Guidelines for Erosion & Sediment Control

THE CITY OF CALGARY
WATER SERVICES

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The City of Calgary
Water Services

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LEGAL DISCLAIMER

Construction activities, including the operation, maintenance and repair of infrastructure and utilities, commonly disturb soil or sediments and create the potential for erosion, sedimentation and off-site releases of sediment and associated contaminants. The design, implementation and management of stormwater and erosion and sediment control practices require detailed knowledge and practical expertise.

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TITLE:	Guidelines for Erosion & Sediment Control
INTENT:	This document provides detailed information on control of erosion and sediment during urban construction, operational and maintenance activities that disturb soil or sediments.
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COMMONLY USED ACRONYMS

AENV	Alberta Environment
AIT	Alberta Infrastructure and Transportation
ASWQG	Alberta Surface Water Quality Guidelines
BFM	Bonded Fibre Matrix
BMP	Best Management Practice
CoR	Coefficient of Run-off
CCME	Canadian Council of Ministers of the Environment
CPAG	Corporate Planning Applications Group (for City of Calgary)
CPESC	Certified Professional in Erosion and Sediment Control
CPRM	Certified Professional in Rangeland Management
CPSWQ	Certified Professional in Stormwater Quality
CRHBA	Calgary Regional Homebuilders Association
C-TRM	Composite Turf Reinforcement Mat
DFO	Department of Fisheries and Oceans Canada
ECB	Erosion Control Blanket
ECO Plan	Environmental Construction Operations Plan
EPA	Environmental Protection Agency (U.S.)
EPEA	Environmental Protection and Enhancement Act (Alberta)
ESC	Erosion and Sediment Control
ESCP	Erosion and Sediment Control Plan
IECA	International Erosion Control Association
NPS	Non-Point Source
NTU	Nephelometric Turbidity Units
RECP	Rolled Erosion Control Product
SWPPP	Stormwater Pollution Prevention Plan (U.S.)
TMDL	Total Maximum Daily Load
TRM	Turf Reinforcement Mat
TSS	Total Suspended Solids
UDI	Urban Development Institute (Calgary Chapter)

OBJECTIVES

The removal of vegetation and topsoil during construction or other soil disturbing activities exposes highly erodible subsoil. Compaction of exposed soil can result in a dramatic increase in run-off and erosion. Poor management of surface water and groundwater during construction, operations or maintenance activities can pollute water with fine sediment and other contaminants.

Sediment transported in stormwater may settle out in infrastructure, damage public and private property, and negatively impact fish and fish habitat, water supply, flood control, navigation, and recreation. In addition, uncontrolled dust from construction activities can be harmful to health, property and the environment. Damage to infrastructure, property, and the environment can be extremely expensive and difficult to repair. Regulatory requirements are in place to protect infrastructure, property, health, and the environment.

Appropriate temporary erosion and sediment control (ESC) practices must be designed, implemented, inspected, and maintained for all stages of projects and operations that disturb or expose soil or sediments. Effective permanent controls must also be designed and implemented to ensure post-construction control of erosion and sedimentation.

Note: Much of the subsoil in the Calgary area contains very high proportions of fine silt and clay-size material, thereby limiting the effectiveness of filtration and settling practices. As the control of fine sediment can be very difficult, ineffective, and expensive, efforts must be primarily directed at the control of run-on and run-off and temporary and permanent stabilization of exposed soils. These practices are collectively known as **source control practices**. Controlling erosion at the source is the most effective and economical strategy in most situations. Well planned and implemented source control practices are then complemented with sediment control practices (ideally placed as close to the source as possible).

While these guidelines predominantly focus on the planning and implementation of best practices to control erosion caused by water, dust caused by wind erosion and disturbance during prolonged dry conditions is also a common problem in Calgary. In addition to some simple site practices available to control dust, some of the controls and practices used to control erosion caused by water can also reduce wind erosion.

Until sites are permanently stabilized, site controls and practices must be frequently inspected and properly maintained. The landowner or their designate (i.e. consultant or construction manager) must ensure that all personnel on site are adequately trained and compliant with regulations and responsibilities. It is generally necessary to assign and empower a person or company experienced in the implementation, monitoring and maintenance of ESC practices.

Effective planning and implementation of ESC and stormwater pollution prevention practices is everyone's responsibility, including City staff. The successful control of run-on, run-off, erosion and sedimentation requires the cooperation of many project stakeholders (City staff, regulators, landowner, consultant, project manager, homebuilder, contractors/trades). Timely communication and action can be the difference between success and failure.

This manual was prepared to help numerous stakeholders understand, evaluate and control run-on, run-off, erosion and sedimentation during construction or other soil disturbing activities undertaken in Calgary. This manual is not a recipe book of best practices. Successful erosion and sediment control depends on site-specific design and innovation, combined with timely implementation, inspection and maintenance, and common sense.

Photo 1: Without practices in place to control run-on/run-off, stabilize soils and capture eroded sediment, excessive removal of vegetation and topsoil can lead to compaction and erosion of fine-grained soils, exponential increases in surface run-off and off-site discharge of sediment-laden water and dust.

SECTION 1.0

INTRODUCTION

1.0 INTRODUCTION

1.1 WHY CONTROL EROSION AND SEDIMENT?

Most construction activities result in major modifications to the landscape. The removal of soil stabilizing vegetation and the exposure and compaction of fine grained soils can result in stormwater run-off and soil erosion rates that are orders of magnitude greater than natural rates. The International Erosion Control Association (IECA) indicates that, in the absence of practices to manage run-on, run-off, erosion, and sedimentation, the production of eroded sediment is typically 200 to 400 times greater on construction sites versus undisturbed conditions.

Operational activities such as construction site dewatering are a potential source of sediment loading into storm sewers. Dust caused by disturbance of exposed, dry sub soils by wind and equipment is also a significant problem in Calgary.

Construction site water management and the control of erosion and sediment is a critical part of any construction activity that disturbs soil. Even small construction sites and operations (such as underground utility repairs) implementation of practices to minimize or control mud tracking onto streets, wind-blown dust, and water-borne sediment.

Deleterious substances such as hydrocarbons, metals, and nutrients are transported with eroded soils and can negatively impact water quality and aquatic habitat.

A wide variety of erosion and sediment control (ESC) practices have been developed, many of which have proven effectiveness when designed and implemented as intended. However, failure to properly control erosion and sediment during construction is still common. Damage to infrastructure, property, and the environment can be costly to repair and can lead to fines and legal action.

1.1.1 Environmental Impacts of Sediment and Associated Pollutants

Disturbed sediment can transport deleterious substances such as hydrocarbons, metals and nutrients, negatively impacting water quality and aquatic habitat.

- Fish habitat can be disturbed or destroyed by increased sediment loading. Sediment can smother spawning beds and suffocate incubating eggs and benthic invertebrates. Chronic high turbidity can reduce productivity, irritate the eyes and gills of fish (reduces oxygen uptake and increases risk of infection and disease), and affect the feeding ability of many species of fish (see Figure 1-1).
- Sediment deposition in water bodies can affect stream channel morphology (increased flooding potential) and damage or destroy terrestrial habitat.

1.2 OBJECTIVES FOR SUCCESS

Construction site stormwater management and control of erosion and sedimentation is often poorly planned and/or implemented. Good communication between all stakeholders and planning, implementation and timely inspection and maintenance of effective practices is critical. To meet the goal of improved planning and implementation the following objectives should be considered:

- Ensure all stakeholders have a good understanding of erosion and sedimentation processes (all stakeholders, including regulatory agencies, require staff with extensive and current knowledge and expertise).
- Always consider the importance of soil texture, site topography, and seasonal variations in climate as they affect stormwater run-off and erosion rates.

