provides erosion protection through development of a shallow root structure from seed germination and plant growth

Applications

- Permanent or temporary measure
- Temporary seeding with rapidly growing plants may be applied to stockpile or excavation areas which will be exposed for more than 30 days
- Permanent seeding may be applied to exposed bare soil areas which have been graded to final contours
- Permanent seeding may be applied to landscape corridors, slopes and channels by broadcasting, furrowing or spraying on with mulch tackifier
- Provides habitat for wildlife after vegetation establishment
- Can be enhanced with a protective layer of mulches or rolled erosion control products (RECP) to improve growth environment

Advantages

- Enhances terrestrial and aquatic habitat with vegetation growth re-establishment
- Aesthetically pleasing with vegetation cover
- Grows stronger with time as root structure develops
- Generates vegetation to enhance infiltration of runoff and evapotranspiration
- Seeding with a mixture of grasses and herbaceous legumes in disturbed areas is an inexpensive method of stabilizing soil, particularly if the area is flat or gently sloping
- Cost of seeding disturbed areas is relatively low and its effectiveness on a long-term basis is relatively high

Limitations

- Grasses may require regular maintenance (mowing) along ditches
- Uncut dry grass may present a fire hazard and site distance obstruction adverse to highway safety
- Seeding of steep slopes may be difficult without using measures such as RECP's or hydroseeding-hydromulching methods
- Seasonal windows on planting (early spring or fall) may not coincide favourably with construction schedule
- Areas that have been covered with seeded topsoil are susceptible to erosion until vegetation is established if RECP are not used.

  - Use of topsoil and mulch can reduce rain drop erosion potential during germination and until vegetation is established
  - Additional erosion control measures, such as RECP, may be required for steep slopes and channels
- Reseeding will be required in areas of limited plant growth
- Time to establish root structure may be unacceptable for some high risk areas; sodding should be considered for these areas

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- The site to be seeded should be prepared prior to seeding
  - Surface should be graded to design grades and then topsoiled
  - Topsoil should be roughened, harrowed, or grooved
  - Seedbed should be 75 to 150 mm deep, with the top 75 mm consisting of topsoil free of large clods or stones
- Seed should be applied immediately after seedbed preparation using broadcast seed spreaders, cyclone (broadcast) spreaders, or seed drills to ensure uniformity of application
- Seedbed should be harrowed, raked, or chain-dragged to ensure proper seed-soil contact
- If soil tests indicate that fertilization is necessary, an appropriate soil amendment should be selected and applied with care; fertilizer use should be carefully controlled as this may increase nutrient loading to receiving streams if runoff is not controlled properly

Construction Considerations

- Selection of proper vegetation seed mix depends on soil conditions, climate conditions, topography, land use, and site location
  - Selected seed mixes must be appropriate for site specific conditions
  - Some jurisdictions have developed recommended seed mixes for specific regions based on historic performance results
  - Qualified agronomists or agrologists should be consulted if a suitable seed mix is not identified
- Seeding rate should be specified according to the type of grass being sown. Natural grasses and high quality tame mixes may require lower rates of application
- Fall rye or oats may be added as a companion crop to provide early growth and protection from soil erosion

- Planting of seeds by hydraulic seeding and mulching techniques should be considered for slopes steeper than 3H:1V, or where application of seed, mulch, and fertilizer in one continuous operation is desirable
- Sod may be installed for faster results, however it is very costly but essential for high risk sensitive areas
- If mulch is placed as a germination medium for seeds, the mulch layer may be further protected with a biodegradable matting to prevent mulch from being washed or blown away

Inspection and Maintenance

- Inspect seeded areas one year after initial seeding or after significant storm events to evaluate germination and seedling density results
- Freshly seeded areas should be inspected frequently to ensure growth is progressing
- Additional erosion control measures should be considered for areas damaged by runoff
- Reseedings may be required within 1 to 5 year intervals after initial seeding
- Small bare spots may need to be reseeded several times at subsequent years after initial application; larger areas may need to be completely retreated
- Cutting or mowing grasses will encourage the establishment and spread of the grass
- If a proper window for seeding is not available, then temporary seeding with fall rye or oats can take place; the area can be overseeded with a permanent mix when a proper seeding window is open

Similar Measures

- Hydraulic seeding and mulching
- Sodding

Design Considerations

- Seeding rate should be specified based on the mix and type of grasses; native seeds should be applied on a pure live seed (PLS) basis
- When using a seed drill or brillion seeder, grasses and legumes should not be planted deeper than 1 cm
- Bacterial inoculants must be used when seeding with legumes
- Seeding should occur during periods when germination can be successful and plants have sufficient time to become established before the end of the growing season
- If seeding occurs after the 50% frost probability date for the site, a dormant seeding method should be used; the seed should be applied late in the season when there is

no chance of germination, and applied with a seed drill so cold temperatures do not damage the seed

- Mulch is required when broadcast seeding or if seeding is carried out after the date specified in which fall seeding should not be carried out
- For specific needs of local growth environment, specific design and advice from local seed supplier or professional agrologist may be required
- Soil testing should be performed to determine an appropriate fertilizer, if any, and rate of application

Mulching

Erosion Control:
Exposed Surface Protection – Vegetated

BMP3

Description and Purpose

- Application of organic material or other normally biodegradable substances as a protection layer to the soil surface to:
  - minimize raindrop/runoff erosion and conserve a desirable soil moisture property for plant growth; and
  - promote seed germination and plant growth
- Mulches conserve soil moisture, reduce runoff velocities and surface erosion, control weeds, help establish plant cover, and protect seeds from predators, raindrop impact, and wind/water erosion

Applications

- Can be used to provide temporary and permanent erosion control
- Can be used as an organic cover or growth medium for seeds where topsoil is not readily available
- May be used with or without seeding in areas that are rough graded or final graded
- May be applied in conjunction with seeding to promote plant growth
- May comprise organic mulches (such as straw, wood fibres, peat moss, wood chips, pine needles, compost) or chemical mulches (such as vinyl compounds, asphalt, rubber, or other water-mixed substances)
- Chemical mulches may be used to bind other mulches in a hydroseeding-hydromulching application

Advantages

- Relatively cheap method of promoting plant growth and slope protection

Limitations

- Application of mulch may be difficult on steep slopes
- May require spray-on method to apply mulch with tackifier to provide adhesion to steep slopes

Installation

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil and seed, if required, subject to topsoil availability
- Apply mulch as per supplier's recommendations
- Certain mulches may require additional anchoring to minimize loss of mulch due to wind or water erosion

Mulching

Erosion Control:
Exposed Surface Protection – Vegetated

BMP3

Construction Considerations

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Install mulches as per manufacturer or supplier recommendations
- Mulches may be crimped into the ground using a disk or tracking method to prevent movement by blowing wind or water
- Organic Mulches
  - Straw
    - Refers to stalks or stems of small grain (primarily wheat) after drying and threshing
    - Straw should be free of weeds
    - Loose straw is very susceptible to movement by blowing wind and water runoff and should be anchored either with chemical tackifier or some form of netting
    - When properly secured to surface, straw is highly suitable for promoting good grass cover quickly, however, it may be a fire hazard in dry conditions
  - Raw Wood Fibre
    - Mixture of cellulose fibres a minimum of 4 mm in length extracted from wood
    - Wood fibres usually require a soil binder and should not be used as erosion control during periods of hot dry weather in the summer or for late fall seeding unless it is used in conjunction with another suitable mulch as it is prone to removal by blowing wind or water runoff
    - Wood fibre is primarily used in hydroseeding-hydromulching operations where it is applied as part of a slurry and when used in conjunction with a tackifier, it is well suited for tacking straw mulch on steep slopes
  - Peat Moss
    - Comprises partly decomposed mosses and organic matter under conditions of excessive moisture
    - Usually available in dried and compressed bundles
    - Should be free of coarse material
    - Useful soil conditioner to improve organic content of soil promoting plant growth
    - Highly susceptible to removal by blowing wind and water runoff if dry and spread on top of soil
    - Should be tested for pH prior to use; may require a soil amendment to prevent acidity from inhibiting vegetation growth
  - Wood Chips
    - By-products of timber processing comprised of small, thin pieces of wood
    - Decompose slowly
    - Suitable for placing around individual plants (shrubs and trees) and for areas that will not be closely mowed

  - Highly resistant to removal by blowing wind and water runoff
- Bark Chips (Shredded Bark)
  - By-products of timber processing comprised of small, thin pieces of tree bark
  - Suitable for areas that will not be closely mowed
  - Have good moisture retention properties and are resistant to removal by blowing wind and water runoff
- Pine Needles
  - Comprise needles from coniferous trees (pine, spruce)
  - Needles should be air dried and free of coarse material
  - Decompose slowly
  - Suitable for use with plants that require acidic soils
  - Resistant to removal by blowing wind and water runoff
  - Pine needles may inhibit growth of other vegetation
- Compost (Straw Manure)
  - Comprised of organic residues and straw that have undergone biological decomposition until stable
  - Should be well shredded, free from coarse material, and not wet
  - Has good moisture retention properties and is suitable as a soil conditioner promoting plant growth
  - Relatively resistant to removal by blowing wind and water runoff if not dried out completely

- Chemical Mulches
  - Comprised of acrylic co-polymers, vinyl compounds, asphalt, rubber, or other substances mixed with water
  - Usually used in hydroseeding-hydromulching applications
  - Should be applied in accordance with supplier's recommendations

Inspection and Maintenance

- Inspect mulched areas at least once per year or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rilling should be regraded if necessary and recovered with mulch immediately
- Additional stormwater control measures should be considered for areas of severe rilling erosion damaged by runoff
- Small bare spots may need to be reseeding and recovered with mulch

Similar Measures

- Topsoiling
- Hydraulic seeding and mulching (hydroseeding, hydromulching)
- Rolled erosion control products (RECP)

This page left blank intentionally.

Hydroseeding-Hydromulching

Erosion Control:
Exposed Surface Protection – Vegetated

BMP4

Description and Purpose

- The spraying-on of a slurry to a slope or channel surface to provide a layer of seed and growth bedding medium
- The slurry consists of seed, fertilizer, mulch, tackifiers, and water which are mixed together in a tank
- Enables quick re-vegetation of very steep or rocky/gravelly slopes where re-vegetation by any other method would be very difficult or unsafe; frequent re-seeding and special mix design may be required
- When sprayed on the soil, the slurry forms a continuous blanket with seeds and protects the soil from wind and water erosion and raindrop impact by aggregating (or adhering) them in place
- The slurry conserves moisture, reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation/drying of soil

Applications

- Can be used to provide temporary erosion control prior to establishment of permanent vegetation
- Slurry is held in suspension through consistent agitation and is sprayed onto disturbed areas using high pressure pumps
- Can be used for spray-on seeding covering large areas efficiently after placement of topsoil
- May be used to provide soil stabilization for seeding disturbed soil areas
- Can also be used with higher efficiency and large area coverage with advantages over conventional methods (broadcast seeders, drill seeders)
- Can be used in areas where little topsoil is available

Advantages

- Relatively cheap and efficient spraying method of seeding and promoting plant growth as well as erosion protection
- Allows spray-on re-vegetation of steep slopes where conventional re-vegetation methods are very difficult
- Minimizes effort required to re-vegetate disturbed areas as hydroseeding-hydromulching usually only requires one spray-on operation in comparison with planting and farrow method
- Relatively efficient operation with high coverage rates
- Provides dust control and protection from wind erosion

Hydroseeding-Hydromulching

Erosion Control:
Exposed Surface Protection – Vegetated

BMP4

Limitations

- Site must be accessible to hydroseeding-hydromulching equipment
  - Usually mounted on trucks
  - Maximum hose range of approximately 150 m
- May require subsequent spraying to reseed bare spots or areas with low growth

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil if available
- Spray on hydroseed-hydromulch as per supplier's recommendations

Construction Considerations

- Seed
  - Selected seed mixes must be appropriate for site specific conditions
  - Some jurisdictions have developed recommended seed mixes for specific regions based on historic performance results
  - Qualified agronomists or agrologists should be consulted if a suitable seed mix is not identified

- Hydraulic Mulches
  - Cellulose
    - Comprised of recycled paper from newspapers, magazines, or other paper sources
    - Rapid method for applying seed, fertilizer, mulch, and water in almost any disturbed areas
    - Usually installed without tackifier in slurry
    - Short fibre lengths and lack of tackifier limits erosion control effectiveness and does little to moderate moisture content and temperature within the soil
    - Residual inks within the recycled paper may leach into soil, which may present a problem in environmentally sensitive areas
    - Longevity significantly shorter than for wood fibre mulches or bonded fibre matrices (BFM)
    - Cheaper than wood fibre mulches and BFM
  - Wood Fibre
    - Comprised of whole wood chips
    - Industry standard, provides quick and uniform method and medium for re-vegetating large areas quickly and economically

  - Longer fibre lengths than for cellulose mulches
  - Longer lasting and has better wet-dry characteristics than cellulose mulches
  - Provides limited erosion control even when sprayed on with tackifiers
  - Provides limited moderation of soil moisture content and temperature when applied at higher rates
  - Cheaper, but less effective than, BFM
  - More expensive, and more effective than, cellulose mulches
- Bonded Fibre Matrices (BFM)
  - Slurry comprised of either cellulose mulch, wood fibre mulch, or a combination of the two
  - Mulches are bound together using chemical bond, mechanical bond, or a combination of the two
  - All fibres and binding agents are premixed by the manufacturer, ensuring uniformity and consistency throughout the application
  - Well suited for sites with existing desirable vegetation and where worker safety and minimal ground disturbance are desired
  - Degree of protection is similar to that obtained from rolled erosion control products (RECP)
  - Quicker installation than for RECP
  - Chemically bonded BFM may require a ‘set-up’ or curing/drying period
    - Application must be limited to periods where there is no threat of rain during curing period
    - Mechanically bonded BFM have no curing time and are effective immediately after application
  - Application on dry soils is not recommended
  - More expensive, and more effective, than cellulose and wood fibre mulches
- Tackifiers
  - May include vinyl compounds, asphalt, rubber, or other water-mixed substances

Inspection and Maintenance

- Inspect hydroseeded-hydromulched areas at least once per year after initial application or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- dyes in the mulch can be used for control of the coverage of the mulch; also important in inspection
- Areas damaged by runoff may need to be repaired and protected
- Small bare spots may need to be reseeded

Similar Measures

- Seeding
- Mulching
- Rolled erosion control products (RECP)

This page left blank intentionally

Riparian Zone Preservation

Erosion Control:
Exposed Surface Protection – Vegetated

Sediment Control:
Infiltration – Trapping

BMP7

Description and Purpose

- Protection of existing plants and trees adjacent to all natural water bodies (riparian zones) adjacent to construction areas
- Existing vegetation acts as an effective vegetative buffer strip as a form of erosion and sediment control measure

Applications

- Permanent measure
- Existing established vegetation acts as an effective erosion control buffer strip barrier to slow down flows and allow infiltration and sediment trapping to occur

Advantages

- Existing dense vegetation is more effective than any man-made structures or devices for sediment or erosion control, however, other forms of sediment and erosion control measures may be required on construction sites in addition to preserved riparian zones
- Any denuding of vegetation along steep valley slopes with erodible soil will be detrimental and increase long-term sedimentation yield; it is important only to strip necessary areas along the footprint of construction. Preservation of riparian zones is generally mandatory along river valley slopes and along the edges of waterbodies

Limitations

- Preservation of riparian zones may interfere with construction efficiency
- Careful planning is required to work around preserved riparian zones

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- It is highly important to preserve an established vegetative buffer as freshly planted vegetation generally require substantial growth periods before they are as effective as established riparian zones
- Wherever possible, as much existing vegetation as possible should be retained between construction areas and sensitive zones (wetlands, marshes, streams, floodplains, etc.) to entrap sediment and to minimize off site sediment transport

Riparian Zone Preservation

Erosion Control:
Exposed Surface Protection – Vegetated

Sediment Control:
Infiltration – Trapping

BMP7

- Define and delineate riparian zones to be preserved in the Erosion and Sediment Control Plan prior to commencement of construction
- Clearly mark riparian zones to be preserved in the field so all personnel involved with construction operations can identify areas to be preserved

Construction Considerations

- Riparian zones must be fenced off immediately to minimize trespassing and to ensure effectiveness of riparian zone is maintained
- Do not allow equipment to enter areas not necessary to construction

Inspection and Maintenance

- Maintain fences protecting riparian zones from traffic

Riprap Armouring

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP8

Description and Purpose

- Large, loosely placed cobbles or boulders placed along channel banks or slopes to protect underlying soil from erosion due to flowing water
- Can protect slopes and channel banks against erosion

Applications

- Permanent measure
- May be used on channel banks and slopes with flow velocities ranging from 2 m/s to 5 m/s (dependent on rock size and thickness); appropriate for slopes that do not exceed 2H:1V
- May be used for protection at culvert inlets and outlets
- Riprap only needs to be placed at lower portion of channel section to the anticipated flow height (mean annual peak flow) plus freeboard; other forms of soft armouring (RECP blankets, seeding) can be used to promote vegetation to protect soil at upper portion of channel slopes, above riprap
- Must be used in conjunction with a non-woven geotextile or filter gravel underlay acting as a filtration separator with basal soil
- For fluctuating high flow channel, the riprap should be underlain by a layer of granular filter material for cyclic drawdown long-term performance with/without an extra layer of non-woven geotextile as underlay

Advantages

- Easy to install and easy to repair
- Very durable, long lasting, and virtually maintenance free
- Flexible

Limitations

- Expensive form of channel lining and stabilization
- Requires heavy equipment and transport of rock to site
- May not be feasible in areas where suitable rock is not available
- Riprap may have to be placed by hand
- Normally 2 to 3 times riprap thickness is required in comparison with gabion mattress thickness for equivalent protection performance under identical hydraulic conditions

Riprap Armouring

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP8

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Grade the slope or channel to final design grade
- Place filter (underlay) layer on prepared slope; filter layer can consist of non-woven geotextile underlay and/or well graded granular material dependent on hydraulic conditions
- Place riprap layer
- The following riprap sizes may be used as a guide to specifying gradation and mass:

		Riprap Size			
Nominal Mass **Nominal Diameter**	**Kg** **mm**	**7** **175**	**40** **300**	**200** **500**	**700** **800**
None heavier than:	kg or mm	40 300	130 450	700 800	1800 1100
No less than 20% or more than 50% heavier than:	kg or mm	10 200	70 350	300 600	1100 900
No less than 50% or more than 80% heavier than:	kg or mm	7 175	40 300	200 500	700 800
100% heavier than:	kg or mm	3 125	10 200	40 300	200 500

Percentages quoted are by mass.
Sizes quoted are equivalent spherical diameters, and are for guidance only.
Source: Alberta Transportation Bridge Specification (2001)

- Non-woven geotextile fabric underlay below riprap should meet typical specifications and physical properties as illustrated below:

Non-Woven Geotextile Filter Fabric Specifications and Physical Properties

Specified Parameter	**Riprap Nominal Diameter**	
	500 mm and Smaller	**Greater than 500 mm**
Grab Strength	650 N	875 N
Elongation (Failure)	50%	50%
Puncture Strength	275 N	550 N
Burst Strength	2.1 MPa	2.7 MPa
Trapezoidal Tear	250 N	350 N
Minimum Fabric Overlap to be 300 mm		

Source: Alberta Transportation Bridge Specification (2001)

Riprap Armouring

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP8

Construction Considerations

- Riprap should be placed in a uniform thickness across the channel so as not to constrict channel width
- Blasted rock is preferred (if available)
- Riprap layer should be 1.5 to 2 times the thickness of the largest rocks used, 1.5 to 3 times the thickness of the d_{50} material, and not less than 300 mm in thickness
- On channel banks, the riprap blanket should be keyed in to a depth equal to the anticipated scour depth; alternatively, a self-launching apron of extra rock can be provided

Inspection and Maintenance

- Little maintenance is required
- Periodic inspections to check for erosion of protected material or movement of riprap

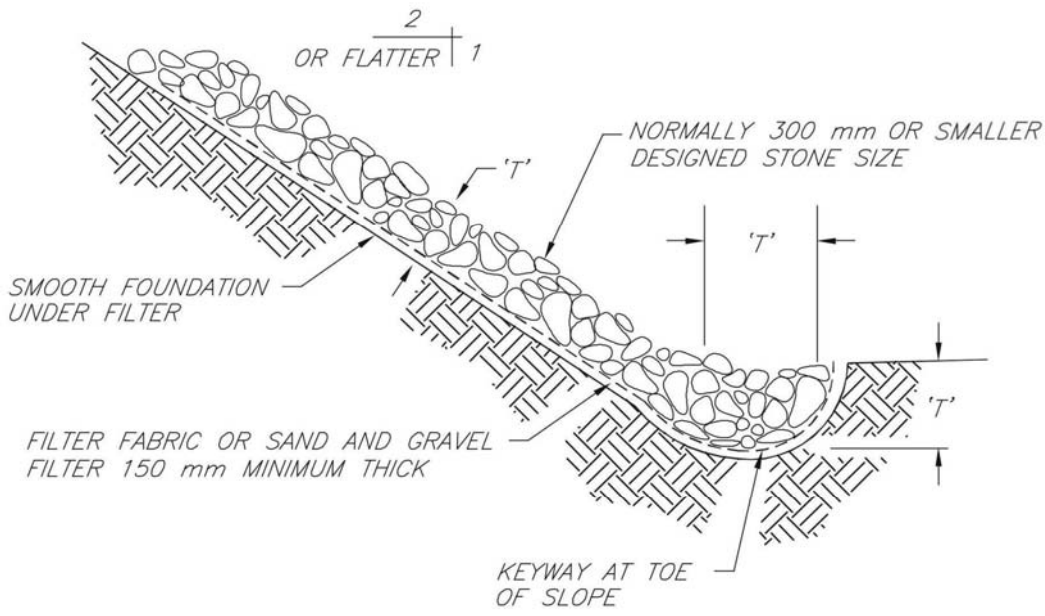
Similar Measures

- Rolled erosion control products (RECP) well vegetated; not for use at severe flow and high velocity areas
- Gabion mattresses

Riprap Armouring

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP8



TYPICAL SECTION

NOTE:

1. 'T' = THICKNESS: THICKNESS SHOULD BE DETERMINED BY THE ENGINEER.
   MINIMUM THICKNESS = 300 mm. (i.e. 1.5x D_{50}) FOR D_{50} = 200 mm.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