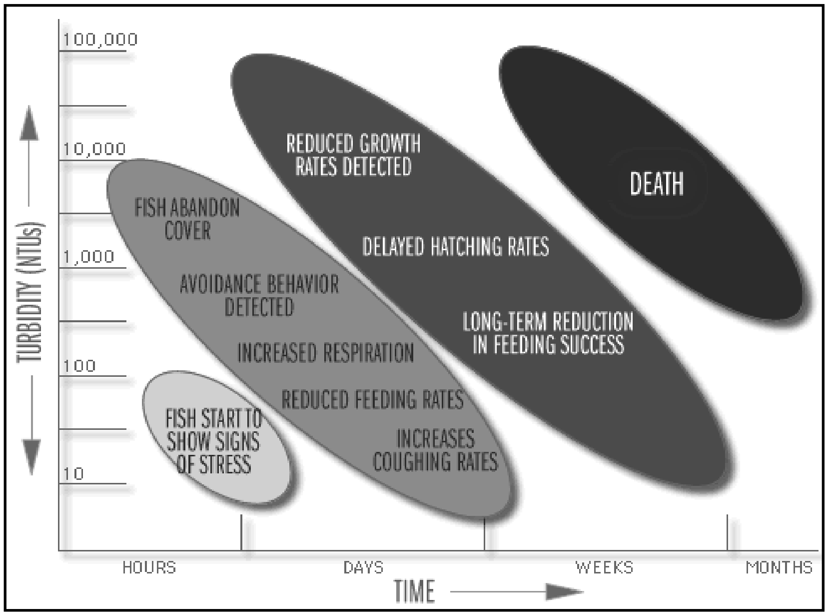


Figure 1-1: The effect of turbidity on activity in freshwater fish

(Source: Water on the Web, http://waterontheweb.org)

- Avoid using a 'one size fits all' approach to erosion and sediment control report and drawings preparation. Except for planning and implementation of simple housekeeping practices, planning is very much site-specific.
- Always hold pre-construction meetings and invite the appropriate stakeholders, including regulatory agencies. Once preliminary erosion and sediment control practices are implemented and, prior to beginning construction, arrange a pre-construction meeting. Typically the meeting should include the landowner/developer, project manager, consultant(s), contractor and sub-contractors, The City inspector (as well as any other regulatory agencies involved).
- Recognize that the erosion and sediment control report and drawings prepared at the project planning stage only provides an initial appraisal of the site conditions, and prescribes practices which are based on that appraisal. Site conditions change and practices need to be easily modified and updated as the project proceeds. This requires ongoing involvement and assistance from regulatory agencies, including City staff.
- Always plan and implement practices to control erosion at the **source** (this requires control of run-on, run-off, and provision of timely and effective soil cover/stabilization). Ensure the sole focus is not on attempting to remove fine sediment from run-off using sediment controls (detention, settling, filtration); these practices are only effective as a secondary line of defence.
- Always identify and recognize the high value of environmental resources, infrastructure and property within, and adjacent to, construction sites. Protect accordingly.
- Clearly understand the purposes and limitations of specific erosion or sediment control practices.
- Ensure specifications and requirements for erosion and sediment control are clearly written into pre-tender documents and contracts. Ensure erosion and sediment control reports and drawings will be easily understood by contractors.
- Ensure a program of timely inspection and maintenance of ESC practices. Almost all practices, especially temporary practices implemented during construction, require frequent inspection and maintenance

1.3 IMPACTS OF SOIL-DISTURBING ACTIVITIES ON EROSION AND SEDIMENTATION

Stormwater run-off is part of the natural hydrological cycle. However, human activities, in particular urbanization, can have a profound impact on the quantity and quality of run-off.

The hydrology of a site changes during construction (see Figure 1-2). Vegetation and topsoil that once intercepted and absorbed rainfall are removed and natural depressions that captured run-off are graded over. Exposed subsoil is compacted by equipment, resulting in increased imperviousness (reduced infiltration of surface water) which leads to increased quantity and rate of surface run-off. The increased surface flow raises the erosive potential of stormwater and snowmelt. Until suitable protective cover is re-established, raindrop impact, wind and run-off can cause significant erosion.

Surface run-off and wind are the most visible erosion agents on construction sites. Surface run-off has the ability to move larger quantities of soil than wind (and can detach and transport larger-sized particles). Uncontrolled dust from Calgary construction sites is a common problem. Wind-blown dust can reduce visibility and has been linked to negative effects on health, particularly for those with respiratory ailments.

Heavy construction equipment also moves large quantities of soil. It is important that any stockpiled soil is placed in a location where erosion and sediment is controlled.

1.4 EROSION AND SEDIMENTATION PROCESSES

Erosion, sediment transport, and sedimentation are commonly considered a single process. In fact, there are a number of distinct sub-processes involved. The intensity and duration of each of these processes determine, to a large degree, the severity of erosion events.

Erosion and sedimentation can be characterized by the four processes of **detachment**, **entrainment**, **transport**, and **deposition**.

- **Erosion** refers to the physical ***detachment, entrainment*** and ***transportation*** of soil particles by erosive agents, commonly wind and water.
- **Sediment** refers to soil particles that have been detached and mobilized by soil erosion.
- **Sedimentation** occurs when the energy of wind or moving water is less than the force of gravity on soil particles, resulting in their ***deposition***.

1.4.1 Detachment

Raindrop impact and the energy of wind or flowing water can detach soil particles. The texture, structure, and organic matter content of exposed soils affect detachment (erodibility) of soil particles.

Soil can primarily be considered a mixture of different sized inorganic materials formed from parent material and influenced by several physical, chemical and biological variables over time. Based on the United States Department of Agriculture (USDA) classification, inorganic materials are classified as follows: sand (0.05 – 2.0 mm diameter), silt (0.002 to 0.05 mm diameter) and clay (< 0.002 mm diameter).

The cohesion and texture of soils has a major influence on detachment. Clay-sized particles typically have a much higher resistance to detachment than larger soil particles such as sand and coarse silt, generally due to greater cohesive forces. Other factors influencing soil cohesion are organic matter content (stabilized organic matter in the soil helps bind particles together, increasing cohesive strength) and soil moisture (moisture improves cohesion up to a threshold, after which increased soil moisture reduces cohesive strength).

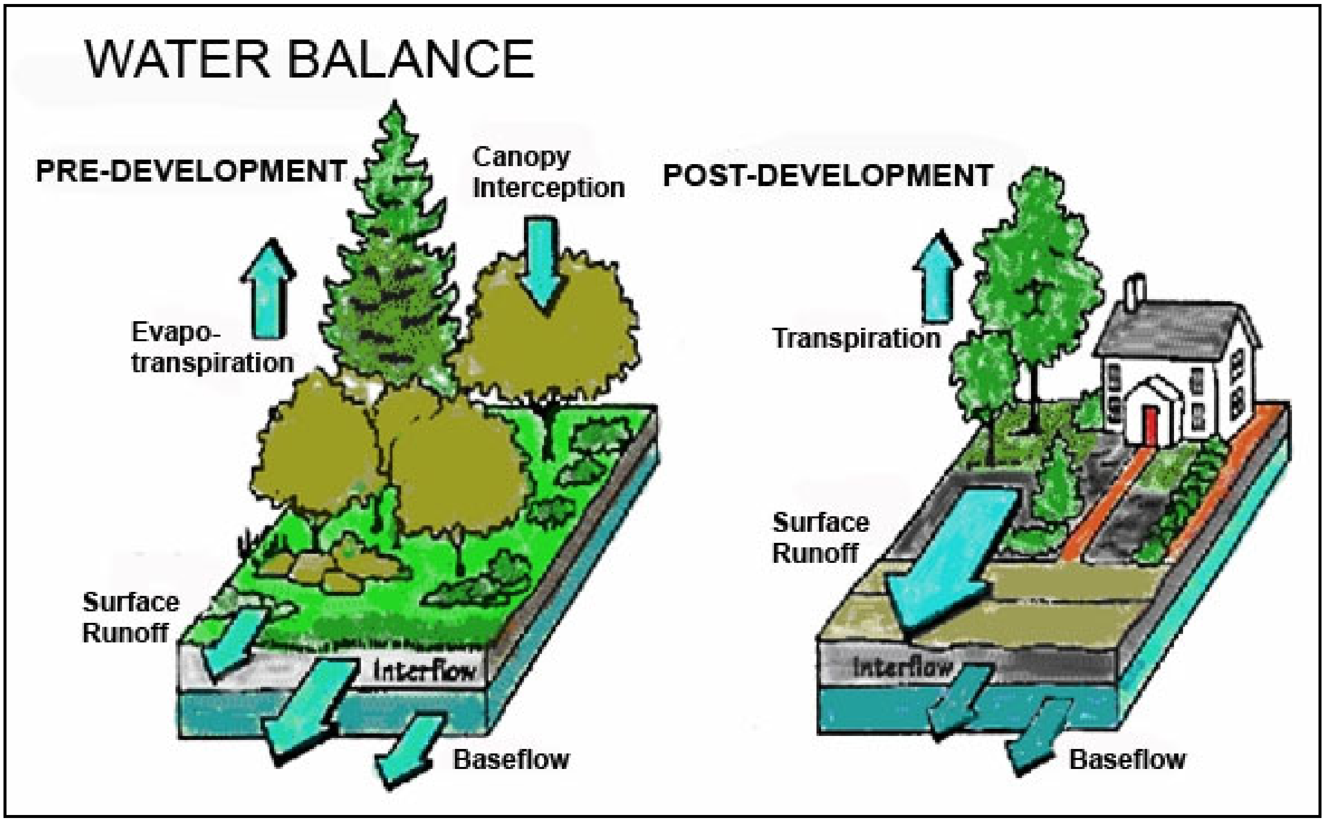


Figure 1-2: Water Balance at Undeveloped and Developed Sites (Schueler, 1987)

The percentage of material larger than the diameter of coarse sand in an exposed soil also influences erosion potential: this material is more resistant to entrainment and transportation and can dissipate the erosive energy of water and wind.

The two basic detachment mechanisms in soil erosion are ***raindrop impact*** and ***abrasion***.

1.4.1.1 Raindrop Impact

The force of falling raindrops is a function of raindrop mass and velocity. Protecting exposed soil from raindrop impact by providing cover is the principal means of controlling erosion.

1.4.1.2 Abrasion

Soil particles transported by water or wind can exert impact and friction on other soil particles, resulting in additional detachment.

1.4.1.3 Minimizing Detachment

- Preserve and maintain existing vegetation cover.
- Phase construction activities to limit the area of exposed soils exposed to raindrop impact at any given time.
- Concurrent Area Stabilization: limit the length of time soils are exposed to erosion by temporarily stabilizing soils prior to final grading (e.g., straw mulch, blankets, plastic sheeting). During

construction, concurrently stabilize soils that are at final grade with permanent cover. Loamed areas require temporary stabilization during establishment of vegetation.

Note: Calgary commonly experiences short, high intensity rain events during peak construction season. The large, heavy raindrops falling in these events have velocities approaching 9 metres/second and can provide sufficient force to break cohesive bonds between soil particles and displace soil particles as large as 10 mm into the air.

This can result in very significant detachment, entrainment and transport of soil particles from exposed soils that have not been **temporarily stabilized**.

1.4.2 Entrainment

Entrainment refers to the picking up of particles detached by erosive agents such as wind and water (Briggs et. al., 1989). It generally takes much more energy to detach particles than to entrain them, so entrainment usually automatically follows detachment. Entrainment is caused by gravitational forces, moving water or wind.

1.4.2.1 Gravity

As slope increases, an increasing proportion of gravitational force operates down the slope and detached particles begin to lose resistance to entrainment. Detached particles can be entrained by gravity as they are airborne or exposed to moving water.

1.4.2.2 Fluid Forces

Run-off and wind exert horizontal drag on particles. The density of the fluid is also critical in determining horizontal drag. Water is about 9,000 times denser than air, so can exert a force some 9,000 times greater than air moving at the same velocity (Briggs et. al., 1989).

1.4.3 Transportation

In addition to material that becomes dissolved in flowing water, detached soil particles that are entrained by air or water are transported in three ways:

- Suspension: Suspended particles move along in the water column or air column without touching the ground. The smallest particles (clays and silts) are easily transported in suspension. Suspended particles can be transported at or near the flow velocity.
- Saltation: Larger, denser particles are somewhat resistant to entrainment and fall in and out of suspension. Falling particles can also dislodge other particles, setting them in motion.
- Traction: Detached particles that are partially entrained by flowing air or water are not suspended, but slowly move along at the surface. Particles transported by traction move much more slowly than flow velocity.

1.4.4 Run-off Induced Erosion

Run-off over exposed soils occurs when the quantity of water reaching the soil surface is greater than the ability of the soil to absorb water. Run-off is governed by three factors:

1. Storm intensity: As storm intensity increases, the volume of water reaching the exposed soil may exceed the soil's ability to absorb water, resulting in surface ponding and/or run-off.

2. Storm duration and antecedent (pre-existing) soil moisture conditions: As the duration of a storm event lengthens, soils become increasingly saturated, increasing the potential for ponding and/or run-off.
3. Soil Permeability / Infiltration Capacity: Fine-grained soils are generally more compact and have smaller pore spaces than coarse-grained soils, resulting in reduced permeability and water infiltration. Working a soil (i.e., scarifying/ripping) can increase permeability and infiltration, whereas compaction by heavy construction equipment decreases soil porosity, reduces infiltration and can cause a marked increase in overland flow.

1.4.4.1 Types of Run-off Induced Erosion

Erosion caused by run-off can be classed into four types: sheet erosion, rill erosion, gully erosion and channel erosion (see Figure 1-3).

Sheet Erosion

Diffuse sheets of water moving across a soil surface (run-off) can result in the entrainment and transport of soil particles detached by raindrop erosion and, to a lesser degree, cause additional detachment of soil particles.

Rill Erosion

On hill-slopes, run-off generally only occurs as sheet flow for a small distance before surface irregularities or turbulence cause run-off to concentrate. Water concentrates into paths of least physical resistance, resulting in micro-channels called rills. As the flow of run-off concentrates into channels, the friction between the flowing water and the soil surface is reduced. The resulting increase in flow velocities increases the erosion rate and the quantity of sediment transported. Road cuts and fills are particularly susceptible to rill erosion.