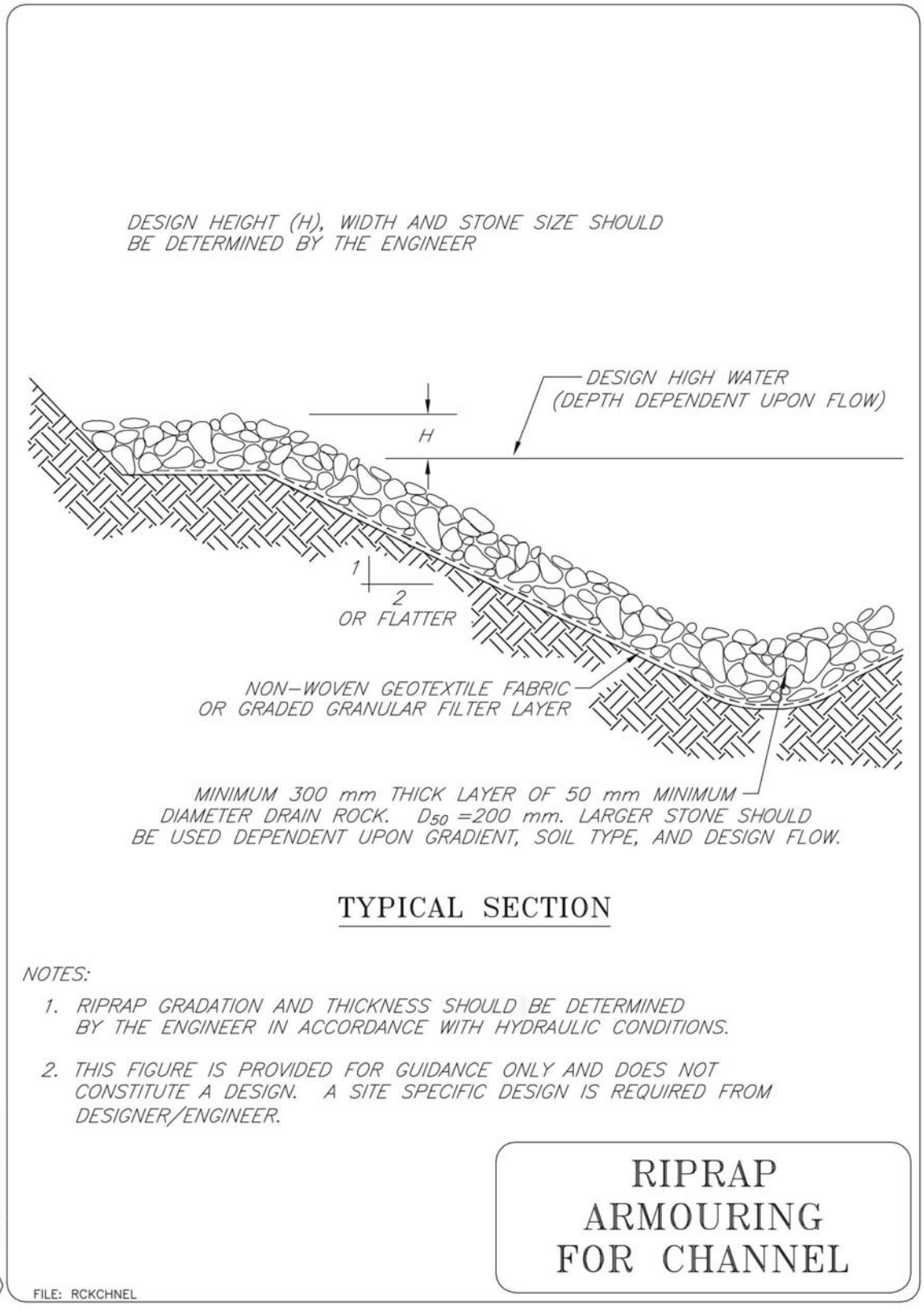
RIPRAP ARMOURING FOR SLOPE

FILE: RIPRAP

Riprap Armouring

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP8



This page left blank intentionally.

Gabions

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP9

Description and Purpose

- Consist of rock placed inside wire baskets to protect steep or erodible slopes from sheet flow erosion
- Protects erodible stream channel banks from potentially high erosive concentrated flow velocities or high tractive forces
- Can be applied to:
  - Slope and banks
  - Single gabion drop structure for ditch channel
  - Double gabion "energy dissipator" drop structure for ditch channel

Applications

- Permanent measure
- May be used on stream bank aprons and blankets where flow velocities do not exceed 6 m/s
- May be constructed to 0.5H:1V as a low height toe protection structure of slope
- May be used on slopes up to 1.5H:1V as slope protection, a grade break and sediment barrier
- Gabion mattresses are an alternative to riprap armouring of channels
- May be used to construct dikes or weirs
- Used as a drop structure (check structure) to reduce grade between structures and as sediment barrier in channels
- Used as a splash pad to reduce flow velocity and dissipate flow energy

Advantages

- Relatively maintenance free
- Long lasting and sturdy structure
- Lower thickness requirement for gabion (can be 1/2 to 1/3 riprap thickness) compared with riprap thickness for identical severe hydraulic conditions.
- Allows smaller diameter rock material to be used where it would normally be erodible with riprap placement
- Gabions are porous, free-draining and flexible so they are less affected by frost heaving and hydrostatic pressures
- Trap sediment and support plant growth to effect higher channel resistance to flow

Limitations

- Construction is labour intensive
- Extra costs associated with wire for mesh cages and rock fill plus geotextile fabric or sand filter layer

Gabions

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP9

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Prepare subgrade on mineral soil at designated gabion location
- Subexcavate trench a minimum of 0.15 m deep to 'key-in' gabion structure
- Construct gabion basket as per manufacturers recommendations
- Line interior of basket with non-woven geotextile OR a gravely sand filter layer (if required by design) along areas where the basket is in contact with soil
- Backfill basket with rock with wire bracing at 1/3 points (or 0.3 m spacings)
- Install gabion basket top
- Backfill trench and compact soil around edges of completed basket

Construction Considerations

- Gabions should be placed on a properly graded surface
- Non-woven geotextile should be used to prevent loss of underlying material and infiltration of fine grained particles into the gabion structure
- Rock in the baskets may be placed by hand to enhance dense packing of stones and decrease void spaces
- Construct gabions with internal wire diaphragms to maintain structural stability (shape)

Inspection and Maintenance

- Should be inspected after major storm events, especially where undermining at the toe of the basket is a concern
- Repairs should be performed immediately when required; repairs may include hand grading and/or infilling undermined area with rocky material

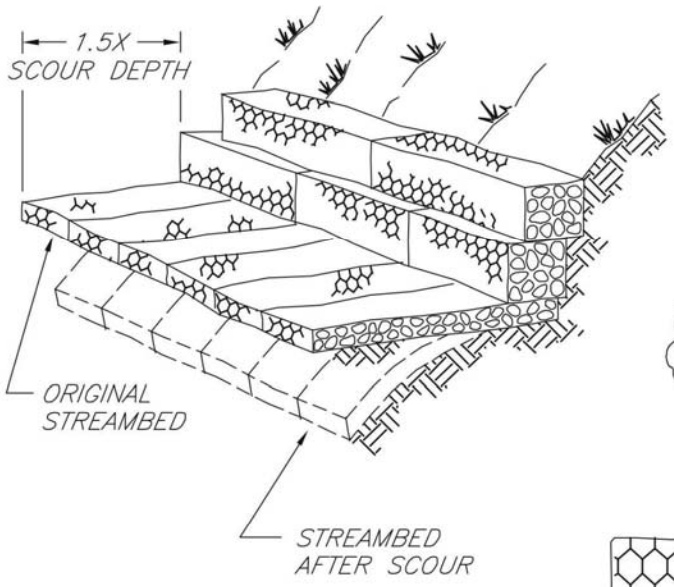
Similar Measures

- Berms/barriers
- Check dams
- Permeable/synthetic barriers
- Rock/brush barriers
- Sand/gravel bag barriers

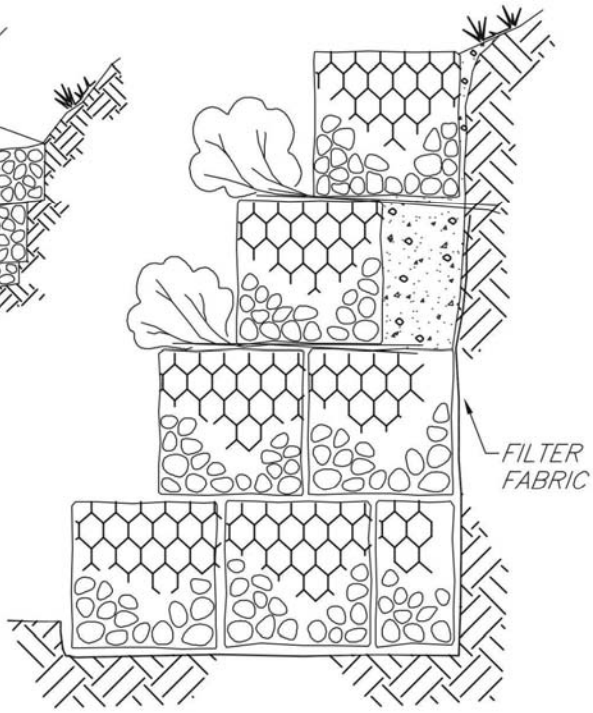
Gabions

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP9

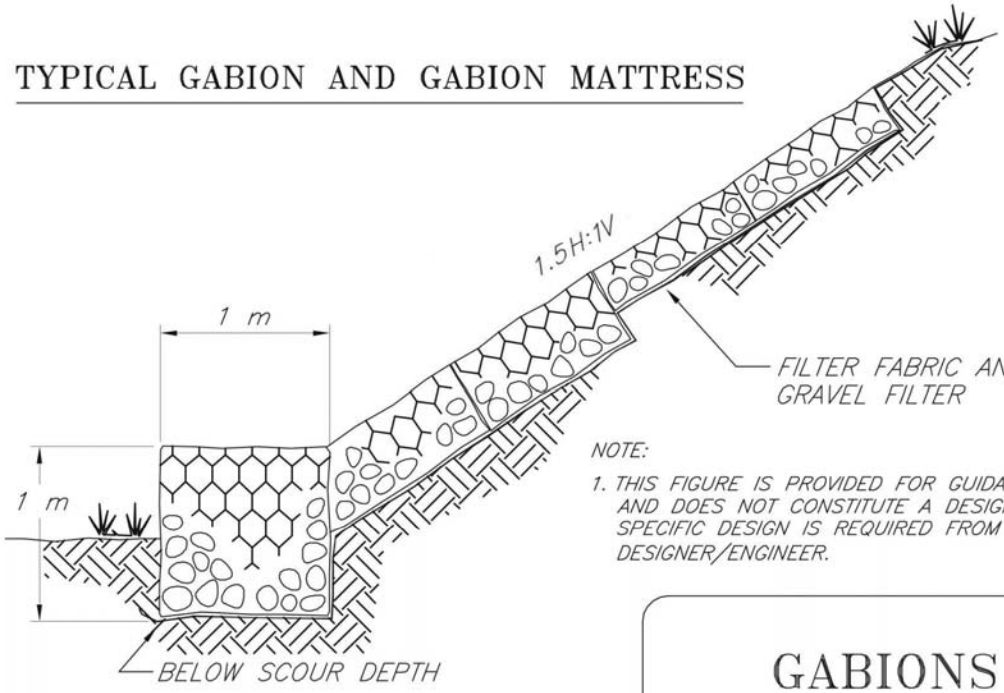


TYPICAL GABION APRON



TYPICAL VEGETATED ROCK GABION

TYPICAL GABION AND GABION MATTRESS



NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

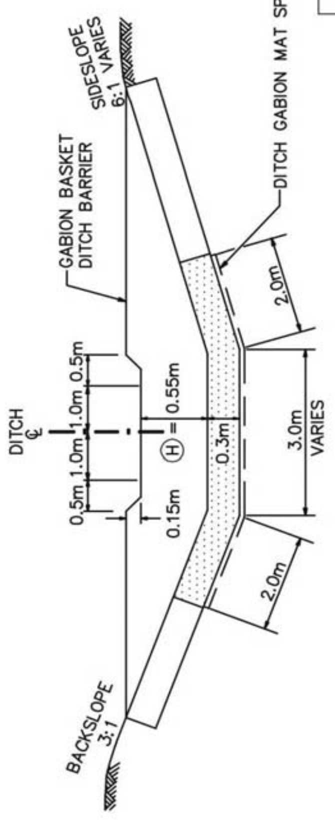
GABIONS
(SLOPE AND BANK)

FILE: GABIONS

Gabions

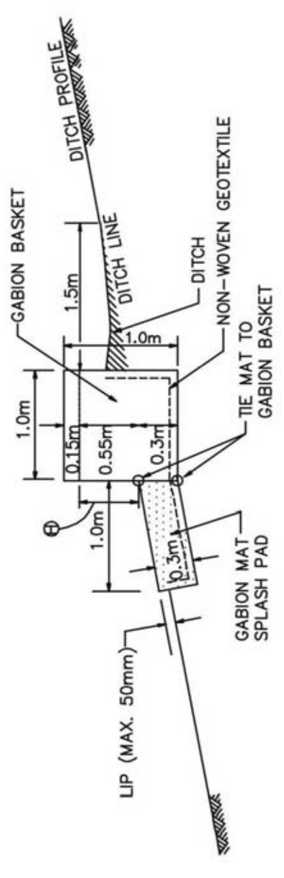
Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP9



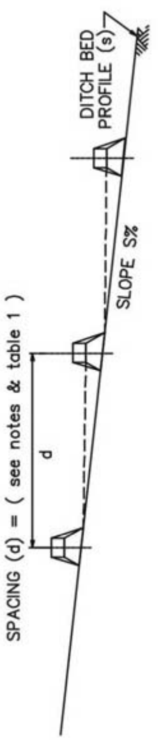
FRONT VIEW FROM DOWNSTREAM
TYPICAL DITCH CROSS-SECTION
GABION BASKET DITCH BARRIER

N.T.S.



CROSS-SECTION VIEW
"SINGLE GABION" BASKET DITCH BARRIER
& GABION MAT SPLASH PAD

N.T.S.



TYPICAL BARRIER SPACING

N.T.S.

S (%)	SUGGESTED SPACING (d) (m)	REMARKS
5–7	30	OPTION TO INSTALL A GRADE BREAK (s.a. WEAVE BARRIER) BETWEEN STRUCTURES.
7–8	25	A DOUBLE GABION FOLLOWS EVERY 2 SINGLE GABIONS.
>8%	≤15	DESIGN BY ENGINEER REQUIRED.

TABLE 1

NOTES:

1. SUITABLE FOR MEDIUM TO STEEP GRADES AND CHANNELS LEADING TO WATER COURSE 4% < S < 10%.
2. i) SPACING TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS. – –

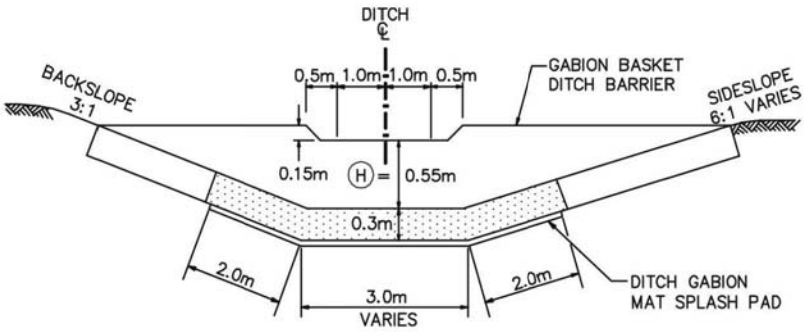
   ii) USE IN CONJUNCTION WITH DOUBLE GABIONS OR OTHER BARRIER STRUCTURES.
3. SOIL COVERING BETWEEN STRUCTURES SUGGESTED FOR STEEP GRADE SOIL DITCH.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

GABIONS
SINGLE GABION
DROP STRUCTURE FOR
DITCH CHANNEL

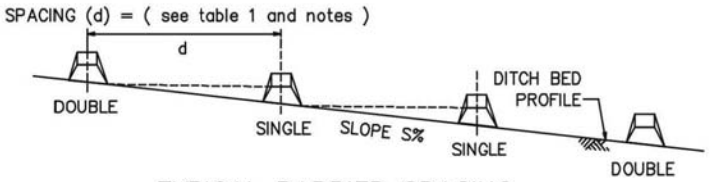
Gabions

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP9



FRONT VIEW FROM DOWNSTREAM
TYPICAL DITCH CROSS–SECTION
GABION BASKET DITCH BARRIER
N.T.S.



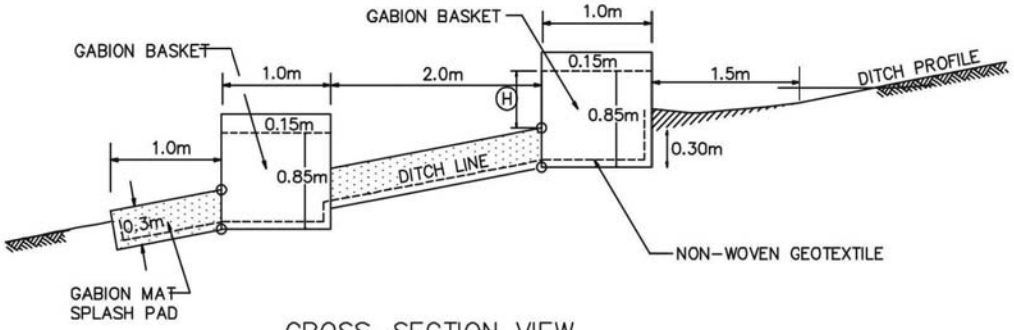
TYPICAL BARRIER SPACING
N.T.S.

SUGGESTED SPACING (d)		REMARKS
S (%)	(m)	
6–8	25	INTER–SPACED WITH 2 SINGLE GABIONS BETWEEN STRUCTURES
	35*	*SEE NOTES
>8%	≤15	DESIGN BY ENGINEER REQUIRED

TABLE 1

NOTES:

1. SUITABLE FOR STEEP GRADES (6%<S<12%) AND CHANNELS LEADING TO WATER COURSE
2. i) SPACING (d) TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
   ii) USE IN CONJUNCTION WITH SINGLE GABIAN AND/OR OTHER GRADE BREAK STRUCTURES.
3. SUGGESTED TWO SINGLE GABIONS AT INTERVAL BETWEEN DOUBLE GABIONS.
4. SOIL COVERING BETWEEN STRUCTURES SUGGESTED FOR STEEP GRADE SOIL DITCH.
5. IF d* = 35 m at 7 to 8% GRADE
   - GRADE BREAK (s.a. PERMEABLE WEAVE BARRIER) SHOULD BE PLACED BETWEEN STRUCTURES.
   - LONG SPACING ALLOWABLE WHEN HYDRAULIC CONDITIONS NOT SEVERE.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.



CROSS–SECTION VIEW
"DOUBLE GABION" ENERGY DISSIPATION GABION STRUCTURE
(TWO SINGLE GABIONS COMBINED)
N.T.S.

GABIONS
DOUBLE GABION
"ENERGY DISSIPATOR"
DROP STRUCTURE
FOR DITCH CHANNEL

This page left blank intentionally.

Aggregate Cover

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP10

Description and Purpose

- Crushed stone or gravel layer/blanket placed directly on erodible slopes susceptible to surface water erosion and groundwater seepage piping erosion
- To secure the soil, reduce erosion, and provide continuous all-weather protection
- For remediation of unstable slopes caused by piping loss of soil resulting from strong groundwater exit gradients and subsurface erosion.
- Protects against piping erosion of underlying soil as well as surface erosion from raindrop impact, and sheet flow
- Prevents transport of soil from areas subject to groundwater seepage
- Acts as a filter to minimize seepage erosion of soil from areas subject to groundwater seepage
- Provides hard armour protection for slopes

Applications

- Permanent measure
- May be used on highly erodible slopes (silt and sand) that cannot be effectively stabilized by vegetative methods
- May be used when cover must be placed immediately as a toe filter to minimize seepage erosion due to strong groundwater seepage exit on cut slopes
- For areas of high groundwater seepage gradients, must be used in conjunction with a non-woven geotextile fabric underlay
- In most situations, aggregate covers are installed in conjunction with subsurface drains

Advantages

- Easily constructed and implemented

Limitations

- Must be designed by qualified geotechnical personnel
- Requires equipment and transport of gravel to site
- May not be feasible in areas where suitable aggregate is not readily available
- Areas of high groundwater seepage may require other subsurface drainage measures

Aggregate Cover

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP10

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Place non-woven geotextile as underlay, as a general good practice to provide filtration separator with subgrade soils
- Place aggregate
- Grade aggregate blanket to design thickness

Construction Considerations

- Aggregate must be placed evenly over slope
- On slopes of highly erodible materials (silt and sand) aggregate blanket thickness should be 0.4 m minimum thickness and should be assessed by a qualified geotechnical engineer
- Generally for slope protection for subground piping erosion, the blanket can be constructed of clean pit run gravel (as specified in the following table) to 0.4 m thickness

Metric Sieve Size (μm)	Percent Passing
125,000	100
50,000	5-100
25,000	38-100
16,000	32-85
5,000	20-65
315	6-30
80	2-10

Inspection and Maintenance

- Inspect gravel blanket after significant storm events and repair any damaged or wash out sections immediately
- Sections washed out may need to be regraded prior to replacing gravel and geotextile

Similar Measures

- Subdrain systems

Stabilized Worksite Entrance

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP11

Description and Purpose

- Comprised of a gravel pad located at site access points (entrances) that are used to reduce the amount of sediment carried off construction sites by vehicles
- Collects sediment from vehicle washing and retains sediment on construction site
- Should include water supply to wash off excess soil from vehicles prior to exiting the construction site

Applications

- Temporary measure
- For use anywhere vehicles enter or exit a construction site

Advantages

- Retains sediment on the construction site
- Reduces deposition of sediments on public roads which may be carried by runoff into natural watercourses or drains

Limitations

- Sediment control measures should be installed to collect sediment laden runoff from gravel pad
- Installation of gravel pads may be limited by space constraints
- A supply of water is required for washing

Implementation

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Install gravel pad at planned entrances to worksite
  - Gravel pad (minimum of 15 m in length) should be of sufficient length to accommodate longest anticipated vehicle entering or exiting the site
  - Width of pad should be sufficient to accommodate the widest anticipated vehicle entering or exiting the site (minimum of 3.6 m in width)
  - Thickness of gravel pad should be a minimum of 0.30 m thick and should comprise 50 to 150 mm diameter coarse aggregate placed on top of woven geotextile filter fabric
- Water supply with pump system should be incorporated to wash vehicle undercarriages and wheels
- Install temporary sediment control measures (such as straw bale barriers or silt fences) to collect washed off sediment from gravel pad