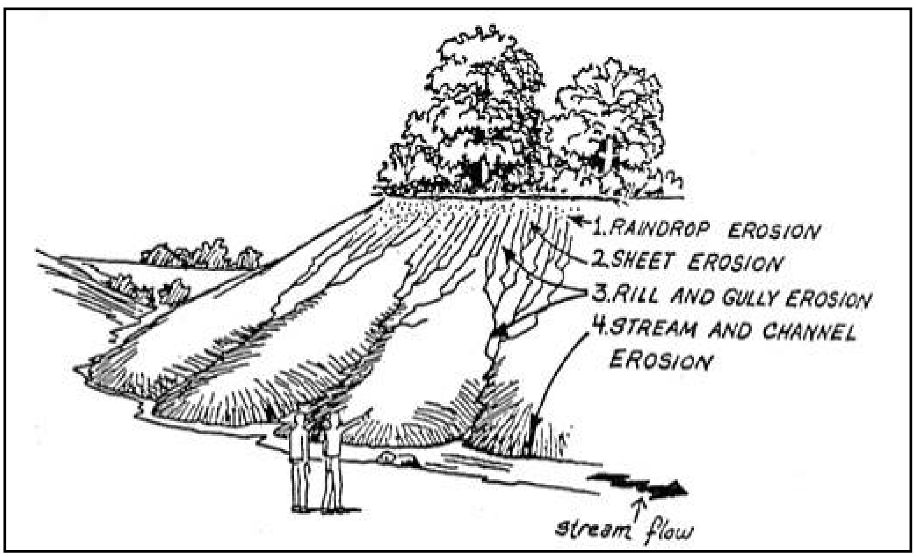


Figure 1-3: Types of Water Erosion

Gully Erosion

Deep, large channels called gullies can develop as an extension of the process of rill development, resulting from further concentration of run-off over erodible soils and a dramatic increase in erosion rates. Gullies can be very costly and time consuming to repair.

Channel Erosion
The erosion of the beds and banks of defined stream channels is often caused by increased run-off volumes, longer duration of peak flows, and altered channel base flow. Increased impervious cover and reduced infiltration resulting from soil compaction and urbanization are common causes of increased run-off and peak discharges. Uncontrolled release of stormwater run-off in urbanized environments can result in significant scour and undercutting of stream channels. Sediment deposits can further alter stream channel characteristics and flow patterns.

1.4.5 Deposition/Sedimentation

Deposition or sedimentation occurs when there is insufficient energy to keep eroded particles entrained in air or water: this is typically caused by a reduction in flow velocity or a reduction in turbulence. Large particles are very sensitive to changes in flow velocity. A very small reduction in flow velocity may be sufficient to change the entrainment and transport of large particles into deposition.

1.5 FACTORS INFLUENCING EROSION

The erosion potential of site soils is influenced by five general variables. These variables are all accounted for in the Revised Universal Soil Loss Equation (RUSLE), which is discussed in more detail in Section 6.4.3. RUSLE is a tool that can be used to estimate soil loss.

Soil Loss Tolerances: For construction projects, The City of Calgary has set RUSLE-based soil loss tolerance at 2 tonnes/hectare/year for sites with storm inlets (inlets that drain to City storm infrastructure) within, or adjacent to the site. Sites without access to storm inlets (within or adjacent to the site) are allowed a soil loss tolerance of 4 tonnes/hectare/year.

Note: construction adjacent to a waterbody such as a wetland or river may be subject to more stringent Provincial and/or Federal requirements.

RUSLE Equation: **A = R * K * LS * C * P** Where:

A = Estimated annual soil loss per area (usually expressed as tonnes/hectare/year)
R = Rainfall erosivity factor (an empirical factor calculated for a local area, and based on the intensity and duration of storms)
K = Soil erodibility factor
LS = Slope steepness and slope length factor (combined)
C = Cover (temporary or existing cover such as vegetation)
P = Management practices (such as silt fence and cat-tracking)

- **Climatic Factors**: partially accounted for by R Factor. Consider rainfall, run-off, snow cover, freeze-thaw, wind
- **Soil Erodibility**: K Factor
- **Topography/Slopes**: LS Factor
- **Soil Stabilizing Cover**: C Factor. Vegetation/other, temporary/permanent cover
- **Management Practices**: P Factor

1.5.1 Climatic Factors

To understand and apply principles of effective erosion control, a thorough understanding of these factors (as they apply to the Calgary region) is necessary. Erosion potential increases with rainfall duration and intensity. Although there is no way to directly control rainfall duration and intensity, it is necessary to manage the effects of rainfall and run-off (including snowmelt) on exposed soils.

1.5.2 Soil Erodibility (K Factor)

Erosion is influenced by soil properties such as soil texture, organic matter content, soil structure, and soil permeability. These factors affect the infiltration capacity of a soil and the resistance of the soil to erosion. Soils containing high proportions of silt and very fine sand are typically non-cohesive and highly erodible. Erodibility decreases as the percentage of clay and/or organic matter increases, due to improved cohesiveness and formation of stable aggregates. Once detached, fine sediments are easily entrained and transported by water.

1.5.3 Topography/Slopes (LS Factor)

The overall area of the project site and the slope characteristics influence erosion potential. While the rate of erosion per unit area may be the same for an identical but smaller project site, larger project sites have the potential to generate more run-off. As slope steepness increases, there is a marked increase in erosion potential (increased velocity of run-off and the effect of gravity increase the potential for particle detachment, entrainment and transport). As slope length increases, soil particles can be increasingly entrained and transported long distances by water, and the potential for rill and gully formation may increase.

1.5.4 Soil Stabilizing Cover (C Factor)

Soil cover is the easiest and most cost-effective erosion control factor that can be managed on a construction site. The ability of various soil covers to reduce erosion is illustrated in Table 1-1. New practices and technologies are constantly being developed.

The ESC Designer must provide supporting information (such as field and laboratory data) for new practices and technologies in the ESC documentation. Product manufacturers and suppliers are often a good source of information. The Erosion Control Technology Council (www.ectc.org) has some excellent data on C Factors for rolled erosion control products.

1.5.5 Management Practices (P Factor)

The timing and duration of construction projects must be considered when assessing erosion risk. Scheduling short construction projects or disturbance of high risk areas during drier seasons is a good practice for reducing risk. Other management practices such as diverting clean run-on away from exposed areas, conveying sediment-laden run-off to sediment basins or traps and installing and maintaining perimeter controls where sediment may leave the site or enter critical areas are also important.

1.6 EROSION CONTROL VERSUS SEDIMENT CONTROL

There are two broad groups of practices: **Erosion Control** and **Sediment Control**. The purpose and function of these two groups of practices is very different.

Table 1-1: Effectiveness of Various Soil Covers at Reducing Erosion

(Mitchell and Bubenzer, 1980)

COVER CONDITION/PRACTICE	TYPICAL EROSION REDUCTION (%)
Mulch: Hay or straw	
1.1 tonnes/hectare	75
2.2 tonnes/hectare	87
4.5 tonnes/hectare	98
Grass: Seeding and sod (no canopy)	
40% cover	90
60% cover	96
90+% cover	99
Shrubs	
25% cover	60
75% cover	72
Trees	
25% cover	58
75% cover	64
Erosion Control Blankets	95 – 99%

1.6.1 Erosion Control (Source Control)

Fine sediment is difficult and expensive to manage, therefore planning and implementing practices designed to **control stormwater run-on and run-off** and to **stabilize exposed soils** must be the primary objective on all construction projects. The purpose of source control is to prevent or minimize the detachment, entrainment and transport of sediment. Good planning and implementation of temporary and permanent erosion control practices reduces the need for expensive, high maintenance sediment control and delivers significant cost savings and better compliance with environmental regulations.

1.6.2 Sediment Control

It is generally impossible and impractical to completely control sediment at the source. This is especially true for operational projects such as underground utility repairs and construction site dewatering. Therefore, it is usually necessary to plan and implement sediment controls to capture and treat sediment-laden water (utilizing settling or filtration to remove sediment).

The effectiveness of sediment control depends on soil texture, sediment concentration in run-off, practices selected, and the installation, inspection and maintenance of the practices.

Sediment controls are generally only useful for retaining coarse silt and larger particles in low volume, low velocity run-off. The effectiveness of sediment control decreases rapidly with decreasing particle size, increasing run-off volumes and increased sediment loadings in run-off.

The **effectiveness of sediment control is generally lowest when the need for sediment control is highest** (i.e. during intense rain events with high rates of run-off and sediment transport).