Stabilized Worksite Entrance

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP11

Construction Considerations

- Should be constructed at all access points to construction sites
- If impractical to construct at all access points, limit vehicle access traffic to stabilized worksite entrances only
- Entrances located with steep grades or at curves on public roads should be avoided
- Woven geotextile filter fabric should be used as underlay below gravel pad as strength requirement
- Install an elevated ridge adjacent to roadway if gradient of the gravel pad is steeper than 2%, sloped towards the roadway

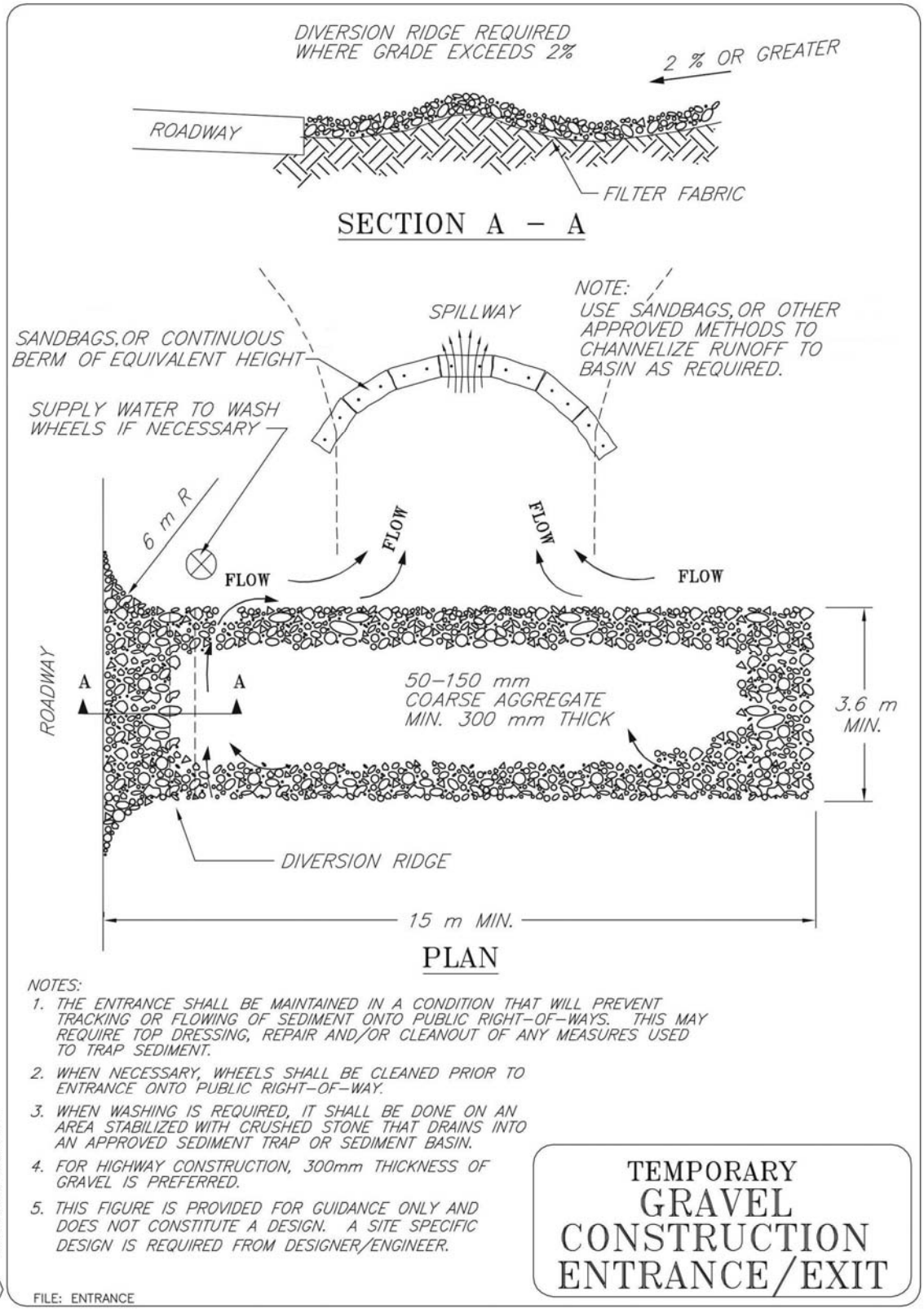
Inspection and Maintenance

- Granular material should be regraded when required
- Material may need to be added to fill large voids to maintain a minimum pad thickness of 0.30 m
- Inspect and clean out downstream sediment control measures at least once per week and after periods of significant rainfall
- Material accidentally deposited onto public roads should be cleaned as soon as possible

Stabilized Worksite Entrance

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP11



NOTES:

1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT–OF–WAYS. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT.
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT–OF–WAY.
3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.
4. FOR HIGHWAY CONSTRUCTION, 300mm THICKNESS OF GRAVEL IS PREFERRED.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT

FILE: ENTRANCE

This page left blank intentionally.

Rolled Erosion Control Products (RECP)

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP12

Description and Purpose

- Biodegradable or synthetic soil coverings used for temporary or permanent protection of disturbed soils at slopes and channels
- Categories of Rolled Erosion Control Products (RECP) can be:
  - Erosion control blankets (ECB) (generally biodegradable and temporary)
  - Turf reinforcement mats (TRM)
  - Composite turf reinforcement mats (C-TRM)
- RECP may be manufactured of organic material, synthetic material, or as a composite of organic and synthetic materials
- Protect disturbed soils from raindrop impact and surface runoff erosion, increase water infiltration into soil, retains soil moisture and decreases evaporation loss
- Protect seeds from raindrop impact, runoff, and predators
- Stabilize soil temperature to promote germination and enhance vegetation growth

Applications

- Temporary or permanent measure
- May be used to protect disturbed, exposed soils for cut or fill slopes at gradients of 2.5H:1V or steeper
- May be used on slopes where erosion potential is high
- May be used on slopes where vegetation is likely to develop slowly
- May be used to protect disturbed exposed soils in ditches and channels by providing additional tractive resistance cover in conjunction with high density vegetative growth

Advantages

- Degree of erosion protection is higher, more uniform, and longer lasting than for sprayed-on products (e.g. mulches)
- Wide range of available temporary (biodegradable) or permanent products

Limitations

- Non-performance of RECP may result from the following:
  - Low density vegetation growth (beneath RECP) due to non-favorable weather and growth conditions (i.e. soil type, moisture, storm events at critical times). The effectiveness of RECP, especially along channels, is dependent on successful vegetation growth. It is important that the designer assess the effectiveness of RECP for site-specific soil, terrain and vegetation growth conditions.
  - Hydraulic uplift of RECP and erosion of underlying soils can occur under rapid snow melt conditions when dammed melt water generates a hydraulic head and high flow velocity in a constricted snow melt channel. This situation can occur along steep channels interlaced with drop structures and with RECP lining installed in between the drop structures. Ponding of melt water and non-anchored

RECP joint areas allow flow entry beneath the RECP and generate hydraulic heads to uplift the RECP. This can occur along un-anchored edges of RECP at upper edges of ditch when snow melt occurs at tops of ditch and flow beneath the RECP. This is especially critical when underlying soil is easily erodible. It is important to trench-in and anchor the edges of the RECP installations and installed anchor pin (staples) at sufficient frequent intervals.
  - Ice buildup from groundwater seepage can uplift and dislocate the RECP and cause flow beneath the RECP to erode the substrate soils. Winter ice accumulation may be related to groundwater regime and investigative design on subsurface drainage by a geotechnical engineer is required.
- Can be labour intensive to install
- Must be installed on unfrozen ground
- Temporary blankets may require removal before permanent measures are installed
- Rolled erosion control products (RECP) are not suitable for rocky sites
- Proper surface preparation is required for intimate contact between blanket and soil
- Plastic sheeting can be used at sensitive slopes with precautions:
  - Plastic sheeting RECP product can be easily torn, ripped, non-biodegradable, and should be disposed of in a landfill
  - Plastic sheeting product, if used, results in 100% runoff, thus increasing erosion potential in downslope areas receiving the increased flow volumes
  - Plastic sheeting should be limited to temporary covering of sensitive soil stockpiles or temporary covering of small critical unstable slope areas

Construction (Slopes)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- RECP should be installed in accordance with manufacturers directions
- The following is a general installation method:
  - Prepare surface and place topsoil and seed
  - Surface should be smooth and free of rocks, debris, or other deleterious materials
  - Blanket should be anchored at top of slope in a minimum 0.15 m by 0.15 m trench for the entire width of the blanket
  - The blanket should be rolled out downslope
    - Where the blanket roll is not long enough to cover the entire length of the slope, a minimum 0.15 m by 0.15 m check slot should be excavated at the location of the lap, and the downslope segment of blanket anchored in the check slot, similar to the method used for the top of the slope, or (2) when blankets, must be spliced down the slope, place blanket end over end (shingle style) with approximately 0.10 m overlap. Staple through overlapped area at 0.3 m intervals.

- The upslope portion of blanket should overlap the downslope portion of blanket, shingle style, at least 0.15 m with staple anchors placed a maximum 0.3 m apart
- Adjacent rolls of blanket should overlap a minimum 0.1 m
- Anchors should be placed along central portion of blanket spaced at 4/m^2 minimum (0.5 m spacing) for slopes steeper than 2H:1V and 1/m² (1 m spacing) for slopes flatter than 2H:1V
- Anchors along splices between adjacent rolls should be placed 0.9 m apart

Construction (Channels)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- A blanket should be installed in accordance with manufacturers directions
- The following is a general installation method:
  - Prepare surface and place topsoil and seed
    - Surface should be smooth and free of large rocks, debris, or other deleterious materials
  - Begin by excavating a minimum 0.15 m deep and 0.15 m wide trench at the upstream end of channel and place end of RECP into trench
    - Use a double row of staggered anchors approximately 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
    - Backfill and compact soil over RECP in trench
  - Roll centre RECP in direction of water flow on base of channel
  - Place RECP end over end (shingle style) with a minimum 0.15 m overlap downgrade
    - Use a double row of staggered anchors approximately 0.1 m apart to secure RECP to soil
  - Full length edge of RECP at top of sideslopes must be anchored in a minimum 0.15 m deep and 0.15 m wide trench
    - Use a double row of staggered staple anchors a maximum of 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
    - Backfill and compact soil over RECP in trench
  - Overlap RECP on sideslopes (shingle style down channel) a minimum of 0.1 m over the centre RECP and secure RECP to soil with anchors spaced a maximum of 0.2 m apart
  - In high flow channels, a check slot across the width of the channel is recommended at a maximum spacing of 10 m to anchor the ends of the RECP to the underlying soil
    - Use a double row of staggered staple anchors a maximum of 0.1 m apart (0.2 m linear spacing) to secure RECP to soil in base of check slot

  - Backfill and compact soil over RECP in check slot
- Anchor terminal ends of RECP in a minimum 0.15 m deep and 0.15 m wide trench
  - Use a double row of staggered anchors a maximum of 0.1 m apart (i.e. 0.2 m linear spacing) to secure RECP to soil in base of trench
  - Backfill and compact soil over RECP in trench

Construction Considerations

- Slopes should be topsoiled and seeded prior to placing RECP
- Ensure blanket is in intimate contact with the soil by properly grading soil, removing rocks or deleterious materials, prior to placing blanket
- In channels, blankets should extend above the anticipated flow height, with a minimum 0.5 m of free board
- For turf reinforcement mat (TRM), blanket should be placed immediately after topsoiling
- Blanket should be anchored by using wire staples, metal geotextile stake pins, or triangular wooden stakes
  - All anchors should be a minimum of 0.15 to 0.20 m in length
  - For loose soils, use longer anchors
- Blankets should be placed longitudinal to direction of flow, with fabric not stretched but maintaining contact with underlying soil
- It is essential to understand product specifications and follow manufacturers instructions on installation methods

Product Quality Assurance/Quality Control (QA/QC) Certification

RECPs should be certified by the supplier/manufacturer to ensure product performance and compliance with specified property requirements. A certificate for QA/QC testing of manufactured products is required. The performance and QA/QC testing should be carried out by reputable laboratories (e.g. TxDoT – Hydraulic and Erosion Control Laboratory or equivalent laboratory) to ensure a commonly acceptable QA/QC standard. Depending on product type and intended performance, the product information certificate should be provided by the product supplier/manufacturer and include the following:

- Performance specification:
  - Permissible Tractive Resistance (include testing methods and vegetative growth conditions)
  - Permissible Flow Velocity (if available)
  - Longevity (for biodegradable or non-biodegradable products)
- Minimum Average Roll Values (MARVs) along with specified testing methods for:
  - Physical properties
    - Mass per unit area
    - Thickness

  - Tensile strength
  - UV Resistance
- Other physical properties (for non-woven below Erosion Mat (if specified)
  - Grab tensile strength
  - Grab elongation
  - Puncture strength
  - Trapezoidal tear
  - UV Resistance

Inspection and Maintenance

- Area covered with blankets should be regularly inspected/repaired, especially after periods of severe rainfall or storm events, to check for blanket separation or breakage
- Any damaged or poorly performing areas should be repaired immediately. Regrading of the slope by hand methods may be required in the event of rill or gully erosion.
- Inspection and maintenance should continue until dense vegetation is established
- Areas with low vegetation density should be reseeded
- After approximately one year, a top dressing of fertilizer may be applied to improve vegetation cover and assist degradation of temporary blankets

Similar Measures

- Mulching (for slopes only)
- Chemical stabilization (for slopes only, e.g. tackifiers)
- Rip rap (primarily in channels)
- Gabion mattresses (primarily in channels)

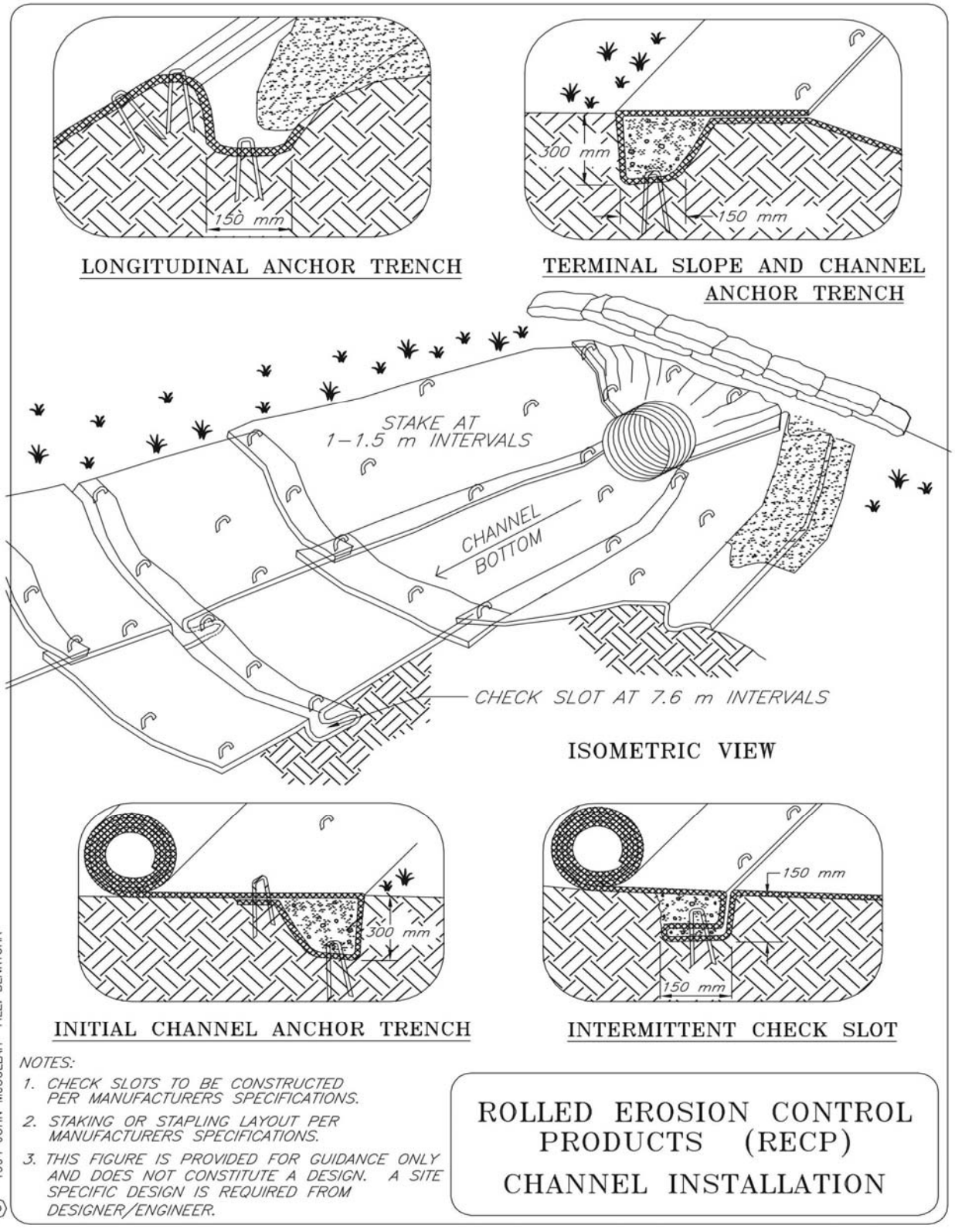
Design Considerations

- Assess hydraulic flow conditions and tractive stress on channel
- Assess local soil, weather and growth conditions (favourable/non-favourable) for revegetation (within 3 to 12 months) to allow a determination on use or non-use of RECP as a protective measure. If the revegetation conditions are assessed favourable, the use of RECP can be considered
- Assess suitability of a RECP product using tractive resistance data tested for (i) bare soil, and (ii) vegetated (a specified duration of growth period) condition
- It is noted that tractive resistance data are adopted as selection criteria of RECP and permissible velocity data can be provided for reference.

Rolled Erosion Control Products (RECP)

Erosion Control:
Exposed Surface Protection – Non-Vegetated

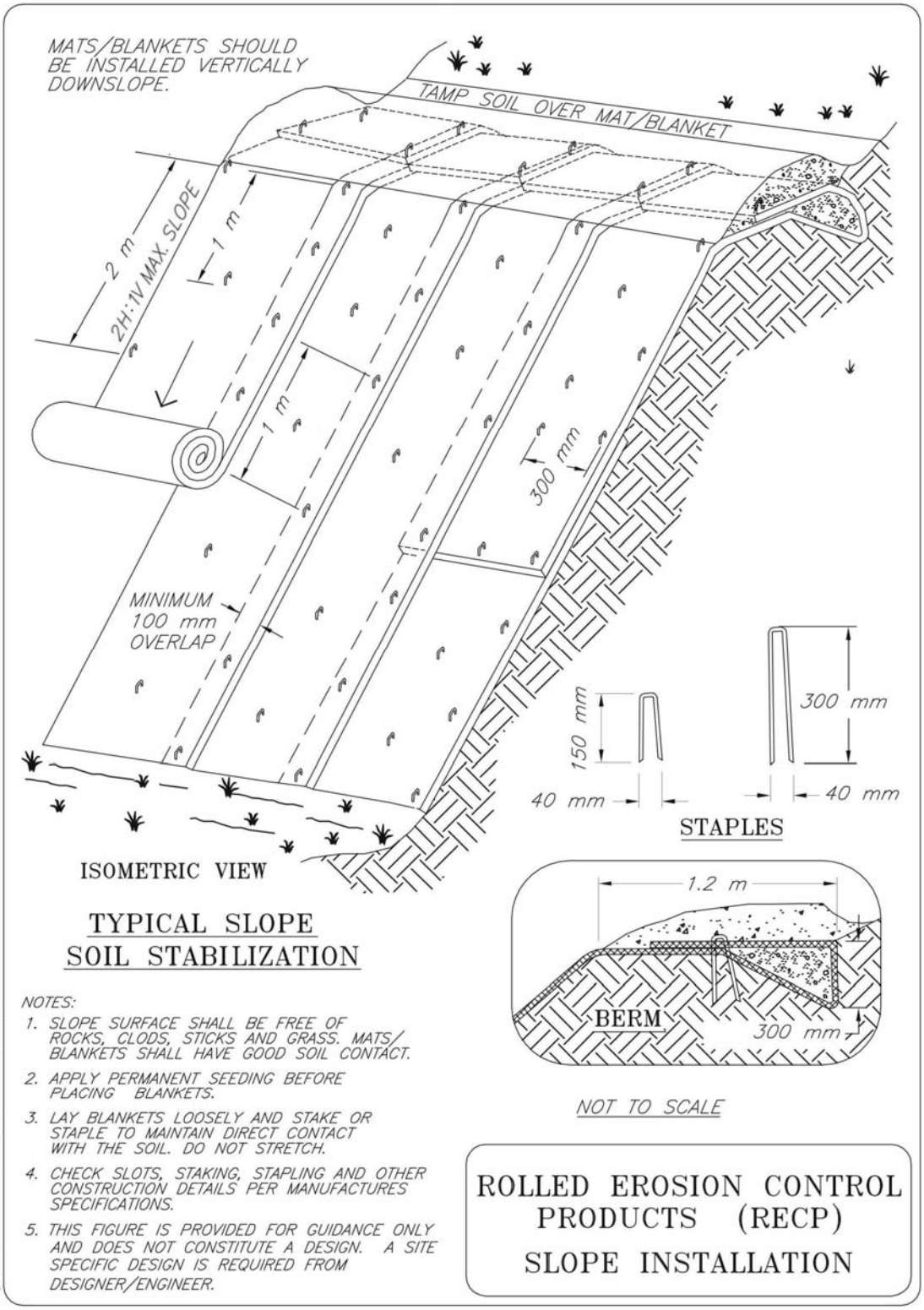
BMP12



Rolled Erosion Control Products (RECP)

Erosion Control:
Exposed Surface Protection – Non-Vegetated

BMP12



Rolled Erosion Control Products (RECP)

Erosion Control:

Exposed Surface Protection – Non-Vegetated

BMP12

This page left blank intentionally.

Slope Texturing / Grading

Erosion Control:
Runoff Control

BMP15

Description and Purpose

- Texturing of slopes, either by roughening the surface, tracking the surface, or installing grooves or serrations
- Texturing reduces the runoff velocity, traps sediment, and increases the infiltration of water into the soil

Applications

- Temporary or permanent measure
- May be used to roughen the exposed soils on the slope surface in the direction of water flow to minimize erosion and to entrap some sediments
- May be used on fresh cut or fill slopes (8 m length or longer practical travel reach of a dozer) with gradients of generally 3H:1V or steeper (2H:1V as general steepness limit) constructed in cohesive soils
- May be used on slope subgrade that will not be immediately topsoiled, vegetated or otherwise stabilized
- May be applied to topsoiled slope to provide track serration to further reduce erosion potential
- May be used in graded areas with smooth and hard surfaces
- Benching of slopes is discouraged for a number of reasons. Benches increase local slope gradients over those which can be achieved without benches. Ponding and discharge from benched areas can concentrate flows and result in gully erosion. If benches must be installed for equipment access, it is important that positive downslope gradients are constructed in all areas.

Advantages

- Reduces erosion potential of a slope
- Texturing will create protrusions to increase surface roughness to reduce overland flow velocities and erosion energy
- Texturing will create minor spaces to entrap a portion of the coarse sediment and reduces amount of sediment transported downslope
- Texturing of slopes will benefit development of vegetation
- Texturing of slopes aids in performance of mulches and hydroseeding
- Texturing with track-walking up/downstream may effect a 10% reduction of sediment yield compared with untracked slope

Limitations

- Surface roughening and tracking may increase grading costs
- Surface roughening and tracking may cause sloughing in certain soil types (i.e. sandy silt) and seepage areas; geotechnical advice is recommended

Slope Texturing / Grading

Erosion Control:
Runoff Control

BMP15

- Texturing provides limited erosion and sediment control and should be used as a temporary measure prior to topsoiling
- Texturing should be used in conjunction with other erosion and sediment control measures (i.e. offtake ditches) to limit the downslope sheet flow

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Surface Roughening
  - Leave soil in rough grade condition, do not smooth grade soil
  - Large lumps of soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Surface Tracking
  - Using tracked construction equipment to move up and down the slope, leaving depressions perpendicular to the slope direction; limit passes to prevent overcompaction of the surface
  - Depressions in the soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Grooving
  - Excavating shallow furrows across the width of the slope, perpendicular to the direction of the slope
  - If used, contour grooves should be approximately 0.1 to 0.2 m in depth
- Grooves can be made by using equipment or hand

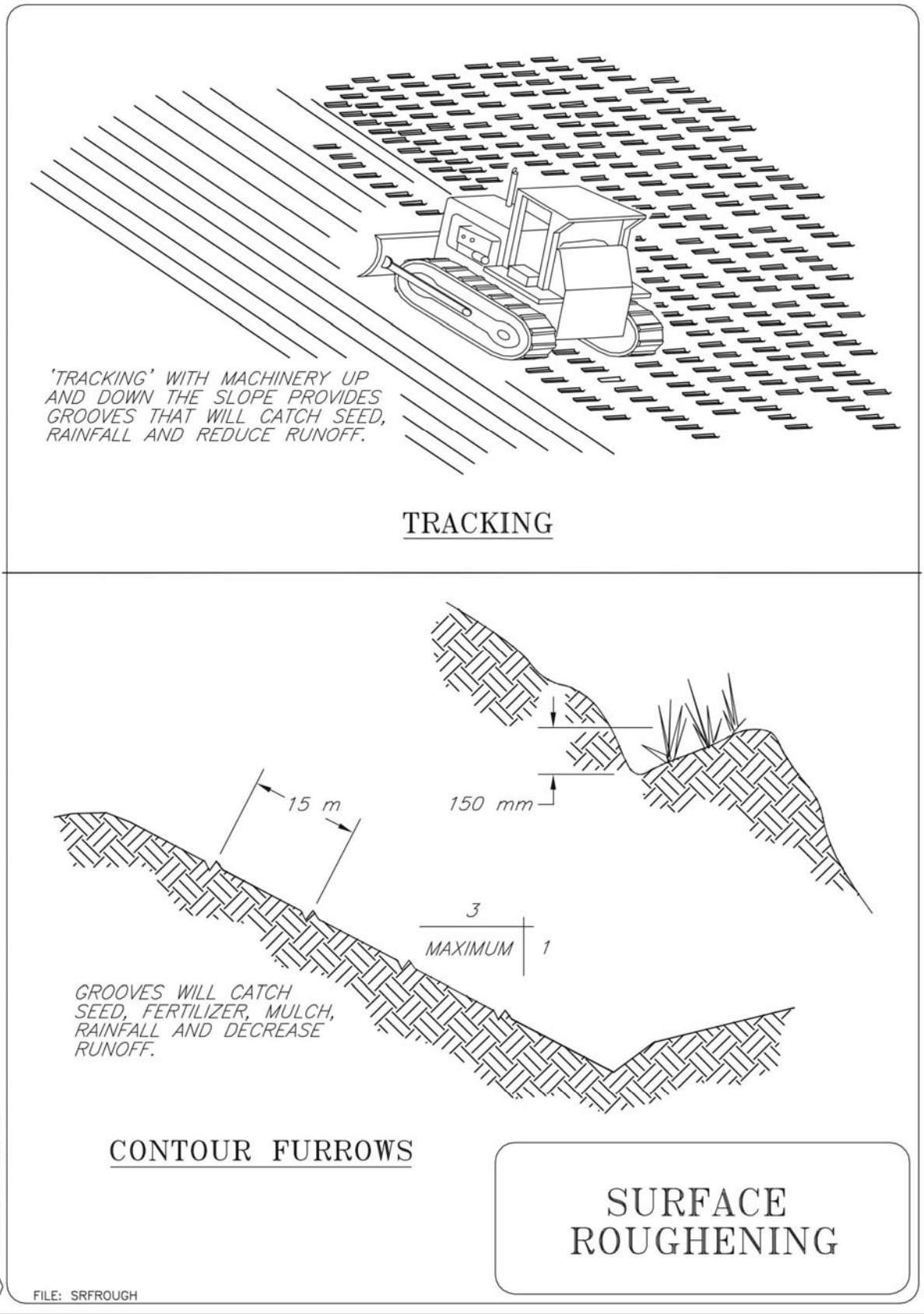
Construction Considerations

- During tracking operations, care must be taken to minimize disturbance to the soil where the equipment turns or changes direction
- Minimize the number of tracking passes to 1 to 2 times to avoid overcompaction, which can negatively impact the vegetation growth
- It is practical to track roughen a slope length of greater than 8 m by up- and down-slope operation of a small bulldozer. It is important to minimize the loosening of soil caused by turning movement of the bulldozer at the end of each pass. As the erosion potential is lower for slopes of low vertical height (<3 m height and 3H:1V slope), the tracking of low height slopes is not required and not practical for a bulldozer tracking operation.

Slope Texturing / Grading

Erosion Control:
Runoff Control

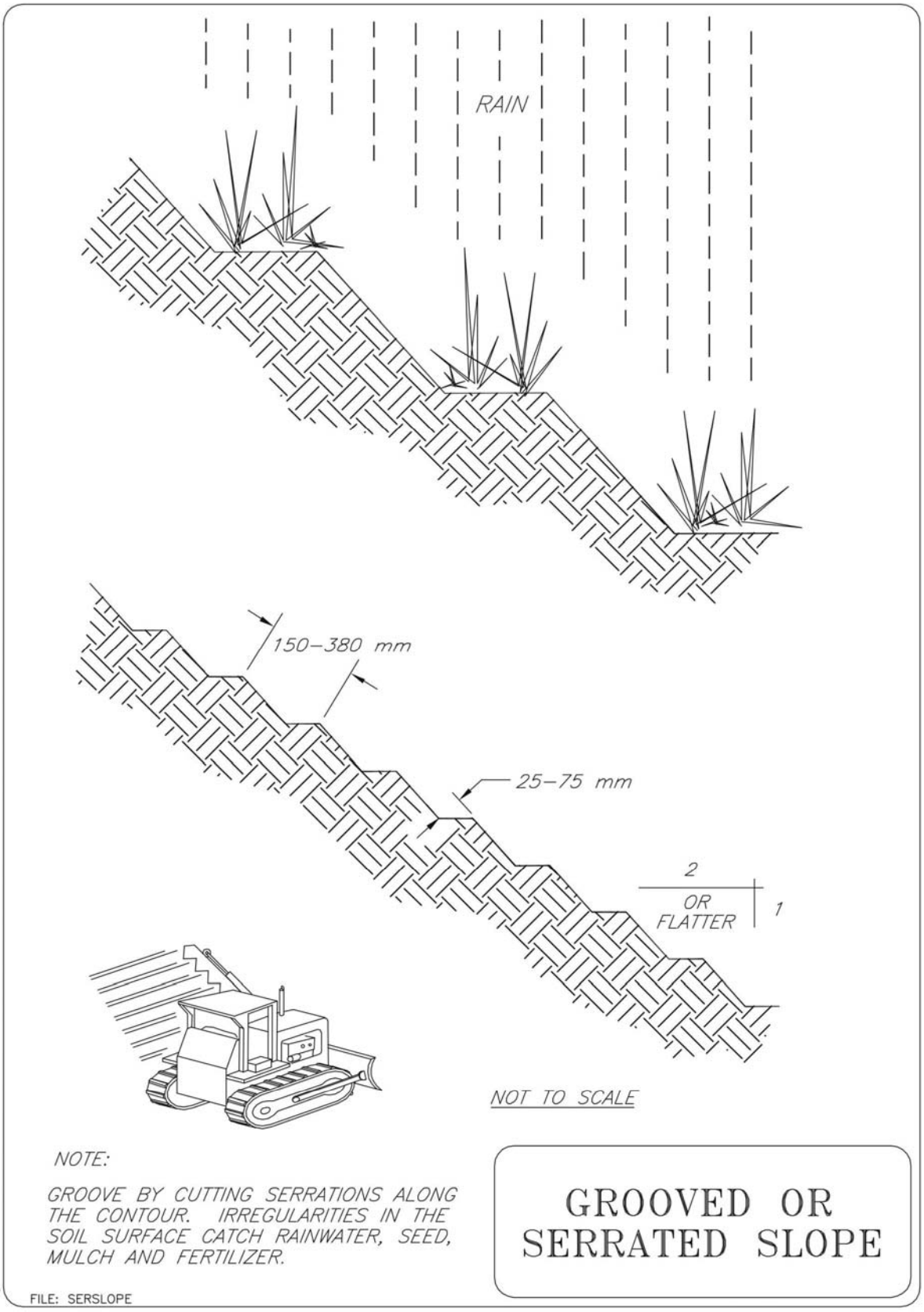
BMP15



Slope Texturing / Grading

Erosion Control:
Runoff Control

BMP15



Slope Drains

Erosion Control:
Runoff Control

BMP16

Description and Purpose

- Heavy duty, flexible pipe that carries water from top to bottom of fill or cut slope to prevent concentrated water flowing downslope and eroding face of slope

Applications

- Temporary or permanent measure
- Used on cut or fill slopes where there is a high potential for upslope runoff waters to flow over the face of the slope causing erosion, especially at areas where runoff converges resulting in concentrated runoff flows
- Used in conjunction with some form of water containment or diversion structures, such as diversion channels, berms, or barriers, to convey upslope runoff water and direct water towards slope drain

Limitations

- Pipes must be sized correctly to accommodate anticipated flow volumes
- Water can erode around inlet if inlet protection is not properly constructed
- Erosion can occur at base if outlet protection or energy dissipator is not constructed
- Slope drain must be anchored securely to face of slope

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Construct diversion or intercept channel, ditch block, barrier, or other inflow apron structure at crest of slope to channel flow toward the slope drain inlet
- Install slope drain through inlet berm or barrier with a minimum of 0.45 m of soil cover above top of drain pipe to secure the inlet
- Install scour inlet protection (such as rip rap, sand bags)
- Install energy dissipator (such as rip rap, gravel, concrete) at downslope outlet end of slope drain; the outlet must not discharge directly onto unprotected soil
- Secure the pipe from movement by tying to steel anchor stakes, hold-down grommets, or other approved anchor method
- Space anchors on each side of drain pipe at maximum 3 m intervals along entire length of drain pipe

Slope Drains

Erosion Control:
Runoff Control

BMP16

Construction Considerations (For guidance only)

- Use coiled drain pipe for low flows only
- If constructing inflow apron at crest of slope out of sandbags, only fill each sandbag ¾ full, this will allow sandbag to be flexible enough to mould around drain pipe and remain in continuous contact with the ground
- Several slope drains may be required if upslope drainage areas are too large for one drain pipe

Inspection and Maintenance

- Inspect slope drains at least once per week, or after significant storm events (1:2 year storm and/or 40 mm precipitation in 24 hours)
- Repair any damaged section of pipe immediately
- If evidence exists of pipe movement, install additional anchor stakes to secure and anchor at zones of movement
- Remove sediment from upslope inflow apron area after each storm event otherwise either downslope sediment transport will occur or cause the drainpipe to be plugged which could result in overtopping of inflow apron structure and sheet flow over slope face

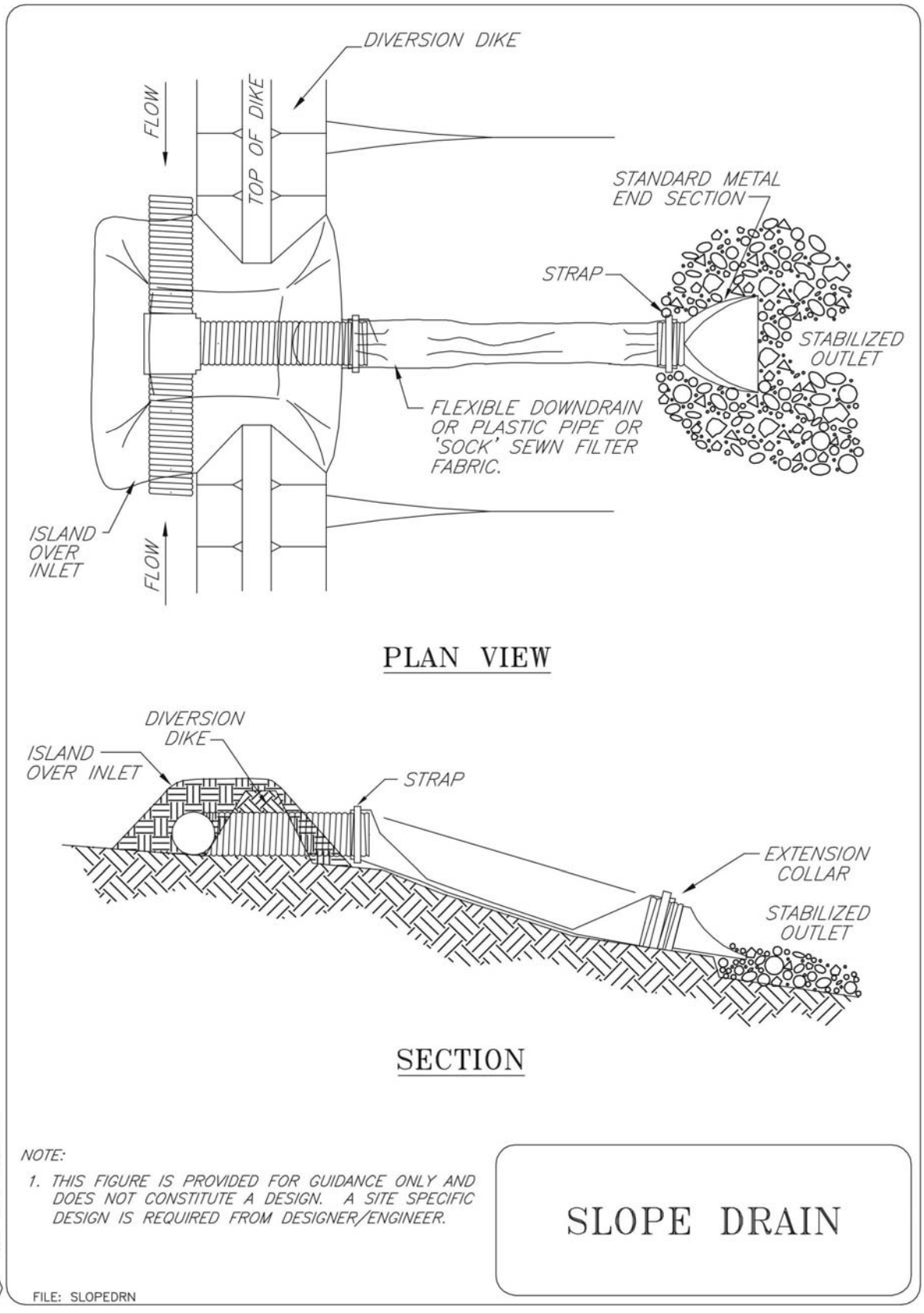
Similar Measures

- Rock lined channel
- Storm sewer

Slope Drains

Erosion Control:
Runoff Control

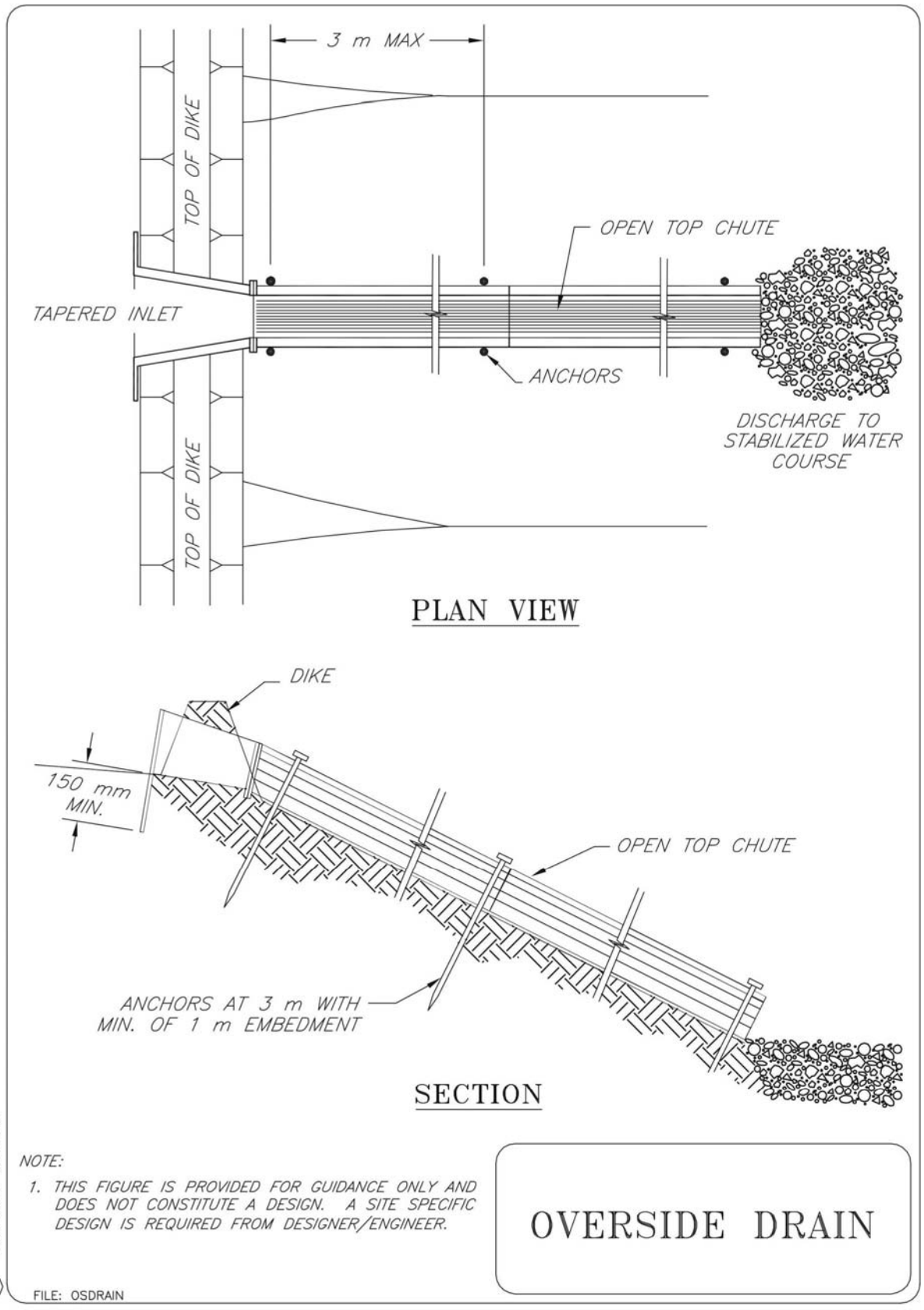
BMP16



Slope Drains

Erosion Control:
Runoff Control

BMP16



Synthetic Permeable Barrier

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP18

Description and Purpose

- Double panel, low profile, uni-body porous synthetic barriers used to dissipate flow energy and reduce velocity
- Barriers of patented design constructed of lightweight and durable synthetic materials
- May be used to create a grade break to reduce flow energy and velocities allowing some sediment to settle out at the upstream barrier panel of the barrier structure
- Can be used to dissipate flow energy and trap sediment during the period of revegetation; should be removed at successful re-establishment of vegetation

Applications

- Temporary structure
- May be placed across trapezoidal ditch to dissipate flow energy and reduce flow velocities
- Can be used to supplement as grade breaks along ditch interval between permanent drop structures along steep ditch grades
- May be used as midslope grade breaks along contours of midslope or at toe of disturbed slopes
- Usually used as grade breaks along ditch (3 to 7% grade) in conjunction with erosion control matting or non-woven geotextile as soil covering mattings; usually used in conjunction with permanent gabion structure at steep grade (>6%) areas
- Designed to be reusable

Advantages

- Prefabricated
- Reusable/moveable
- More appropriate for installing at transition areas of changing grades of channels so that hydraulic jumps (or change of flow regime from supercritical to subcritical) may be triggered to dissipate flow energy, thus minimizing erosion potential
- Provide portable drainage control for construction sites, ditches, channels, roads and slopes
- The double panel porous barrier may cause significant energy loss as the flow of water undergoes from supercritical flow to subcritical flow from the upstream panel to the downstream panel with a more laminar flow evolving downstream and roughly parallel to the stream bed. Less turbulence and erosion energy may be created when compared with cascading, over-topping and tumbling flow from drop structures (i.e. gabions or check structures)
- Barriers constructed of UV resistant material may be left in place for final channel stabilization as UV degradation is low

- Observed to enhance aggregation of silt material and to function as a sediment barrier with the formation of an earth block behind the upstream barrier panel area; the downstream flow exiting at the downstream barrier panel may be less erosive

Limitations

- More appropriate for use as a grade break and may be installed between permanent drop structures
- Partially effective in retaining some sediment and reducing flow velocities
- Less sturdy as drop structures in resisting high flow impact
- Not to be designed as drop structures
- Must be hand installed
- Become brittle in winter and may be easily damaged by highway maintenance activities or by public
- At the time of deactivation of the structure after vegetation establishment, metallic anchor pins, if not biodegradable, may require removal at time of completed revegetation
- Stick-up of metallic anchor pin above ground may be a nuisance and, may present a hazard to human safety and maintenance equipment
- The use of biodegradable anchor pins may be advisable