SECTION 2.0

REGULATORY REQUIREMENTS AND RESPONSIBILITIES

2.0 REGULATORY REQUIREMENTS AND RESPONSIBILITIES

NOTE/DISCLAIMER: This section provides an overview of the common regulatory requirements that may apply to projects and activities that could result in erosion and sedimentation. This information is NOT offered, or intended to be used as, legal advice. Always obtain specific legal advice and contact all relevant regulatory agencies when planning a construction project. All information is with respect to the latest edition of statutes, regulations, codes of practice, and bylaws at the time of writing.

2.1 **OVERVIEW**

A number of federal, provincial, and municipal acts, legislation, guidelines, and codes of practice contain provisions requiring control of erosion, sediment, and sedimentation resulting from land disturbing activities. Everyone involved in construction and field operations, including City staff, has a responsibility to follow regulatory requirements.

Note: Offences related to inadequate erosion and sediment control can result in enforcement action being taken against a company and/or individual by more than one level of government.

This information provides a summary of some of the common federal, provincial, and municipal statutes, regulations, codes of practice and bylaws containing provisions addressing (or inferring the requirements for) the control of erosion, sedimentation, and construction site water management. The City of Calgary, Water Resources, has also prepared, and maintains, a document which provides a more thorough review of "Regulations and Responsibilities" relating to erosion and sediment control, available at: www.calgary.ca/wqs

2.2 **FEDERAL LEGISLATION**

A number of Federal Acts have sections pertaining to erosion and sediment control:

- **Fisheries Act**, R.S., 1985, c. F-14
- **Navigable Waters Protection Act**, R.S., 1985, c. N-22
- **Canadian Environmental Assessment Act**, 1992, c. 37
- **Canadian Environmental Protection Act**, 1999, c. 33

Table 2-1 provides a quick reference guide to applicable sections and fines.

2.2.1 Fisheries Act

Please note that the *Fisheries Act* is currently under review and may be subject to change.

The *Fisheries Act* was established to manage and protect fish and fish habitat and is binding in all Canadian Provinces and Territories. The *Act* is administered by Fisheries and Oceans Canada (DFO), although Environment Canada may also enforce sections of the *Fisheries Act* such as Section 36(3). As sediment is considered a common pollutant that can have **deleterious** effects on fish and fish habitat, the erosion of exposed soils and off-site transport of sediment into natural water bodies can violate the pollution prevention provisions of this Act. Some key definitions in the *Fisheries Act* are:

Fish – "parts of fish; shellfish, crustaceans, marine animals, and any parts of shellfish, crustaceans or marine animals; and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals".

Fish Habitat – "spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes".

Note: Where any contravention of the *Fisheries Act* or the regulations is committed or continued on more than one day, it constitutes a separate offence for each day on which the contravention is committed or continued.

Photo 2: Major sediment release into the Bow River from an unauthorized, uncontrolled construction dewatering activity

Some of the highlights of the *Fisheries Act* relevant to erosion and sediment control include:

Section 35(1): No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction (HADD) of fish habitat.

Section 35(2): The harmful alteration, disruption or destruction of fish habitat may be authorized under conditions authorized by the Federal Fisheries Minister.

Note: **Always** contact DFO prior to starting work in or near a water body. For projects that could cause a HADD, it is important that contact be made with DFO early in the planning stages to discuss proposed plans and determine what information DFO requires to have submitted for review.

Section 36(3): Prohibits anyone depositing or permitting the deposit of a **deleterious** substance in an area frequented by fish or where water may enter such an area.

"**Deleterious**": defined as harmful, toxic, lethal or injurious. Sediment is considered a deleterious substance (see Photo 2).

Section 38(4): Creates a duty to report the deposit of a deleterious substance.

Note: If your project results in the deposit of a deleterious substance in a water body or into a system where it may enter a water body (i.e. storm sewer), immediately notify Alberta Environment (24 hour number: 1-800-222-6514).

Section 38(5): Requires persons responsible to prevent any deposit or mitigate or remedy any adverse effects that result or may result from a deposit.

Section 38(6): A designated inspector has the authority to take measures and direct action if immediate action is deemed necessary.

2.2.2 Navigable Waters Protection Act

The Navigable Waters Protection Act (NWPA) is administered by Transport Canada and is intended to protect the public right of navigation in Canadian waters. The *Act* prohibits unauthorized work involving construction or placement in, on, over, under, through, or across any navigable water. *Navigable water* includes "a canal and any other body of water created or altered as a result of the construction of any work." The NWPA definition of *works* includes:

- bridge, boom, dam, wharf, dock, pier, tunnel or pipe;
- any dumping of fill or excavation of materials from the bed of a navigable water;
- any telegraph, power cable, wire, or;
- any structure, device or thing that may interfere with navigation.

Section 21: "No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any sawdust, edging, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation in any water, any part of which is navigable, or that flows into any navigable water."

Section 22: "No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water, any part of which is navigable or that flows into any navigable water, where there are not at least twenty fathoms of water at all times".

(Note: 1 fathom = 1.83 m).

2.2.3 Canadian Environmental Assessment Act

Authorizations under the *Fisheries Act* and the *NWPA* are both "triggers" for a more detailed federal environmental review under the *Canadian Environmental Assessment Act (CEAA).* If an authorization is required pursuant to either *Act*, this will trigger *CEAA.* Part V and Part VII under the *Inclusion List Regulation (SOR/94-637)* under *CEAA* lists *NWPA* and *Fisheries Act* related projects that may require an Environmental Assessment. Projects which receive Federal funding may also be subject to a review.

The Canadian Environmental Assessment Agency (CEAA) website (www.ceaa.gc.ca) has useful information called "*A Primer for Industry*".

2.2.4 Canadian Environmental Protection Act

The *Canadian Environmental Protection Act (CEPA), 1999,* is jointly administered by Environment Canada and Health Canada. The focus of *CEPA* is pollution prevention. *CEPA* prohibits and controls the use and release of toxic substances in the environment.
Section 64 of *CEPA* states "a substance is *toxic* if it is entering or may enter the environment in a quantity or concentration or under conditions that:

(a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;

(b) constitutes or may constitute a danger to the environment on which life depends, or;

(c) constitutes or may constitute a danger in Canada to human life or health."

CEPA **Schedule 1** lists particulate matter (which includes ***dust from construction sites***) as a toxic substance ("respirable particulate matter less than or equal to 10 microns").

Note: **Section 95** of CEPA contains requirements for reporting releases of substances listed as toxic under CEPA Schedule 1. When reporting a release under CEPA, call 1-800-222-6514 (24 hours) and clearly state that you are reporting under CEPA.

Table 2-1: Summary of Applicable Federal Legislation

Note: Legislation is subject to change. Please be sure to consult the applicable bylaw, regulation, act, or enactment. The City of Calgary is not responsible for the accuracy of this information.