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Install as per manufacturers recommended installation instructions
- Normally installed in conjunction with erosion control matting in ditches and channels
- Prepare soil surface
- Install basal layer of erosion mat or geotextile fabric; key-in basal mat/fabric at upstream end
- Place and anchor barrier panels with adequate pin anchors to basal soils

Construction Considerations

- Maintain intimate contact between base of barrier and soil with laying of basal matting/fabric intimate to ground surface
- Ensure side panel of barrier is extended to outer edges of channel to sufficient height to provide freeboard of channel flow

Inspection and Maintenance

- Inspect barriers at bi-weekly intervals and after each significant rainfall event

- Remove sediment build-up before it reaches one-half the check structure height
- Do not damage barrier panel during removal of sediment
- Partial or non-removal of sediment build-up will create a non-permeable barrier and low level earth mini-drop structure which will force water flow over-topping the barrier. The option of non-removal of sediments may be open to converting the sediment build-up into a "vegetated earth mini-drop structure" along the ditch with the non-removal of synthetic permeable barrier in-place. This will require topsoil and seeding (or intensive mulch seeding) to promote vegetation growth.
- If erosion is noted at the toe or upslope edges of the structure, hand regrading or suitable repairs should be made immediately to prevent failure of the structure
- Remove and deactivate one year after vegetation is established

Similar Measures

- Silt fences are equally effective at retaining sediment
- Brush or rock filter berms

Design Considerations

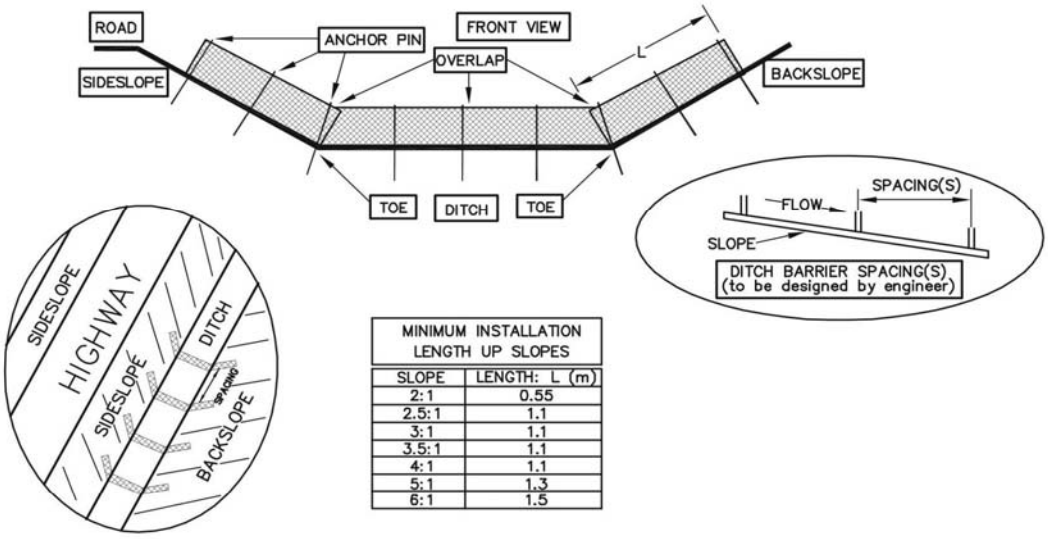
- Install synthetic permeable barrier along ditch interval between permanent drop structures (i.e. gabion); can be economic alternative and supplemental to total hard armouring of complete channel length, or high frequency of gabion installation required for high flow applications in steep ditch grade

Synthetic Permeable Barrier

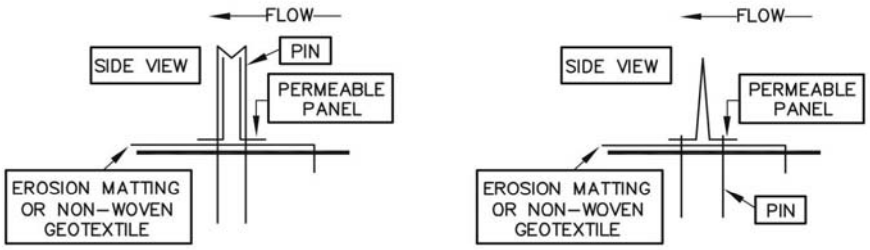
BMP18

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***



MINIMUM INSTALLATION LENGTH UP SLOPES	
SLOPE	LENGTH: L (m)
2:1	0.55
2.5:1	1.1
3:1	1.1
3.5:1	1.1
4:1	1.1
5:1	1.3
6:1	1.5



1) DOUBLE PANEL

2) TRIANGLE PANEL

SYNTHETIC PERMEABLE DITCH BARRIER

N.T.S.

NOTES:

1. *FOR USE MAINLY AS A GRADE BREAK STRUCTURE FUNCTIONING AS A FLOW ENERGY DISSIPATOR AND VELOCITY RETARDER.*
2. *FOR SECONDARY USE AS SEDIMENT BARRIER.*
3. *REQUIRES NON-WOVEN GEOTEXTILE FABRIC OR BIODEGRADABLE (COCONUT FIBRE PREFERABLE) EROSION BLANKET MAT AT BASE AND KEY-IN TO SOIL AT UPSTREAM END.*
4. *MAY BE INSTALLED AS GRADE BREAK AT GRADE TRANSITION AREAS TO CREATE DISSIPATION OF FLOW ENERGY AND A MORE LAMINAR FLOW REGIME DOWNSTREAM OF STRUCTURE.*
5. *THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.*

SYNTHETIC PERMEABLE (ditch) BARRIERS

Fibre Rolls and Wattles

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP19

Description and Purpose

- Straw rolls consist of bundled straw or natural fibre, wrapped in photo-degradable open-weave plastic netting, and staked into the soil along slope contours as a grade break to reduce erosion potential
- Wattles consist of bundled live fascines, staked into the soil along slope contours
- Fibre rolls are installed across slope contours as a grade break to reduce erosion potential by reducing overland flow velocities and encouraging ponding and sediment deposition
- Live stakes can be installed to anchor the fibre rolls and wattles to provide deep root vegetation with potential favourable moisture retention provided by the fibre roll
- Fibre rolls and wattles capture sediment, organic matter and seeds carried by runoff

Applications

- Temporary measure
- May be used on slopes stable enough to support vegetation (steep, confined, slopes and channel banks with gradients greater than 1H:1V may have low success)
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used along long slopes as a grade break to shorten slope length between lines of fibre rolls at different contour elevations
- May be used as grade breaks, where slopes transition from flatter to steep gradients
- May be used on lake shores as wave breaks to assist in revegetation and stabilization of banks
- Can be used in conjunction with live staking as bioengineering measure

Advantages

- Function as a grade break measure to lower sheet and rill erosion potential
- Can be used on slopes too steep for silt fences
- In time, plastic netting will degrade due to the sunlight and straw will degrade and be incorporated into the soil
- Primary purpose is erosion control, but fibre rolls also provide some sediment control

Limitations

- Designed for low sheet flow velocities
- Designed for short slopes with a maximum gradient of 1H:1V
- May be labour intensive to install
- Straw rolls have short life span due to natural degradation; usually only functional for two seasons
- Susceptible to undermining and failure if not properly keyed into the soil

- Labour intensive maintenance may be required to ensure rolls are in continuous contact with the soil, especially when used on steep slopes or sandy soils

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Prepare slope face and remove large rocks or other deleterious materials
- Excavate small trenches approximately one-half roll diameter deep and wide across the width of the slope, perpendicular to slope direction, starting at the toe of the slope and working upwards towards crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place fibre rolls into trench, ensuring continuous contact with soil surface
- Butt-joint adjacent fibre roll segments tightly against one another
- Use a metal bar to make pilot hole through middle of the fibre roll a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1.2 m apart
- Secure fibre roll to soil using wooden stake or other appropriate anchor; live stake may be used as alternate anchor
- Place soil excavated from trench on upslope side of fibre roll and compact to minimize undermining of fibre roll by runoff
- Seed the soil along the upslope and downslope sides of the fibre roll

Construction Considerations

- Use live stakes instead of wooden stakes
- If the slope soil is loose and uncompacted, excavate trench to a minimum depth of 2/3 of the diameter of the fibre roll
- On steep slopes, anchors may be required on the downslope side of the fibre roll

Inspection and Maintenance

- Inspect structures at biweekly intervals or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Areas damaged by washout or rutting should be repaired immediately
- Additional erosion control measures should be considered for rilling areas damaged by runoff

Similar Measures

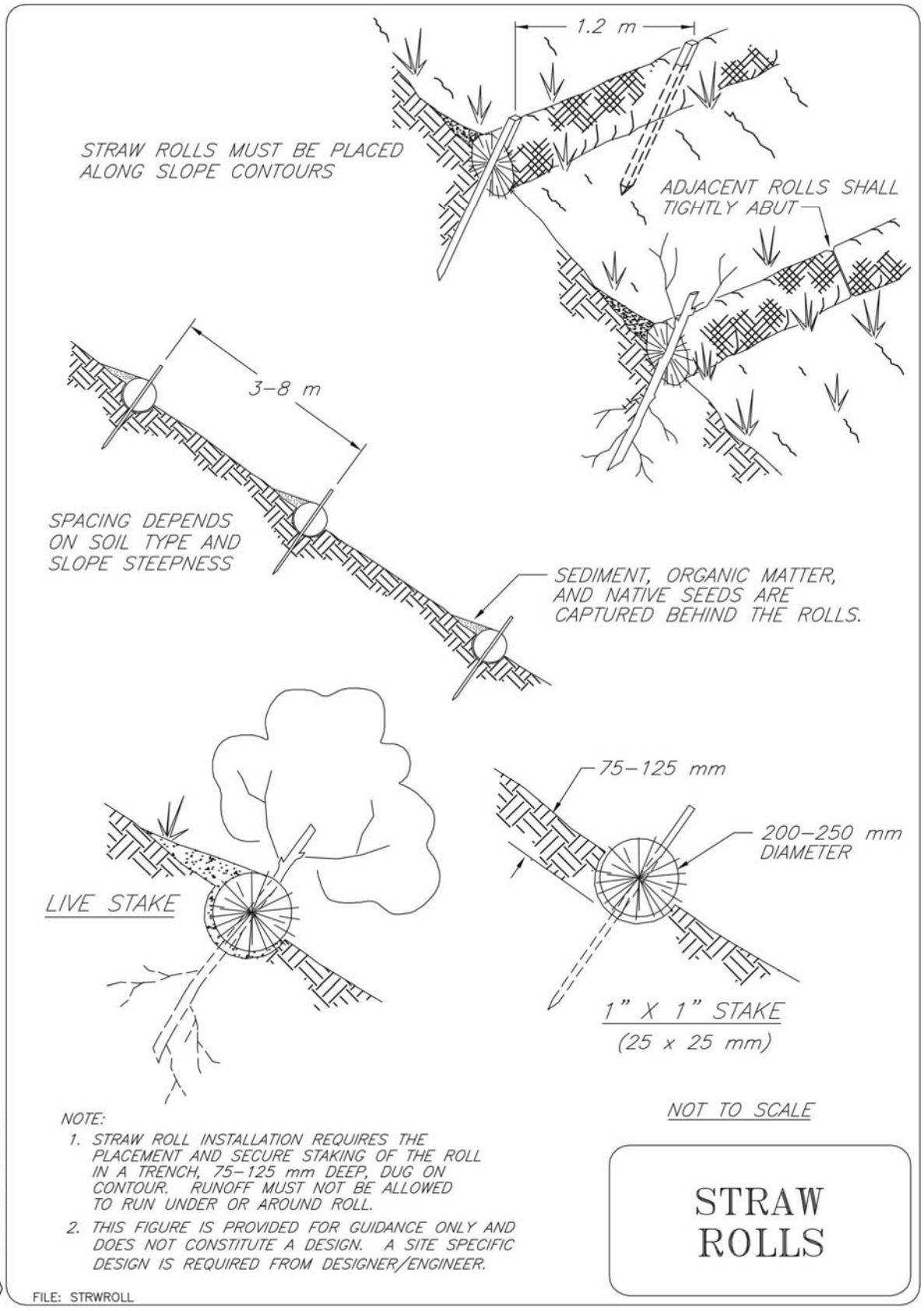
- Synthetic permeable barriers

Fibre Rolls and Wattles

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP19

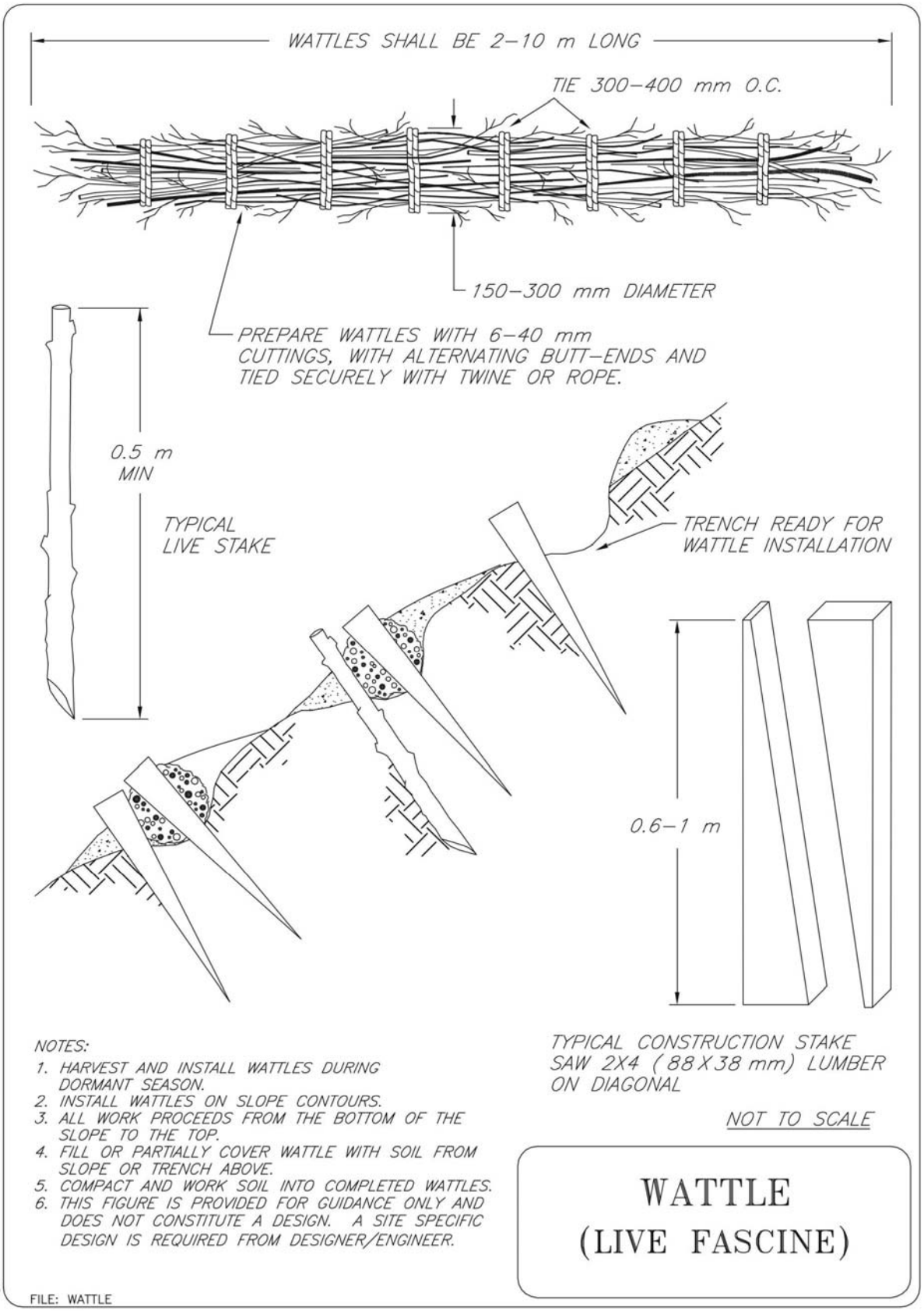


Fibre Rolls and Wattles

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP19



Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20

Description and Purpose

- Small dam constructed across a drainage channel
- May be constructed of rock, aggregate-filled sandbags, straw bales or logs
- Ponded water decreases flow velocities to reduce erosion caused by storm runoff
- Sediment laden runoff is retained, allowing sediment to settle out

Applications

- Temporary or permanent measure
- Reduces long steep grade to intervals of gentle grades between structures
- Reduces flow velocities to decrease erosion potential caused by runoff
- Sediment laden runoff is retained behind structure allowing sediment to settle out
- May be used in channels that drain 4 ha or less (2ha or less for straw bales)
- May be used in steep channels where runoff velocity is less than 1.5 m/s (limited to 0.3 m/s for straw bales)

Advantages

- Cheaper than using riprap armouring or gabion structures in a ditch
- Rock, sandbag and straw bale structures are relatively easy to construct
- Cement can be incorporated into sandbag aggregates for a permanent application
- Timber structures are suited to areas where timber can be salvaged from clearing operations and other materials are in short supply

Limitations

- Not appropriate for flow velocities greater than 1.5 m/s (0.3 m/s for straw bales)
- Not appropriate for channels draining areas larger than 4 ha (2 ha for straw bales)
- Not appropriate for grass lined channels unless erosion is anticipated
- Susceptible to failure if water undermines or outflanks structure
- Timber structures are labour intensive to construct, gaps between logs may render them ineffective and they will decay and rot with time
- Straw bales should only be used as a temporary measure and have a short service life (1-2 years); they are susceptible to failure if bales are not properly trenched and anchored

Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20

Construction (Rock Check Dam)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Excavate a trench key a minimum of 0.15 m in depth at the rock check structure location
- Place non-woven geotextile fabric over footprint area of rock check structure
- Construct structure by machine or hand
- Structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of structures should be less than 0.8 m in height to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 3H:1V (minimum)
- Upstream slope of the check dam should be 2H:1V (minimum)

Construction Considerations (Rock Check Dam)

- Height and spacing between structures should be designed to reduce steep channel slope to intervals of flatter gradient
- Rock check structures should be constructed of free draining aggregate
- Aggregate used should have a mean diameter (D_{50}) of between 75 mm and 150 mm and must be large enough to remain in place during high velocity flow situations. Maximum rock diameter should not exceed 150 mm if the structure is to be used as a sediment trap.
- If rock check structures are in channels with significant high flows, they must be properly designed for stone size and structure spacings

Construction (Sandbag Check Dam)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Place sandbags by hand at check structure location with geometry similar to that shown for the rock check dam
- Check structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of check structures should be less than 0.8 m to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 2.5H:1V (minimum)
- Upstream slope of the check dam should be 1.5H:1V (minimum)

Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20

Construction Considerations (Sandbag Check Dam)

- Height and spacing of check structures should be designed to reduce channel slope to intervals of flatter gradient
- Sandbags should only be filled ¾ full to allow bag to mould to contours, allowing continuous contact between the bag and the soil

Construction (Straw Bale Check Dam)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Excavate a trench approximately 0.15 m deep with a width of two straw bales at the straw bale check structure location
- Place two rows of straw bales in excavated trench perpendicular to flow direction ensuring bales are staggered so that no joints are aligned on the upstream and downstream rows. Ensure twine or wire is not in contact with the soil
- Infill all joints with straw
- The centre of the crest of the check structure should be at least 0.15 m lower than the outer edges along the channel walls
- Drive two 1.2 m long square section wooden stakes through each straw bale, ensuring each stake is embedded a minimum of 0.15 m into soil
- Backfill and compact the upstream and downstream edges of the check structure to seat the straw bales into the base of the ditch
- Geotextile wrapping may be specified; the geotextile should be pinned to the straw bale subgrade

Construction Considerations (Straw Bale Check Dam)

- Height and spacing of structures should be designed to reduce gradient to a flatter grade
- To avoid impounding large volumes of runoff, check structures should be a maximum of one straw bale high
- Straw bales should be:
  - Machine-made
  - Weed free cereal crop straw such as wheat, oats, rye, or barley
  - Tightly compacted and bound with two rows of wire or synthetic string and shall show no signs of weathering
  - No more than year old

Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20

Construction (Log Check Dam)

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Embed ends of logs at least 0.5 m into channel or ditch bed
- Ensure there are minimal gaps between logs
- Install horizontal cross brace at top of the downstream side of structure to connect logs together providing integral support
- Structure should extend from one side of the ditch or channel to the other
- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- To avoid impounding large volumes of runoff, check structures should be less than 0.5 m in height above the base of the ditch.