REGULATORY AUTHORITY	LEGISLATION	RELEVANT SECTIONS	KEY POINTS	FINES
GOVERNMENT OF CANADA ***Fisheries & Oceans Canada (Calgary)*** ***Tel: 292-5160*** **www.dfo-mpo.gc.ca** ***Transport Canada*** ***Tel: 1-888-463-0521*** **www.tc.gc.ca** ***Environment Canada (Calgary)*** ***Tel: 292-5150*** **www.ec.gc.ca**	***Fisheries Act***	Section 35 (1)	No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.	➢ Up to $300,000 (first summary offence) ➢ Up to $300,000 and/or 6 months in jail (subsequent offences) ➢ Up to $1,000,000 (first indictable offence) ➢ Up to $1,000,000 and/or 3 years in jail (subsequent indictable offences)
		Section 35 (2)	No person contravenes subsection(1) by causing the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor in Council under this Act.	
		Section 36 (3)	Do not deposit deleterious substances in waters frequented by fish. Deleterious substances are those that could potentially have a harmful, toxic, lethal or injurious impact.	
		Section 38 (4), (5) & (6)	(4) Duty to report deposits of deleterious substance, (5) Person responsible for substance deposited shall remedy or mitigate any adverse effects and (6) Inspectors may order to take remedial measures.	➢ Up to $200,000 (first offence) ➢ Up to $200,000 and/or 6 months imprisonment (subsequent offences)
	Navigable Waters Protection Act (NWPA)	Section 21	No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any sawdust, edging, slabs, bark or like rubbish of any description whatever that is liable to interfere with navigation in any water, any part of which is navigable or that flows into any navigable water.	➢ $5000 per offence
		Section 22	No person shall throw or deposit or cause, suffer or permit to be thrown or deposited any stone, gravel, earth, cinders, ashes or other material or rubbish that is liable to sink to the bottom in any water, any part of which is navigable or that flows into any navigable water, where there are not at least twenty fathoms of water at all times.	
	Canadian Environmental Assessment Act (CEAA)	Section 14	Environmental Assessment Process may involve a screening, comprehensive study, mediation or panel review.	➢ N/A
	Inclusion List Regulations (SOR/94-637)	Part V & VII	Activities or Approvals under the NWPA or Fisheries Act may require an Environmental Assessment.	➢ N/A
	Canadian Environmental Protection Act (CEPA)	Section 64	Defines a toxic substance.	➢ Up to $300,000 and/or six month in jail (summary offence) ➢ Up to $1,000,000 and/or three years in jail (indictable offence)
		Section 95	Releases of toxic substances must be reported, prevented and mitigated to prevent any danger to the environment or human life or health.	

2.3 PROVINCIAL LEGISLATION

A number of Provincial Acts, Regulations and Codes of Practice have sections pertaining to erosion & sediment control. Table 2-2 provides a quick reference guide to applicable sections and fines.

- **Environmental Protection and Enhancement Act**, R.S.A. 2000, c. M-26
- **Release Reporting Regulation**, A.R. 117/93
- **Wastewater and Storm Drainage Regulation**, A.R. 119/93
- **Water Act**, R.S.A. 2000, c. W-3
- **Water (Ministerial) Regulation** (AR306/98)
- **Water Act Codes of Practice**
- **Soil Conservation Act**, R.S.A. 2000, c. S-15
- **Public Lands Act, R.S.A. 2000, c. P-40**

2.3.1 Environmental Protection and Enhancement Act

The purpose of the *Environmental Protection and Enhancement Act (EPEA)* is to support and promote the protection, enhancement and wise use of the environment. This *Act* is administered by Alberta Environment (AENV). Some key provisions in *EPEA* include:

Section 109: It is prohibited to:

(1) knowingly release or permit the release, or;

(2) release or permit the release, of a substance into the environment in an amount, concentration or level or at a rate of release that causes or may cause a **significant adverse effect**.

Adverse Effect: "means impairment of or damage to the environment, human health or safety or property". This includes sediment and dust from construction sites.

Section 110: Duty to report release

(1) "A person who releases or causes or permits the release of a substance into the environment that may cause, is causing or has caused an adverse effect must, as soon as that person knows or ought to know of the release, report it to:

  (a) the Director (AENV);

  (b) the owner of the substance, where the person reporting knows or is able to ascertain the identity of the owner;

  (c) any person to whom the person reporting reports in an employment relationship;

  (d) the person having control of the substance, where the person reporting is not the person having control of the substance and knows or is readily able to ascertain the identity of the person having control, and;

  (e) any other person who the person reporting knows or ought to know may be directly affected by the release."

Releases must be reported **as soon as a person knows or ought to have known** of the release. A person "ought to have known" a release has occurred when, based on the information available, it is possible a release has occurred. That person should then confirm whether a release has occurred and report accordingly.

Section 111: Manner of reporting

(1) "A person who is required to report to the Director pursuant to **Section 110** must report in person or by telephone and must include the following in the report, where the information is known or can be readily obtained by that person:

(a) the location and time of the release;

(b) a description of the circumstances leading up to the release;

(c) the type and quantity of the substance released;

(d) the details of any action taken and proposed to be taken at the release site;

(e) a description of the location of the release and the immediately surrounding area.

(2) In addition to a report under section (1), the person must report in writing where required by the regulations.

(3) A person who reports under subsections (1) and (2) must give to the Director any additional information in respect of the release that the Director requires."

Section 112: Duty to take remedial measures

"Where a substance that may cause, is causing or has caused an adverse effect is released into the environment, the person responsible for the substance shall, as soon as that person becomes aware or ought to have become aware of the release,

(a) take all reasonable measures to:

(i) repair, remedy and confine the effects of the substance, and;

(ii) remove or otherwise dispose of the substance in such a manner as to effect maximum protection to human life, health and the environment, and;

(b) restore the environment to a condition satisfactory to the Director."

2.3.1.1 Release Reporting Regulation (AR117/93)

The *Release Reporting Regulation* under *EPEA* deals with the release of substances into the environment and sets out requirements for reporting releases to AENV. Although **Sections 107** to **122** under *EPEA* deal with the release of substances into the environment, the *Release Reporting Regulation* consolidates reporting requirements found in previous provincial legislation such as the *Clean Air Act* and the *Clean Water Regulations*. This consolidation provides consistent reporting requirements for all types of releases.

As stated in **Section 3(1)(b)** of the *Release Reporting Regulation*, any release into any watercourse or surface water body requires immediate notification to AENV. Subsequent to immediate verbal reporting, ***Section* 4(1)** states written reports are required within seven days. Reports should be made to the Environmental Service Response Centre:

- Verbally report by calling: (780) 422-4505 or 1-800-222-6514 on a 24 hour basis. A reference number will be provided at the time of the oral report to confirm that the report of the release was made.
- Written reports can be faxed to: (780) 427-3178 or mailed to:

Environmental Service Response Centre
111 Twin Atria Building
4999 – 98th Avenue
Edmonton, AB, T6B 2X3

2.3.1.2 Wastewater and Storm Drainage Regulation (AR119/93)

The *Wastewater and Storm Drainage Regulation* is also part of *EPEA*. **Section 7** deals with prohibited substances and releases and states:

(1) "No person responsible for a wastewater system or storm drainage system shall use or permit the use of a substance in or dispose of or permit the disposal of a substance into the wastewater system or storm drainage system in an amount, concentration or level or at a rate of release that may:

(a) impair the integrity of the wastewater collection system;

(b) impair the integrity of the storm drainage system;

(c) impair the operation or performance of a storm drainage treatment facility;

(d) impair the operation or performance of a wastewater treatment plant, or;

(e) impair the quality of storm drainage or treated wastewater and the gases and sludge produced in the treatment process, unless the use or disposal is authorized by an approval.

(2) Subsection (1) does not apply to the use or disposal of a substance in or into a wastewater system or storm drainage system that results from or is for the purposes of controlling an emergency.

(3) Subsection (1) does not prohibit the use or disposal of substances intended for use in wastewater drainage collection systems."

2.3.2 Water Act

The *Water Act* governs the management and protection of water in Alberta. Pursuant to **Section 36** of the *Water Act*, an approval may be required for certain activities.

Some relevant *activities* defined in the *Water Act*, Section 1(1)(b), include:

(i) "placing, constructing, operating, maintaining, removing or disturbing works, maintaining, removing or disturbing ground, vegetation or other material, or carrying out any undertaking, including but not limited to groundwater exploration, in or on any land, water or water body, that:

(a) alters, may alter or may become capable of altering the flow or level of water, whether temporarily or permanently, including but not limited to water in a water body, by any means, including drainage;

(b) changes, may change or may become capable of changing the location of water or the direction of flow of water, including water in a water body, by drainage or otherwise;

(c) causes, may cause or may become capable of causing the siltation of water or the erosion of any bed or shore of a water body, or;

(d) causes, may cause or may become capable of causing an effect on the aquatic environment;

(ii) altering the flow, direction of flow or level of water or changing the location of water for the purposes of removing an ice jam, drainage, flood control, erosion control or channel realignment or for a similar purpose."