Construction Considerations (Log Check Dam)

- Height and spacing of structures should be designed to reduce gradient to a flatter grade
- Wood check dams should have their spacing and height design according to the anticipated hydraulic condition (flow depth and velocity)
- Bracing should be installed to provide support to embedded logs

Inspection and Maintenance

- Inspect barriers at least once a week and before and after each significant rainfall event (more than 25 mm in a 24 hour period)
- Remove sediment build up before it reaches one half the check structure height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace dislodged materials immediately or consider a more robust structure

Similar Measures

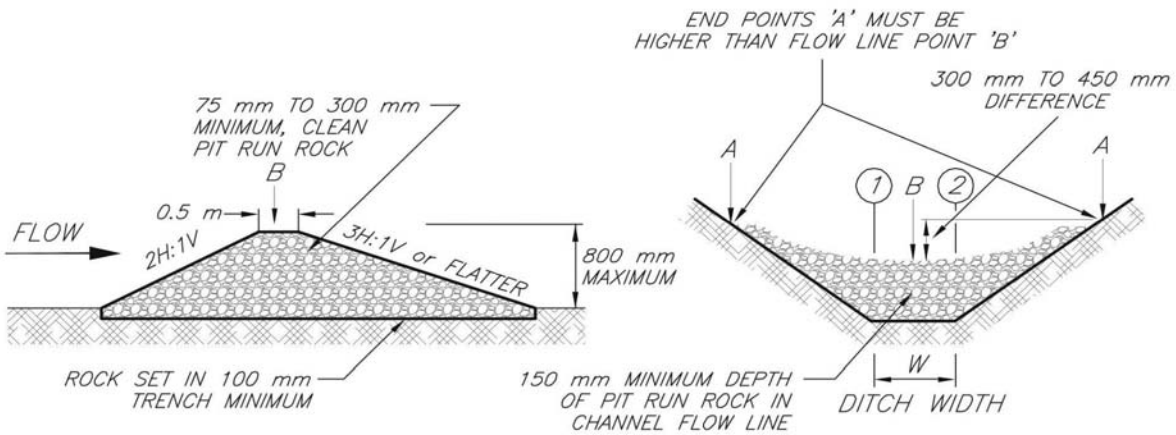
- Synthetic permeable barrier

Check Dams

Erosion Control: ***Runoff Control***

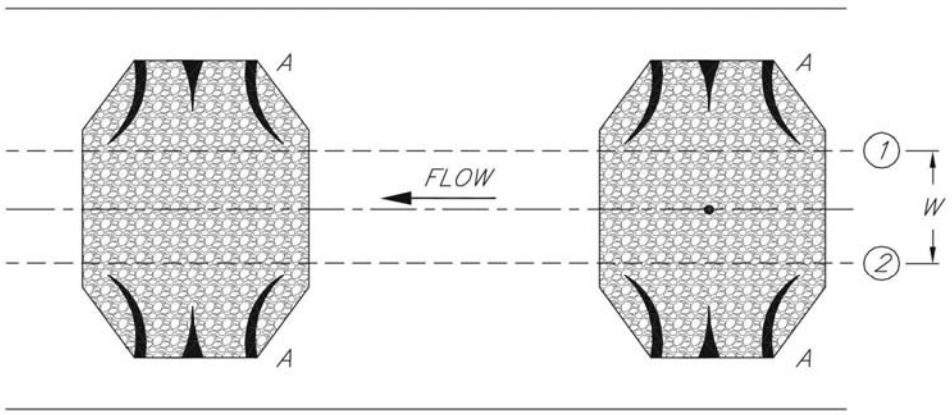
Sediment Control: ***Settling***

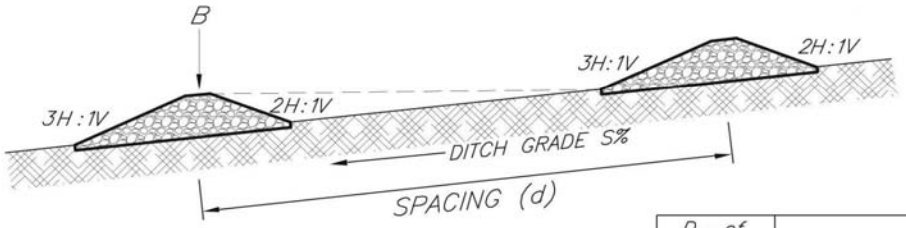
BMP20



SIDE VIEW

FRONT VIEW





D_{50} of ROCK (mm)	MAXIMUM FLOW DEPTH OVER ROCK (mm)
75	50
150	100

SUGGESTED ROCK DIAMETER AND OVERFLOW DEPTHS

NOTES:

1. SUITABLE FOR FLOW VELOCITY ≤ 1.5 m/s.
2. SUITABLE FOR DRAINAGE AREA ≤ 4 ha.
3. SUITABLE FOR GRADES FROM 5% TO 8%.
4. SPACING (d) AND ROCK SIZE (D_{50}) TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

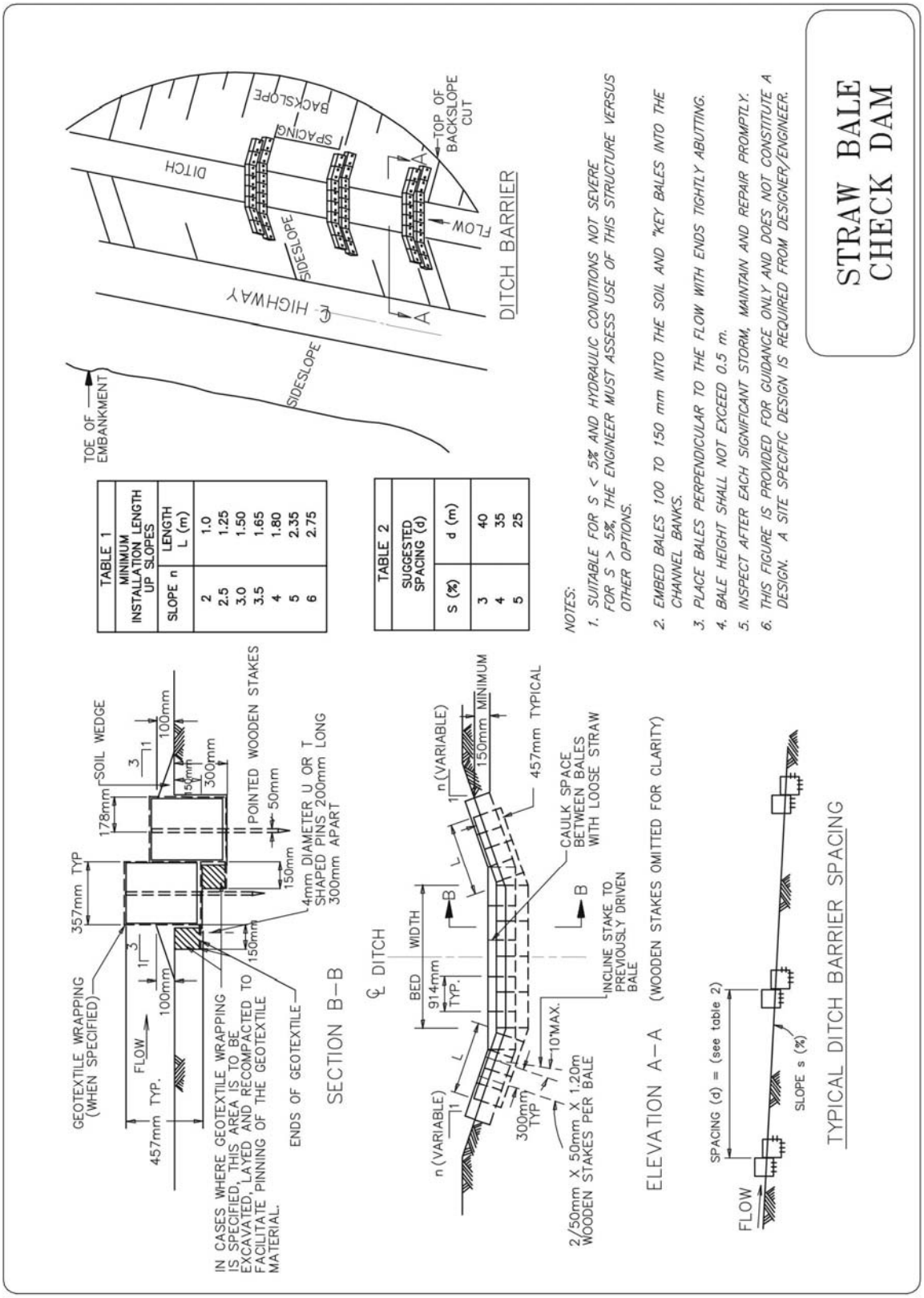
ROCK CHECK DAM

Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20

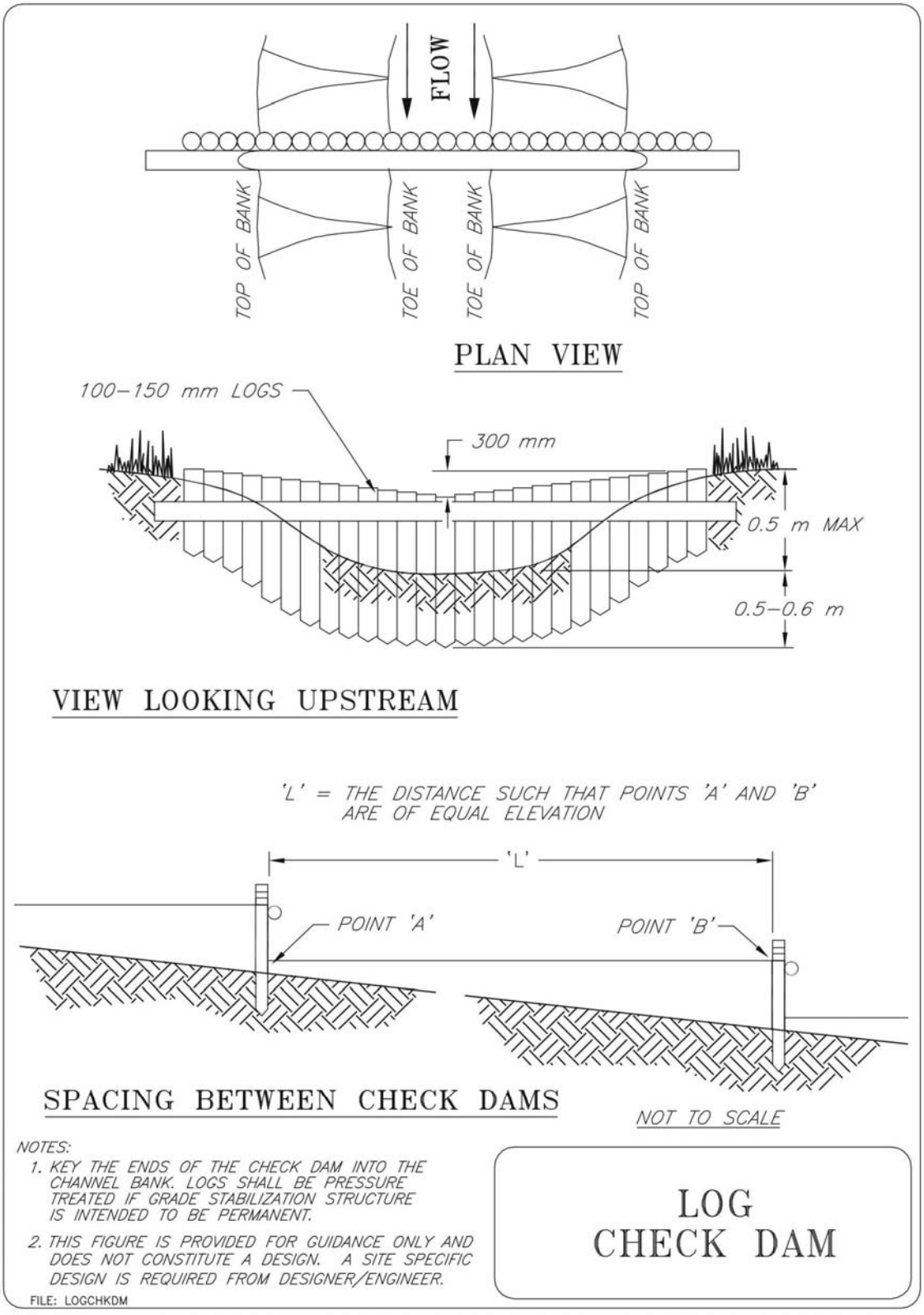


Check Dams

Erosion Control: ***Runoff Control***

Sediment Control: ***Settling***

BMP20



This page left blank intentionally.

Diversion Ditch

Erosion Control:
Runoff Control

BMP21

Description and Purpose

- Channels or swales commonly located along the crest of cuts slopes to intercept and convey runoff away from bare soil slopes and to minimize erosion of slopes from sheet flow
- Often convey water to slope drains which carry water downslope

Applications

- Permanent measure
- Effective method of intercepting runoff to avoid excessive sheet flow over slope
- Effective at reducing erosion on cut slopes in highly erodible soils
- Can be used in conjunction with slope drains
- May be lined with vegetated or non-vegetated erosion control BMPs, but this requirement may be appropriate only in highly sensitive areas
- Can be used in conjunction with sediment control measures, such as check structures or permeable synthetic barriers, but this requirement may be appropriate only in highly sensitive areas

Limitations

- Ditch may require lining to minimize soil erosion from concentrated flow
- Ditch may require detailed design by qualified personnel if flow velocities and/or volumes are large
- Channel must be graded to maintain adequate depth and positive drainage; ponding and breaching of the channel could lead to overtopping of the channel and downslope erosion
- Removal of sediment build up and ditch maintenance may be difficult due to limited access space, because diversion ditches are commonly constructed at slope crests

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Use backhoe to excavate the ditch a minimum offset distance of 2 m between the crest of the cut slope and the top of the diversion ditch sideslope
- Place and compact excavated soil to form a dyke between crest of highway slope and diversion ditch channel to provide adequate depth of the diversion ditch
  - The consequence of failure of this dyke will determine the level of compaction effort required
  - Sideslopes of the diversion ditch should not be steeper than 2H:1V (depending upon material type)

- The depth of the diversion ditch (from base of ditch to top of embankment) should be a minimum of 1 m in depth; the width of ditch should be 1 m minimum
- The ditch should be graded at a minimum of 1% to promote positive drainage and outfall

Construction Considerations

- Channel should be graded towards nearest outfall or drainage pipe

Inspection and Maintenance

- Inspect ditches at least at biweekly intervals and after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
- Repair any damage to channel immediately

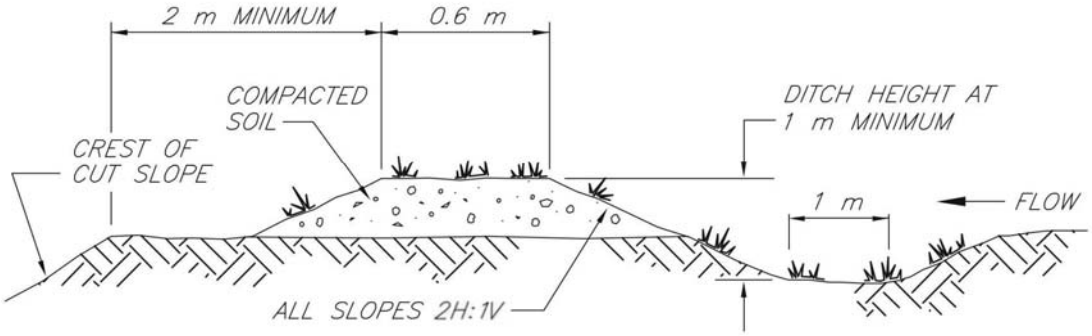
Similar Measures

- Berms
- Barriers

Diversion Ditch

Erosion Control:
Runoff Control

BMP21



TYPICAL DIVERSION DITCH

NOTES:

1. THE DITCH BEHIND THE DYKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
2. THE DYKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.
3. FOR SENSITIVE HIGH RISK AREAS, THE DITCH SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

DIVERSION DITCH

FILE: TEMPDIKE

This page left blank intentionally.

Energy Dissipators

Erosion Control:
Runoff Control

BMP22

Description

- Minimizes scour at flow impact location with dissipated flow energy
- Hard armour (rip rap, gravel, sand bags, concrete) placed at pipe outlets, in channels and downstream of check structures to reduce velocity and dissipate energy of concentrated flows
- Standard drain trough terminal protection structure generally used on bridge headslopes

Applications

- Permanent measure
- May be used at outlets of pipes, drains, culverts, conduits, or channels with substantial flows
- May be used at slope drain outlets located at the bottom of mild to steep slopes
- May be used where lined channels discharge into unlined channels
- May be used as a splash pad downstream of gabions, check structures, berms, barriers, and silt fences to prevent erosion caused by overtopping

Advantages

- Reduces flow energy in a relatively small area

Limitations

- Small rocks or stones can be dislodged during high flows
- Grouted rip rap may break up due to hydrostatic pressure, frost heave, or settlement
- May be expensive if construction materials (rip rap, gravel, or concrete) are not readily available
- May be labour intensive to place and construct
- Extreme flow velocities may require paved outlet structures, stilling basins, plunge pools, drop structures, baffles, or concrete splash pads which will require special design by qualified personnel. Energy dissipators constructed of rip rap may not be adequate for extreme flow velocities

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Grade the area to final design grades and elevations
- Sub-excavate energy dissipator location to thickness of energy dissipator
- Place filtration bedding material on base of excavation

  - Bedding can be comprised of well graded sand and gravel or non-woven geotextile
  - Acts as separating filter between fine grained subgrade and riprap size energy dissipator material
- Place energy dissipator material (rip rap, gravel, sand bags, concrete) over filtration bedding material
  - Top of energy dissipator should be flush with surrounding grade

Construction Considerations

- Length of energy dissipator (L_a) at outlets shall be of sufficient length to dissipate energy
  - L_a = 4.5 x D (where D is the diameter of the pipe or channel at the outlet)
  - Energy dissipator should extend upstream of the outlet approximately a minimum distance of 0.5 x D
- Width of energy dissipator (W_a) at outlets shall be of sufficient width to dissipate energy
  - W_a = 4 x D
- Thickness of energy dissipator (d_a) at outlets shall be of sufficient thickness to dissipate energy
  - d_a = 1.5 x maximum rock diameter (with a minimum thickness of 0.30 m)
- Energy dissipator (splash pad, apron) shall be set at zero grade and aligned straight, with the direction of flow at the outlet
- Bedding (filtration) layer can comprise either non-woven geotextile or a minimum of 0.15 m well graded sand and gravel layer
- Energy dissipator should be constructed of well-graded rip rap
  - Minimum d_{50} = 150 mm. Preferable d_{50} = 300 mm
  - Minimum thickness = a) 1.5 x d_{50} or b) 0.30 m to 0.45 m thickness. (a or b whichever is greater)
- Energy dissipator shall be designed to accommodate a 10-year peak runoff or the design discharge of the upstream channel, pipe, drain, or culvert, whichever is greater

Inspection and Maintenance

- Periodic inspections to check for damage should occur at least once a month, or after storm events (1:2 year storm and/or 40 mm rainfall over 24 hour duration)
- Any damage should be repaired immediately

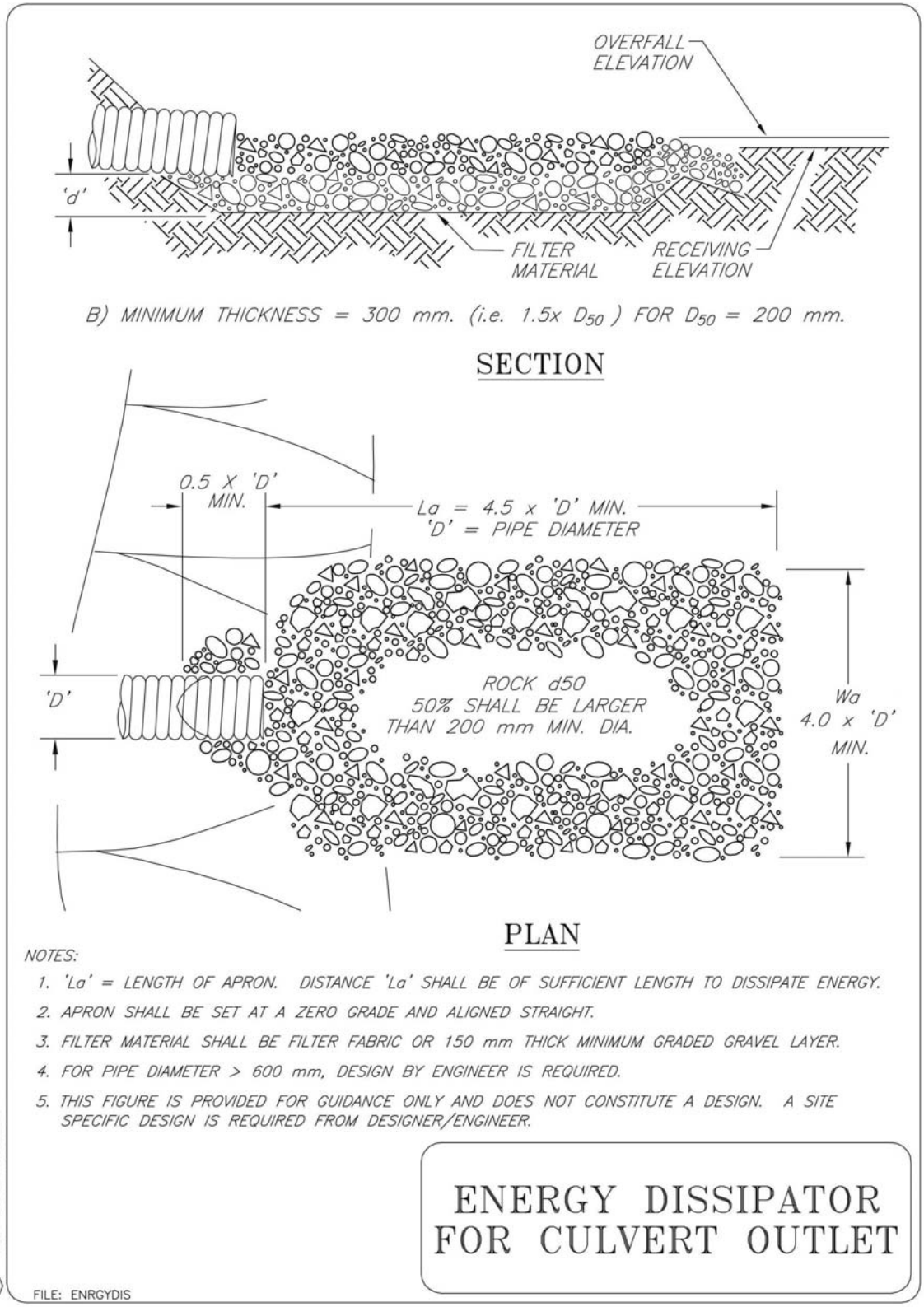
Similar Measures

- Gabion mattresses

Energy Dissipators

Erosion Control:
Runoff Control

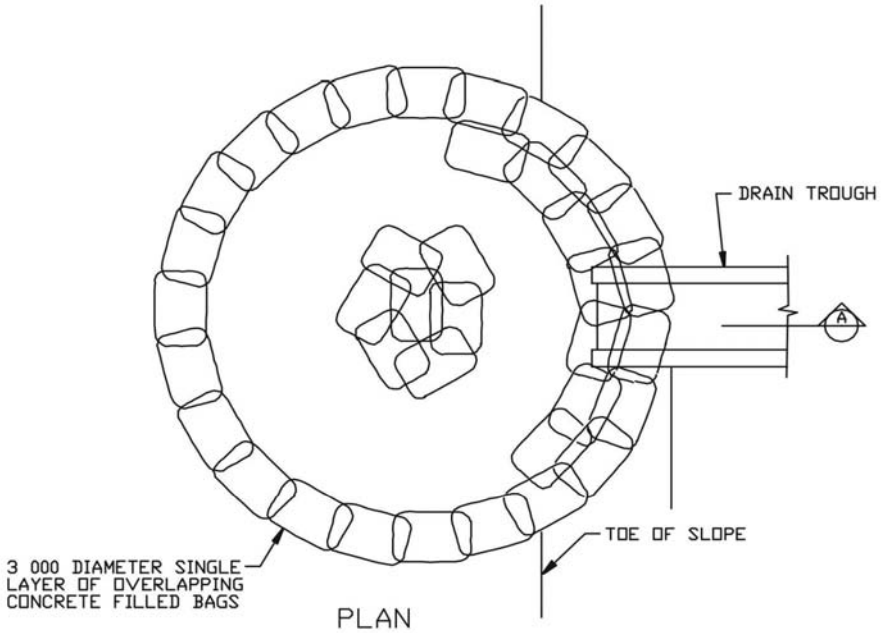
BMP22



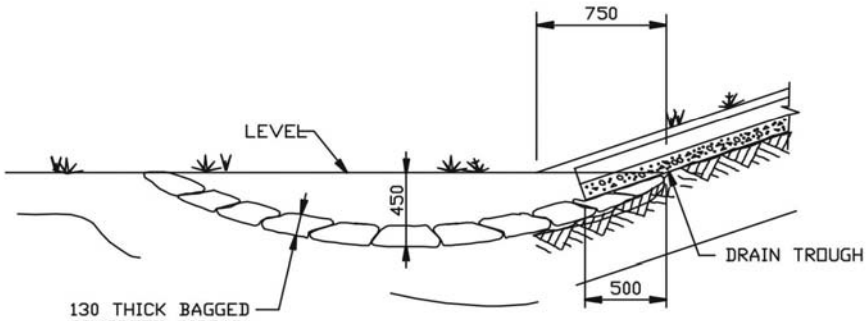
Energy Dissipators

Erosion Control:
Runoff Control

BMP22



PLAN



A SECTION

GENERAL NOTES

- DIMENSIONS ARE GIVEN IN mm. DETAILS ARE NOT TO SCALE.
- PLACING OF BAGGED CONCRETE RIPRAP SHALL START AT THE BOTTOM CENTRE OF THE DISHED AREA AND SHALL PROCEED IN A CONTINUOUS SPIRAL FASHION OUTWARD UNTIL THE ENTIRE DISH IS COVERED. EACH CONCRETE FILLED BAG SHALL LAP OVER THE EDGES OF THE PREVIOUSLY PLACED BAGS.

  SOURCE: ALBERTA TRANSPORTATION: SPECIFICATIONS FOR BRIDGE CONSTRUCTION
  DRAWING: S-1410-91

- THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

ENERGY DISSIPATOR
FOR SEMI-CIRCULAR TROUGH DRAIN TERMINAL PROTECTION FOR BRIDGE HEADSLOPE

Silt Fence

Sediment Control: Settling

BMP23

Description and Purpose

- Permeable fabric barriers installed vertically on support posts along contours to collect and/or filter sediment laden sheet flow runoff
- Causes water to pond and sediment to settle out as fabric impounds water
- Decreases flow velocity in channels with low to moderate flows (<0.03 m^3/s)
- Entraps and minimizes coarse sediment from sheet flow or overland flow from entering waterbodies
- Perimeter control for sediment transport and deposition
- Also known as “sediment control fence”

Applications

- Temporary measure
- Used at bottom of cut or fill slopes to collect sediment laden runoff
- Used along streams or watercourse banks
- Used around stockpiles
- Midslope grade-break (using "J-hook" or "smile" pattern to cause ponding and sedimentation)

Advantages

- Low permeability silt fences have high ponding and settling capabilities for fine sand to coarse silt

Limitations

- **Successful performance is highly dependent on proper installation**; silt fence is commonly installed incorrectly and failures can cause erosion
- Applicable for sheet flow, normally cannot handle concentrated channel flow volumes
- May fail under high runoff events or due to damage caused during sediment removal
- Limited to locations suitable for temporary ponding of sediment laden runoff
- Low permeability silt fences may not be strong enough to support weight of water retained behind it and may require reinforcement (i.e. wire mesh and stronger support posts)
- Sediment build up needs to be removed at 1/2 height and on a regular basis
- Has a useable life of approximately one year, depending on maintenance and sediment requirement

Silt Fence

Sediment Control: Settling

BMP23

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Two methods of installation are commonly used:
  - Trench method
  - Mechanical (slicing) installation method (e.g. Tommy Silt Fence Machine or equivalent)

  The mechanical installation method is recommended because it results in less disturbance to native ground and in general provides a stronger end product
- Trench Method
  - Select the location of the silt fence (usually along contours)
  - Excavate a trench 0.30 m deep by 0.15 m wide for the entire length of fence
  - Drive the support posts a minimum of 0.6 m into the ground along the downstream side of the trench, spaced a maximum of 2 m apart; use a spacing of 1 m for critical water-retaining areas
  - Attach the wire mesh or snow fencing, if used as reinforcement to fence fabric, to the upstream side of each post with staples
  - Extend the filter fabric to the base of the trench and attach it over the wire mesh or snow fence, if used, on the upstream side of posts
  - Backfill and compact the soil in the trench, being careful not to damage the fence
- Mechanical Installation Method
  - Select the location of the silt fence (usually along contours)
  - Use a mechanical installation machine to embed the fabric a minimum of 0.2 m to 0.3 m into the ground. One mechanical installation method involves slicing (with special equipment) the geotextile fabric to embed it into the ground without excavation or backfill. This results in only minor disturbance of the ground and only minor tamping of the ground is required for compaction.
  - Drive the support posts a minimum of 0.6 m into the ground, spaced a maximum of 2 m apart; use a spacing of 1 m for critical water-retaining areas
  - Attach the wire mesh or snow fencing, if used as reinforcement, to the silt fence fabric and to the upstream side of posts with staples
- Note on Type 2 Silt Fence
  - Heavy grade silt fence may be required by regulatory agencies for installation near watercourses
  - Type 2 silt fence uses steel posts, with filter fabric supported by wire fencing material and a compacted gravel toe anchorage

Construction Considerations

- Site Selection
  - Size of drainage area to a silt fence should be no greater than 0.4 ha

  - Maximum flow path length above silt fence should be no greater than 30 m
  - Maximum slope gradient above the silt fence should be no greater than 2H:1V
- Fence should be placed on the contour to produce proper ponding
- Fence should be placed far enough away from the toe of slope to provide an adequate ponding area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of the fence should be angled upslope to collect runoff
- Fence should not extend more than 0.6 m above grade
- Posts can be wood or metal, depending on design and ground conditions
- Posts should be placed on the downstream side of the fence
- Posts should be driven at least 0.6 m into the ground
- Posts should not be spaced greater than 2 m apart
- Wire mesh or snow fencing may be placed between the posts and the filter fabric to provide additional strength and support reinforcement
- Filter fabric should be cut from a continuous roll to avoid joints. If joints are necessary, filter fabric should be wrapped around the fence post with a minimum overlap of 0.2 m, and staples should be used to attach the fabric to the post
- Fence (and wire mesh or snow fence, if used) should be attached to the posts with heavy duty staples, tie wires, or hog rings
- Fence (and wire mesh or snow fence, if used) should be dug into a trench at least 0.30 m deep to prevent undercutting of fence by runoff
- Trench backfill should be compacted
- Long runs of silt fence are more prone to failure than short runs
  - The maximum length of each section of silt fence should be 40 m
  - Silt fence should be installed in 'J' hook or 'smile' configuration, with maximum length of 40 m, along contours allowing an escape path for ponded water (minimizes overtopping of silt fence structure)

Inspection and Maintenance

- Inspections should occur twice per week and after significant storm events (1:2 year storm event and/or >40 mm rainfall over 24 hours duration)
- Repair undercut fences and repair or replace split, torn, slumping or weathered fabric immediately
- Sediment build up should be removed once it accumulates to a depth of 0.2 m or at 1/2 height of fence
- Remove fence after vegetation is established
- Deactivate fabric by cutting off the top portion of fabric above ground; the bottom trenched-in portion can be left in-ground to minimize ground disturbance

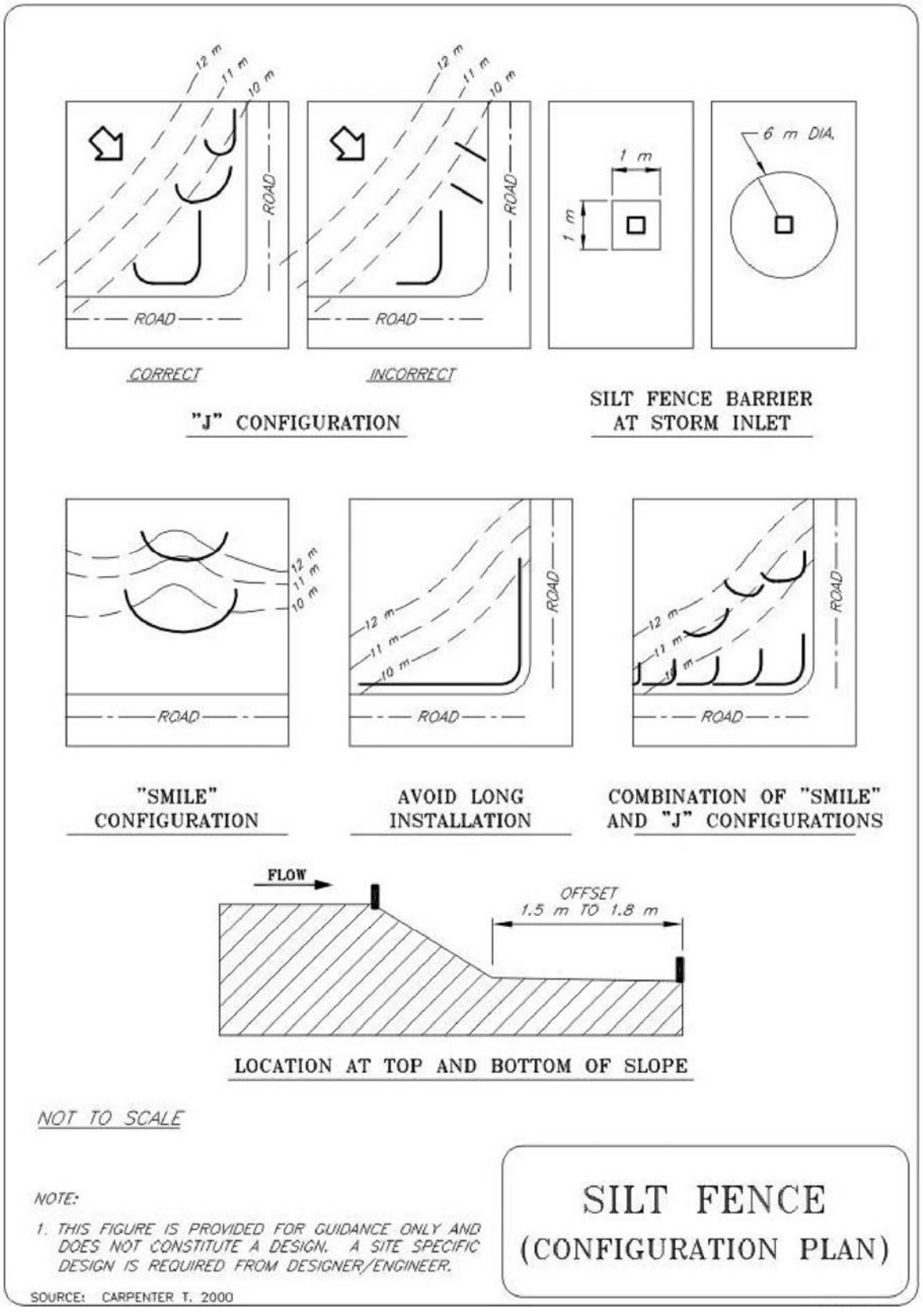
Similar Measures

- Check Dams
- Permeable synthetic barriers

Silt Fence

Sediment Control: Settling

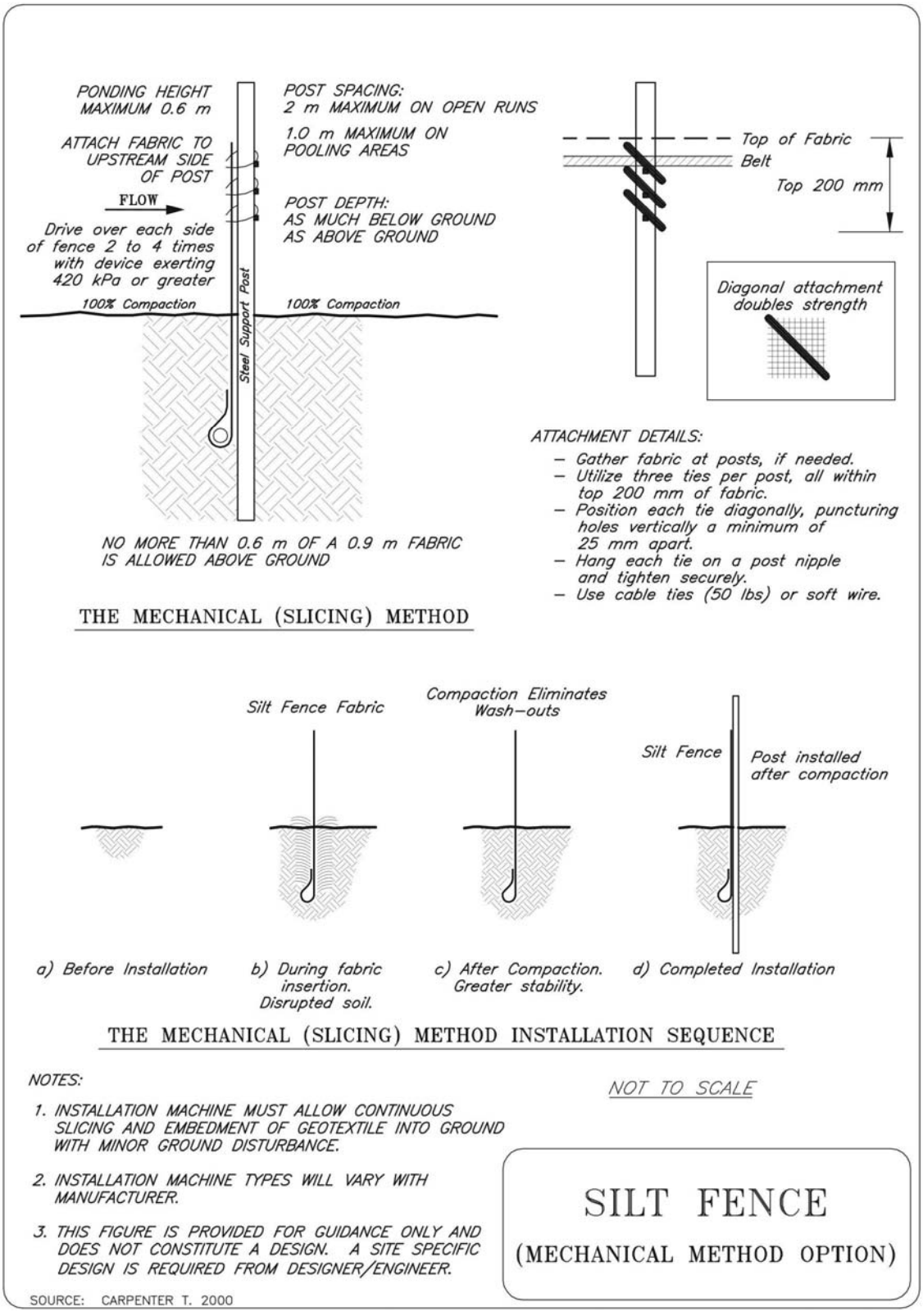
BMP23



Silt Fence

Sediment Control: Settling

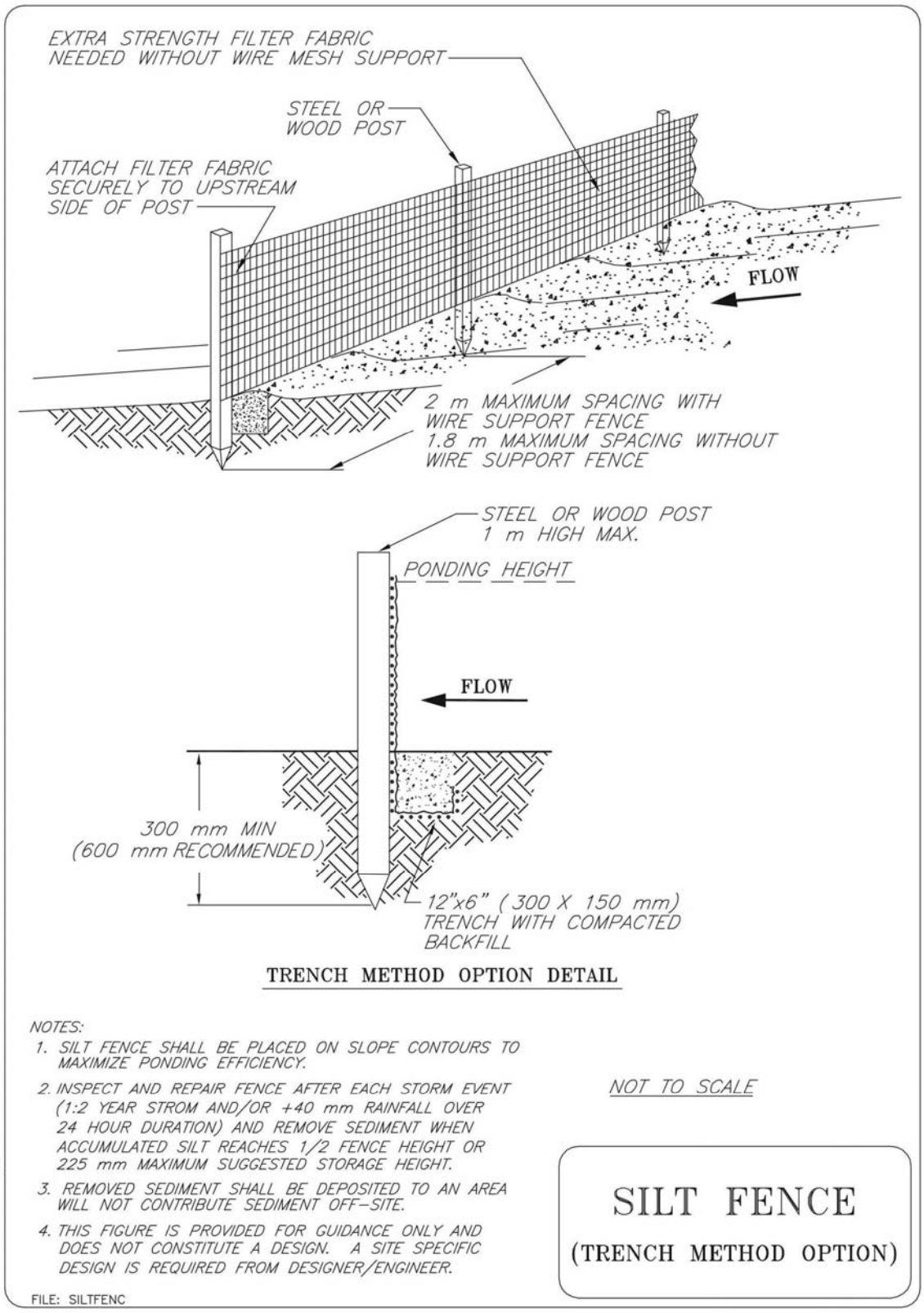
BMP23



Silt Fence

Sediment Control: Settling

BMP23



Brush or Rock Berm

Sediment Control:
Settling

BMP24

Description and Purpose

- Temporary barriers of brush and/or rock wrapped in geotextile and secured in place to intercept sediment laden stormwater runoff from disturbed areas, retain sediment, and release water as sheet flow

Applications

- Temporary measure
- Perimeter control
- Near toe of slopes subjected to sheet flow and rill erosion
- Along crest or tops streams and channels
- Around drain inlets
- Maximum drainage area of 250 m^2 per 25 m length of barrier

Advantages

- May be equally effective as silt fences

Limitations

- Temporary measure only
- Maximum drainage area of less than 250 m^2 per 25 m length of barrier
- Sufficient area behind berm required for ponding and clean out of sediment
- Not effective for diverting runoff (allows runoff to seep through)
- Rock berms are expensive to remove at completion of service life
- Not to be used across ditches, channels, or swales where high concentrated flows are anticipated

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Brush berm
  - Size of the brush berm will vary depending upon amount of material available and condition of the site
  - The height of the berm shall be at least 1 m and the width shall be a minimum of 1.5 m at its base
  - Berm is constructed by piling brush, roots, stumps and/or stones into a mounded row along contours
    - During clearing and grubbing, equipment can push the material into windrows along toe of slopes or other areas prone to erosion

  - Geotextile is then laid across the berm, with edges overlapping, and secured in a trench immediately upstream of the berm
    - Trench shall be 15 cm wide and 15 cm deep and shall run for the entire length of the berm
  - The geotextile in the trench shall be staked down with stakes spaced approximately 1 m apart
  - The trench is then backfilled and compacted over the staked geotextile
  - The geotextile is anchored with twine/wire to stakes on the downstream side of the berm
- Rock filter berm
  - Constructed similar to brush berm, replacing brush with rock (D_{50} = 75 mm to 150 mm)

Construction Considerations

- Use rock or brush material smaller than 150 mm in diameter, or use geotextile to encapsulate the material
- There is no predetermined shape for berms
- Water must be forced to pond behind the berm to encourage settling
- Brush barriers can generally be constructed of clean organic material made available from clearing and grubbing operations that is normally burned or discarded
- Rock and brush berms are temporary measures and should be removed upon completion of service life, after revegetation of areas upslope

Inspection and Maintenance

- Inspect berms on a weekly basis and before and after significant rainfall events (1:2 year storm event and/or 40 mm rainfall over 24 hours duration)
- Reshape berms as needed and replace lost or dislodged rock, brush, and/or geotextile
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-third the berm height or 300 mm, whichever occurs first
- Inspect for toe undercutting, weathered/deteriorated geotextile, and end runs and erosion of the berm and repair immediately

Similar Measures

- Berms/barriers
- Check dams
- Permeable synthetic barriers

Brush or Rock Berm

Sediment Control:
Settling

BMP24

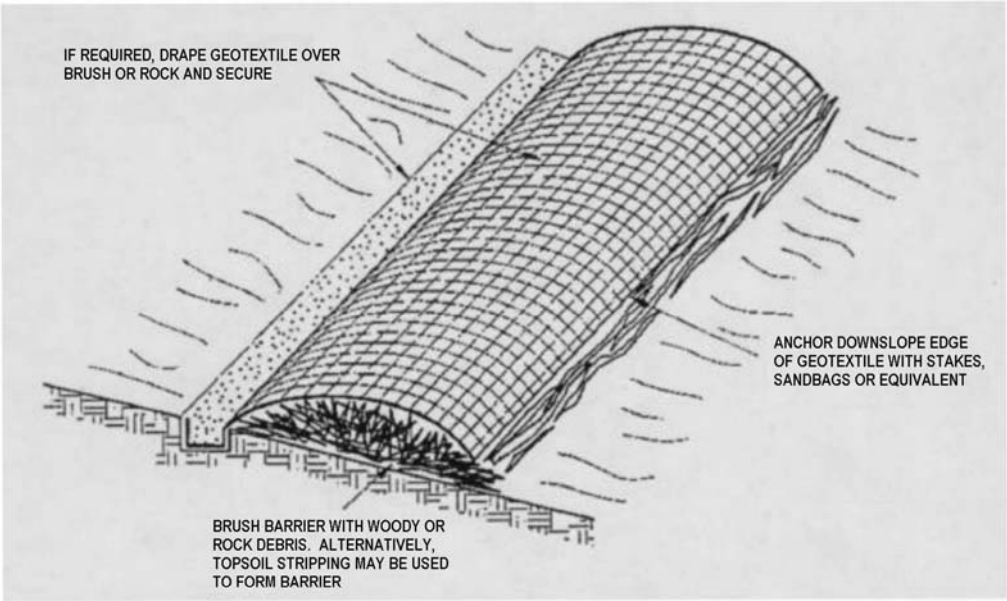
Design Considerations

- Material properties
  - Rocks
    - Shall consist of hard, durable, clean mineral particles free of organic matter, clay lumps, soft particles, or other substances that might interfere with drainage and filtering properties
    - D_{50} of 75 mm to 150 mm preferable
  - Brush
    - Material shall be less than 150 mm in diameter

Brush or Rock Berm

Sediment Control:
Settling

BMP24



NOT TO SCALE

NOTES:

1. EXCAVATE 150 mm X 150 mm TRENCH ALONG UPSTREAM SIDE OF BRUSH OR ROCK BERM.
2. DRAPE GEOTEXTILE OVER BRUSH OR ROCK BERM ENSURING UPSTREAM SIDE IS IN TRENCH.
3. BACKFILL AND COMPACT SOIL OVER GEOTEXTILE IN EXCAVATED TRENCH.
4. SECURE GEOTEXTILE OVER BRUSH OR ROCK BERM BY STAKING ON DOWNSTREAM SIDE OF BERM.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

BRUSH or ROCK BERMS

Earth Dyke Barrier

Sediment Control:
Settling

BMP27

Description and Purpose

- Barrier constructed of compacted soil to intercept and divert flow of runoff water away from sensitive areas or water bodies
- May require a spillway outlet of erosion-resistant granular material constructed to allow exit of diverted water to less sensitive areas.