2.3.2.1 Water (Ministerial) Regulation (AR205/98)

Under the *Water (Ministerial) Regulation,* Schedule 1, Section 2, some activities are exempt from the requirement for an approval under the *Water Act*, including:

(a) placing, constructing, installing, maintaining, replacing or removing a crossing in a water body where:
   (i) the water body is not frequented by fish;
   (ii) the hydraulic, hydrologic or hydrogeological characteristics of the water body are not altered at flood events below the 1 in 25 year flood event;
   (iii) the size of the culvert used in constructing the crossing, if applicable, is 1.5 metres or less in diameter;
   (iv) there is no diversion of water from the water body; and
   (v) the installation of the crossing is not part of a causeway through a lake, slough, wetland or other similar water body;

(b) landscaping that is not in a watercourse, lake or wetland if the landscaping does not result in:
   (i) an adverse effect on the aquatic environment on any parcel of land, or;
   (ii) any change in the flow or volume of water on an adjacent parcel of land;

(c) installing a water supply line in, adjacent to or beneath a water body for the purpose of diverting water from the water body, if the line is installed by directional drilling or boring, and if a licence is not required for the diversion of the water;

(d) installing a portable pump or portable water supply line in or adjacent to a water body if there is not a significant alteration or disturbance of the bed or shore of the water body;

(e) removal of debris from a water body that is not frequented by fish if the person removing the debris owns or occupies the land adjacent to the water body where the debris is located.

The following diversions of water are some examples that are exempt from the requirement for a temporary diversion license taken from Schedule 3, Section 1:

(f) ”a diversion of water for the purpose of **dewatering a sand and gravel site or construction site** if:
   (i) the water diverted as a result of the dewatering is:
      (a) moved into and retained in an on-site pit, without using the water, or;
      (b) diverted back into a water body without using the water, if the water is equal to or of the same quality as the water that was originally diverted;
   (ii) the dewatering site, the water body and the on-site pit referred to in sub clause (i) are hydraulically connected;
   (iii) there is no adverse effect on the aquatic environment or on a household user, licensee or traditional agriculture use, and;
   (iv) in the case of a construction site;
      (a) there is no adverse effect on any parcel of land, and;
      (b) the maximum duration of the dewatering operation is 6 months or less for the entire construction project.”

2.3.2.2 Water Act Codes of Practice

Codes of Practice that are associated with the *Water Act*, and that relate to earthwork projects around water bodies include:

- *Code of Practice for Watercourse Crossings*
- *Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body, and*

- *Code of Practice for Outfall Structures on Water Bodies*

All watercourses in the province have been given a designation under the Codes of Practice identifying their sensitivity to habitat alteration. The degree of sensitivity was established based on knowledge of fish species living in particular watersheds. Each watercourse has also been classified showing its Restricted Activity Period (RAP) within which in-stream construction works are more restricted. These RAPs are typically instituted to protect times during the year when fish or fish habitat is more sensitive to disturbance, primarily from sedimentation impact (i.e. spawning or embryo stage).

2.3.3 Public Lands Act

The *Public Lands Act* may require an approval to undertake an activity in or near a water body or watercourse. Sections of the *Public Lands Act* that are relevant to erosion & sediment control concerns include:

Section 54(1): "No person shall cause, permit or suffer:

(a) the accumulation of waste material, debris, refuse or garbage on public land…,

(b) the disturbance of any public land in any manner that results or is likely to result in injury to the bed or shore of any river, stream, watercourse, lake or other body of water or land in the vicinity of that public land, or;

(c) the creation of any condition on public land which is likely to result in soil erosion."

2.3.4 Soil Conservation Act

The intent of the *Soil Conservation Act* is to protect soils for agricultural purposes. In some cases, uncontrolled erosion and sedimentation on construction projects within Calgary may lead to loss or deterioration of soil on adjacent agricultural land. Sections of the *Soil Conservation Act* that are relevant to erosion & sediment control concerns include:

Section 3: Duty of Landowner

"Every landholder shall, in respect of the landholder's land, take appropriate measures:

(a) to prevent soil loss or deterioration from taking place, or

(b) if soil loss or deterioration is taking place, to stop the loss or deterioration from continuing."

Section 4: Direction to Take Remedial Measures

"If an officer is satisfied that, with respect to land, appropriate measures are not being taken

(a) to prevent soil loss or deterioration from taking place, or,

(b) in the case where soil loss or deterioration is taking place, to stop the loss or deterioration from continuing;

the officer shall serve on the landholder a notice directing the landholder to take, within the time specified in the notice, the remedial measures set out in the notice."

Section 6, Remedial Measures

(1) "Where a landholder does not comply with a notice within the period of time specified in the notice, an officer or a person authorized by an officer may:

(a) enter onto the land specified in the notice, and;

(b) carry out the remedial measures set out in the notice.

(2) Subject to **section 13(2)**, where expenses are incurred in carrying out remedial work under subsection (1), the local authority shall:

(a) notify the landholder and, if the landholder is not the owner, the owner, of those expenses, and

(b) demand payment for those expenses within 30 days from the date of notification."

Table 2-2: Summary of Applicable Provincial Legislation

Note: Legislation is subject to change. Please be sure to consult the applicable bylaw, regulation, act, or enactment. The City of Calgary is not responsible for the accuracy of this information.

<table>
<tr><th>REGULATORY AUTHORITY</th><th>LEGISLATION</th><th>RELEVANT SECTIONS</th><th>KEY POINTS</th><th>FINES</th></tr>
<tr><td rowspan="13">PROVINCE OF ALBERTA

Alberta Environment
Tel: 297-3362
Emergencies/
Complaints:
Tel: 1-800-222-6514
www.gov.ab.ca/env

Alberta Sustainable Resource Development (Calgary)
Tel: 297-8800
www3.gov.ab.ca/srd</td><td rowspan="4">Environmental Protection & Enhancement Act (EPEA)</td><td>Section 108 & 109 – Releases</td><td>Do not release into the environment any substances in an amount, concentration, level or a rate of release that causes or may cause a significant adverse effect.</td><td rowspan="4">➢ Section 108 & 109 (1): Up to $100,000 and/or up to 2 years imprisonment; Corporations: fine of not more than $1,000,000.