Applications

- Temporary or permanent measure
- Used instead of (or in conjunction with) diversion ditches
- Placed along contours at toes of slopes to divert runoff from sensitive areas
- Used to divert water to sediment control structures

Advantages

- Easy to construct
- Can be converted to sediment basin or trap with the design of a permeable filter berm at the exit spillway area

Limitations

- Generally, an earth dyke barrier can be 1 to 2 m in height. Design by a geotechnical engineer is required for barriers greater than 3 m in height in accordance with dam design guidelines and regulatory requirements. The consequences of failure will influence the level of design and construction requirements.

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- Construct barrier from bottom up by placing and compacting subsequent lifts of soil
- Degree of compaction of each lift to be determined by the design engineer based on consequences of failure

Construction Considerations

- The barrier shall be trapezoidal in section
- Low barriers should have the slopes tailored to the construction material used
  - 1.5H:1V for granular soils (predominantly gravel)
  - 2H:1V or flatter for compacted mixed or fine grained soils
  - Slope should be a minimum of 3H:1V for uncompacted fine grained soils

Earth Dyke Barrier

Sediment Control:
Settling

BMP27

Inspection and Maintenance

- The degree and extent of inspection and maintenance performed on an earth dyke barrier is directly related to the consequences of failure. Depending on the consequences of failure, an engineer experienced in embankment design and inspection may be required for inspection, design of remedial measures and supervision of their implementation.
- Inspect barriers on a weekly basis and before and after significant rainfall events (1:2 year storm and/or 40 mm rainfall over 24 hour duration)
- Piping failures may be remedied by replacing saturated soils with drier compacted soil and/or by placement on the failed area of a stabilizing toe berm constructed of granular materials over non-woven geotextile
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-half the barrier height
- Deactivate and remove barrier once soils upslope have stabilized and return barrier location to conditions that are equivalent or better than prior to barrier construction

Similar Measures

- Continuous berms
- Sand/gravel bag barriers

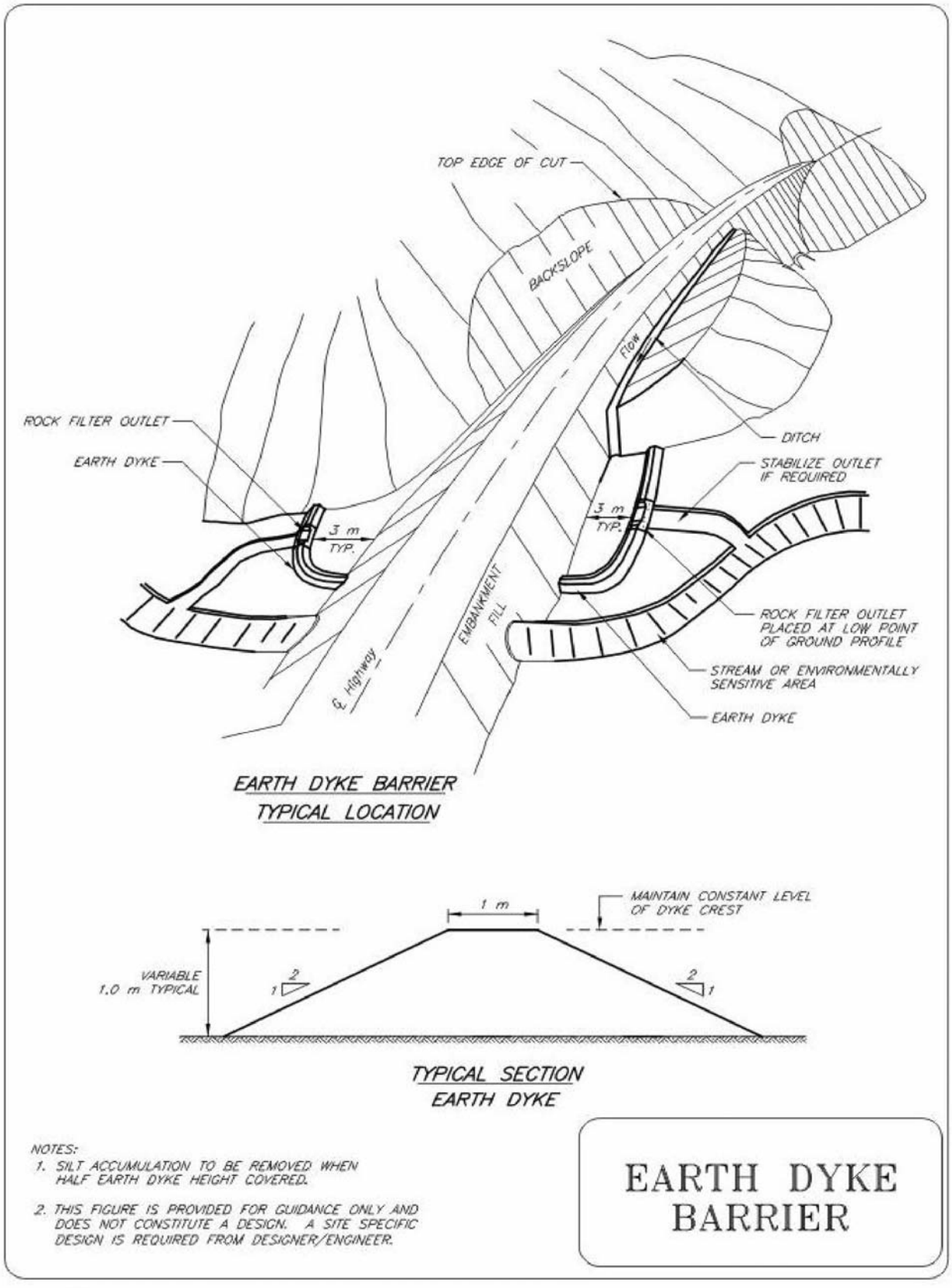
Design Considerations

- Geotechnical design required for barriers constructed of fine grained soils and greater than 3 m in height

Earth Dyke Barrier

Sediment Control:
Settling

BMP27



This page intentionally left blank.

Sediment Traps and Basins

Sediment Control:
Settling

BMP28

Description and Purpose

- Low height dam enclosure for impoundment of sediment laden storm water, sedimentation and release of treated runoff
- Used to trap sediment laden run off and promote settlement of sediment prior release
- Constructed by excavating a pond or building embankments above the original ground surface
- Sediment traps and basins can be divided by size of pond impoundment enclosure
  - Basin (Type I) for pond area $\geq$500 m²
  - Trap (Type II) for pond area $\leq$500 m²

Applications

- Temporary (for construction period) or permanent measure
- Used at terminal or selected intermediate points of concentrated runoff for impoundment of runoff and sedimentation of silt prior to release of treated runoff
- Used as a sediment control measure at outlets from construction sites where runoff may enter watercourses, storm drains, or other sensitive areas
- Used where there is a need to impound a significant amount of sediment from significant areas of land disturbance
- Removal of small diameter particles may require use of flocculants. This should be done with caution to prevent adverse effects on aquatic life
- Sediment basins (Type I) used for disturbed drainage areas greater than 2.0 ha
- Sediment traps (Type II) used for disturbed drainage areas of 2.0 ha or less
- Where practical, contributing drainage areas should be subdivided into smaller areas and multiple sedimentation impoundment installed

Advantages

- High capacity of runoff impoundment and more efficient means of sedimentation necessary along perimeters of construction sites with high risk sensitive environmental areas and watercourses
- Sediment can be cleaned out easily
- Robust
- Can be deactivated easily by breaching the enclosure dyke

Limitations

- Requires specialized design by qualified personnel
- Sediment traps and basins do not remove 100% of the sediment; net efficiency for sedimentation of silt may be around 50% dependent on design
- Anticipated service life of 3 years or longer due to possible clogging of outlets in the long-term

- Sedimentation traps and basins with a riser outlet should have an auxiliary spillway with adequate erosion protection to permit overflow in the event that the riser pipe outlet clogs during a storm event
- For drainage areas greater than 40 ha, multiple basins may be required
- Efficiency of sedimentation is very dependent on surface area; sediment basins require large surface areas to permit settling of sediment
- Fences and signage may be required to reduce danger to the public
- May provide breeding habitat for mosquitoes and other pests
- Sediment traps only remove medium and large diameter silt particles and upstream erosion or sediment control measures are required to reduce the amount of sediment laden to the runoff at downstream sensitive areas
- Periodic removal of accumulated sediment is required

Construction

(Note: The following method is provided for guidance only. A site-specific design by a qualified designer is required.)

- The consequences of failure for any water retaining structure will determine the level of effort in the design and construction phases. The construction guidelines presented herein are minimum requirements. A geotechnical engineer should design water retaining structures if warranted by the consequences of failure
- All footprint areas for embankment dykes should be stripped of vegetation, topsoil, and roots to expose a mineral soil subgrade
- Embankment fill material should be clean mineral soil with sufficient moisture to allow proper compaction
- Fill should be placed in lifts not exceeding 150 mm in compacted thickness and should be compacted to a minimum of 95% Standard Proctor maximum dry density (SPD)
- The main outlet structure should be installed at farthest possible point from inlet
  - The outlet should be placed on firm, smooth ground and should be backfilled to 95% SPD
  - Proper inlet and outlet protection should be installed to protect from scour
  - The outlet pipe should consist of corrugated steel pipe to protect against pinching and blockage
- The embankment should be topsoiled, seeded or protected with gravel or riprap immediately after construction
- Construct an emergency spillway to convey flows not carried by the principal outlet
  - The emergency spillway should consist of an open channel (earth or vegetated) over native undisturbed soil (not fill)
  - If the spillway is elevated, it should be constructed of rip rap
  - The spillway crest should be depressed at least 0.15 m below embankment

Sediment Traps and Basins

Sediment Control:
Settling

BMP28

Construction Considerations

- It is preferable to strip to mineral soil only along the footprint area required for dyke construction; the pond floor centre area can be left cleared but unstripped
- The pond can be constructed by excavating, constructing embankments, or a combination of the two methods
- Baffles should be provided to prevent short-circuiting of flow from inlet to outlet. The optimum ratio of flow length to flow width is 5:1
- Construct sediment ponds and basins at the construction site perimeter prior to wet season and construction activities
- Sediment pond/basin bottom should be flat or gently sloping towards outlet
- Dyke slopes should not be steeper than 2H:1V and should be well-compacted
- Basins should be located where:
  - Low embankment can be constructed across a swale or low natural terrain
  - It is accessible for maintenance work, including sediment removal

Inspection and Maintenance

- Regular inspection is required to identify seepage, structural soundness, outlet damage or obstruction and amount of sediment accumulation
- Inspections should be performed weekly and after significant storm events (1:2 yr storm and/or 40 mm rainfall in 24 hours)
- Sediment should be removed upon reaching 1/2 height of the containment berm or within 0.4 m of crest of embankment
- Sediment traps may be deactivated or removed after vegetation of previously disturbed upstream areas has been established

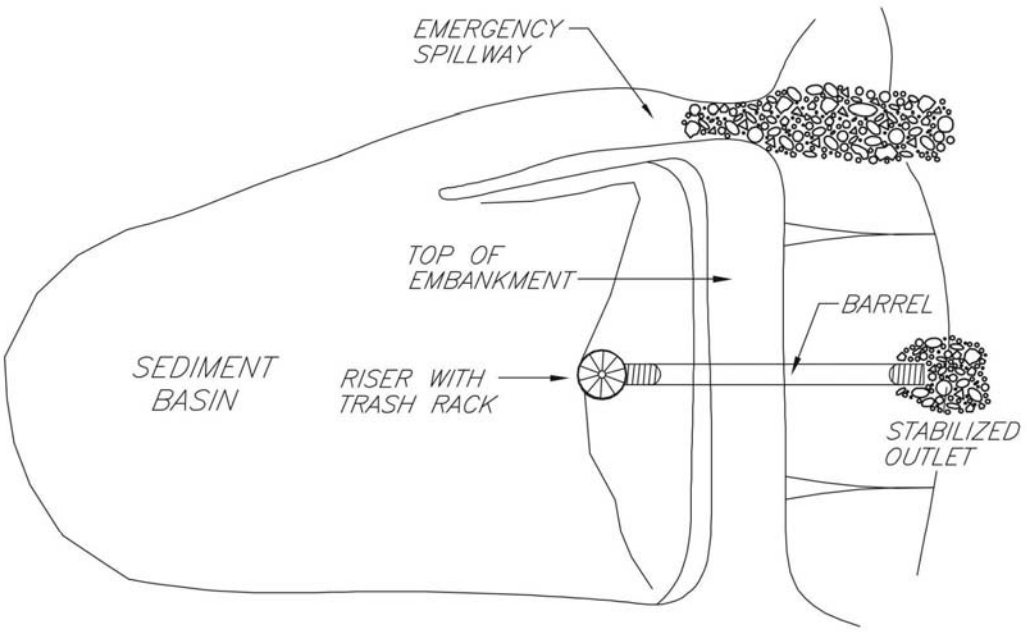
Design Considerations

- The design can use a riser outlet option or a permeable rock berm outlet option. The permeable rock berm outlet option is recommended for most applications
- Minimum particle size for rock rip rap shall be 200 mm
- If the design of a riser outlet is utilized
  - Main outlet pipe shall be fabricated from corrugated steel pipe conforming to CSA standard CAN 5-G401-M81 or the latest revision thereof
  - Outlet pipe shall consist of a horizontal pipe welded to a similar vertical riser at a 45° mitre joint
- Close to the base of the riser pipe, a 100 mm diameter hole shall be fabricated and a mesh with 12 mm square openings tack welded over the hole as a screen
  - A similar hole shall be provided along the riser pipe immediately above the elevation of the maximum sediment buildup (usually 0.4 m below crest of embankment)

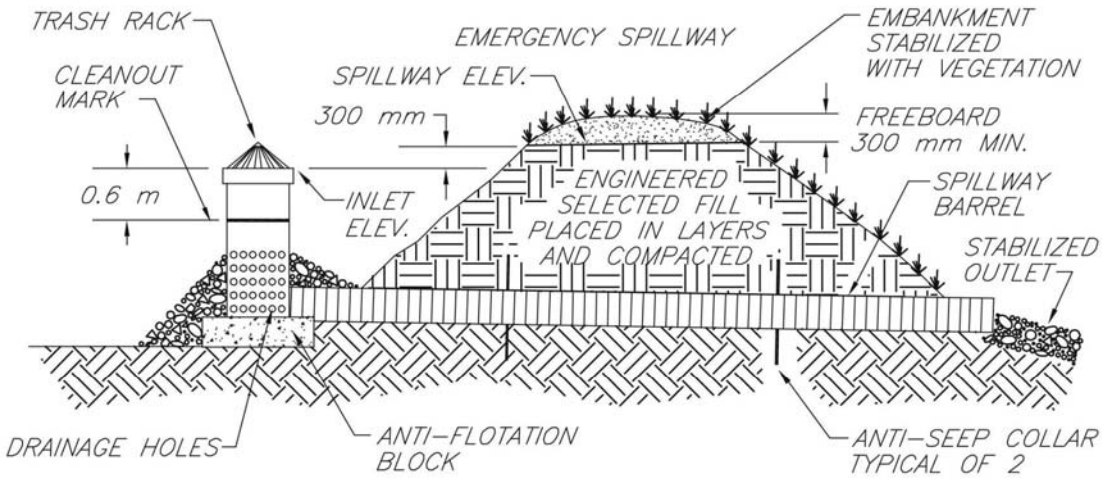
Sediment Traps and Basins

Sediment Control:
Settling

BMP28



PLAN



SECTION

NOTES:

1. THE TEMPORARY SEDIMENT BASIN, DESIGNED BY A QUALIFIED PROFESSIONAL, IS REQUIRED FOR DISTURBED AREAS GREATER THAN 2.02 HECTARES (5 ACRES) WITH A DRAINAGE AREA LESS THAN 40.4 HECTARES (100 ACRES).
2. THE SEDIMENT BASIN MAY BE REMOVED WITHIN 3 YEARS.
3. HEIGHT OF ENGINEERED SELECTED FILL EQUAL TO 1 m.
4. FOR CONFIGURATION AND FLOW CHAMBER DESIGN (i.e. LENGTH(L) & WIDTH(W_e) OF BASIN), REFER TO NEXT PAGE.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

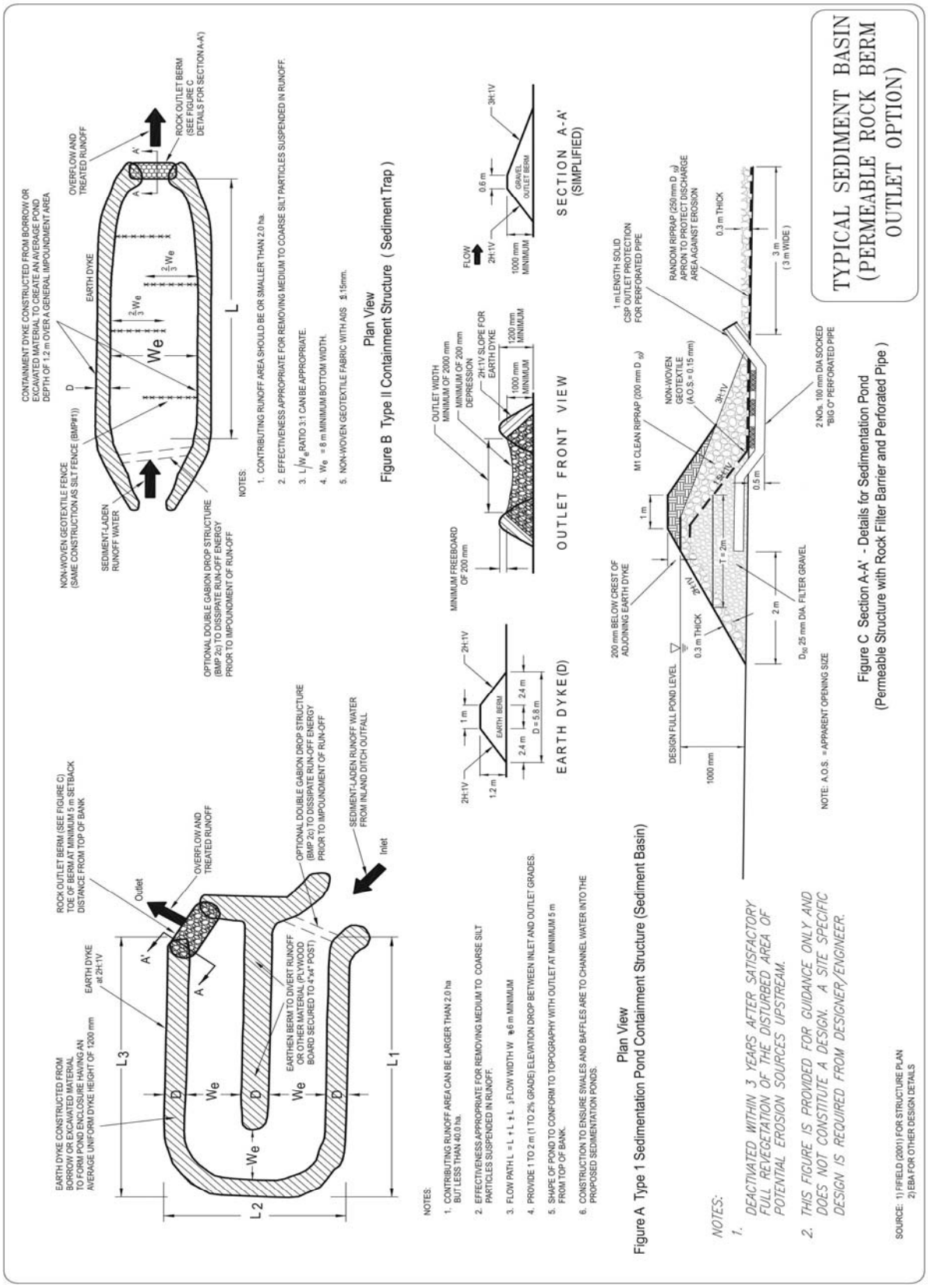
FILE: SEDBASIN

TYPICAL SEDIMENT BASIN (RISER OUTLET OPTION)

Sediment Traps and Basins

Sediment Control:
Settling

BMP28



This page left blank intentionally.