➢ Sections 108 & 109 (2), 110, 111, 112: Individuals: up to $50,000; Corporations: up to $500,000</td></tr>
<tr><td>Section 110 – Duty to Report Releases</td><td>Immediately report releases of a substance into the environment where it has caused, is causing or may cause an adverse effect.</td></tr>
<tr><td>Section 111 - Manner of Reporting</td><td>Persons required to report to the Director pursuant to Section 110 shall report the location and time of releases, circumstances leading up to the release, the type and quantity of substance released, action taken and proposed at the release site and a description of the release location by telephone or in person.</td></tr>
<tr><td>Section 112 – Remedial Measures</td><td>The person responsible for a release shall ensure the substance is removed and/or remedied, as well as providing repair and restoration of the environment.</td></tr>
<tr><td rowspan="2">Release Reporting Regulation

(AR117/93)</td><td>Section 3 – Substances Regulated by Federal Act</td><td>Reportable substances.</td><td rowspan="2">➢ N/A</td></tr>
<tr><td>Section 4 – Written Report</td><td>Written reports are required within seven days of verbal report.</td></tr>
<tr><td>Wastewater & Storm Drainage Regulation

(AR119/93)</td><td>Section 7 – Prohibited Substances and Releases</td><td>Do not release substances into the storm or wastewater (sanitary) systems that may impair the integrity or operation of the system.</td><td>➢ Individuals: up to $50,000; Corporations: up to $500,000</td></tr>
<tr><td>Water Act</td><td>Section 36(2) – Approval Required</td><td>An Approval may be required for certain activities as defined in the Act.</td><td>➢ Individuals: Up to $100,000 and/or up to 2 years imprisonment; Corporations: fine of not more than $1,000,000.</td></tr>
<tr><td>Water (Ministerial) Regulation (AR205/98)</td><td>Schedules 1 & 3</td><td>Schedule 1 lists activities exempt from requiring an approval.
Schedule 3 lists activities exempt from requiring a licence.</td><td>➢ N/A</td></tr>
<tr><td>Public Lands Act</td><td>Section 54 - Prohibitions</td><td>No person shall cause, permit or suffer the disturbance of any public lands that may result in injury to the shore or bed of a watercourse or soil erosion.</td><td>➢ $5000 per day</td></tr>
<tr><td rowspan="3">Soil Conservation Act</td><td>Section 3 – Duty of Landowner</td><td>Landowners shall take appropriate measures to prevent soil loss or deterioration from taking place or stop soil loss from occurring.</td><td>➢ $500 per day up to a maximum of $10, 000</td></tr>
<tr><td>Section 4 – Direction to Take Remedial Measures</td><td>An officer may serve a notice directing the landowner to take remedial measures to prevent or stop the loss or deterioration.</td><td>➢ Up to $5000</td></tr>
<tr><td>Section 6 – Remedial Measures</td><td>Where a landowner does not comply with a notice, an officer may enter the land, carry out the remedial measures and demand payment for the expenses.</td><td>➢ Up to $5000</td></tr>
</table>

2.4 MUNICIPAL LEGISLATION (CITY OF CALGARY)

A number of City of Calgary Bylaws have sections pertaining to erosion & sediment control (refer to Table 5 for quick reference). In addition, The City of Calgary also has a policy and procedures for reporting substance releases.

- **Drainage Bylaw** 37M2005
- **Street Bylaw** 20M88
- **Sewer Service Bylaw** 24M96
- **Community Standards Bylaw** 5M2004
- **Corporate Release Reporting Policy & Procedures**

Alberta's *Municipal Government Act* (MGA) gives municipalities bylaw-making powers and considerable authority to regulate private land uses through planning and zoning. Copies of Bylaws can be obtained from The City of Calgary website at: www.calgary.ca/cityclerks

2.4.1 Drainage Bylaw 37M2005

As of September 1, 2005, a new Drainage Bylaw 37M2005 came into effect in Calgary. The updated bylaw regulates the storm drainage system by requiring that the public, industry and City of Calgary employees ensure they are in compliance with provisions intended to manage storm drainage and water quality.

Section 4(1): Prohibition

"No person shall release or allow to be Released any Prohibited Materials into the Storm Drainage System, except as permitted in subsection (2)."

Prohibited Materials means any Substance that may, directly or indirectly, obstruct the flow of Water within the Storm Drainage System or may have a Negative Impact to the Storm Drainage System, human health or safety, property, or the environment. This includes, but is not limited to, soil, sediment or other solid matter.

Under **Section 4**(3) (e): Permitted Discharges

"Water in accordance with a permit or written approval from the Director, Water Resources".

Under **Section 5**(1): Unauthorized Discharges

"Any Person who Releases, or causes or allows to be Released, any Prohibited Material into the Storm Drainage System in contravention of this Bylaw must take all reasonable measures to immediately notify:

(a) the 9-1-1 emergency telephone number if there is any damage or immediate danger to:

(i) human health or safety;

(ii) property;

(iii) the environment; or

(iv) the Storm Drainage System;

(b) the City, by calling the 24-hour 3-1-1 telephone number;

(c) the owner of the Premises where the Release occurred; and

(d) any other Person that may be affected by the Release.

(2) The Person reporting the Release described in Subsection (1) must provide the following information:

(a) the name and contact information of the Person reporting the Release;

(b) the time and location of the Release;

(c) the type of material Released and any known associated hazards;

(d) the volume of material Released; and

(e) any corrective action taken, or proposed to be taken, to control the

Release.

(3) The Director, Water Services or the Director, Water Resources may require the owner or Person responsible for the Release described in Subsection (1) to:

(a) compensate the City for any costs incurred by the City to mitigate the effects of the Release; and

(b) submit to the Director, Water Resources a plan setting out how the risk of future similar Releases will be prevented or eliminated.

(4) Any Person who Releases, or causes or allows to be Released, any Prohibited Material into the Storm Drainage System in contravention of this Bylaw must immediately take all reasonable measures to:

(a) mitigate the Release, including but not limited to taking measures to prevent the obstruction of the Storm Drainage System or measures to prevent a Negative Impact; and

(b) cover and clearly mark all hoses used to direct Water to the Storm Drainage System to protect the public from injury."

Section 7: Directing Storm Drainage

"Except in an emergency, no person shall direct impounded water from a parcel to the Storm Drainage System without the consent of the Director, Water Resources."

Under **Section 11** (3): Interference with the Storm Drainage System

"No Person, unless authorized by the Director, Water Services or the Director, Water Resources, shall obstruct, restrict or prevent:

(a) access to the Storm Drainage System; or

(b) flow of Storm Drainage into or within the Storm Drainage System."

Section 15(1): Authority of Director

"The Director, Water Resources may:

(b) establish any conditions or requirements of an approval or permit to Release Water to the Storm Drainage System, including but not limited to:

- (i) testing, monitoring or reporting requirements;
- (ii) equipment or equipment maintenance requirements, and;
- (iii) filtration, settling or other treatment requirements."

2.4.1.1 Drainage Permits

Before pumping or directing any impounded water (including surface water ponding on a site or surface water run-off and/or groundwater captured in an excavation) into a storm sewer, obtain a **Drainage Permit** from The City of Calgary Water Resources Business Unit . This requirement applies to City-owned construction projects and operations as well as private sites. Operations and maintenance activities (such as water main repairs, utility installation, and snow melting) requiring a drainage permit may be able to obtain a City-wide blanket permit (issued for up to one year at a time). The requirement for blanket permits also applies to City Business Units conducting operations and maintenance activities that require disposal of water.

A sanitary permit is required to discharge impounded water into a sanitary sewer. Permit application information can be found at www.calgary.ca/wqs or contact: 3-1-1.

2.4.2 Street Bylaw 20M88

The purpose of the *Street Bylaw (20M88)* is to control and regulate the use of streets and to restrict and regulate activities on, adjacent, or near to streets. The following provisions in the *Street Bylaw* pertain to erosion & sediment control and construction dewatering:

Section 17(1): "Except to the extent specified in and subject to the conditions of a permit signed by or on behalf of the Traffic Engineer, no person shall:

(a) place, dispose, direct or allow to be placed, directed or disposed, any Material belonging to that person or over which that person exercises control, on any portion of a Street;

(b) store, place or dispose of Material in such a way that it may enter onto the Street by any means, including Natural Forces;

(c) place or allow to be placed an electrical cord, hose, chain, or other similar obstruction over or across any portion of a Street.

Section 17(2): Notwithstanding Subsection (1), sand, gravel, salt or calcium chloride placed upon icy portions of a Street to reduce the danger of slippery conditions shall be allowed under this Bylaw.

Section 18: A Landowner shall ensure that Material on his property or on property in his control is stored, placed or Disposed of in such a way that the Material does not enter onto the Street by any means including Natural Forces.

Section 19: A person authorized under permit to develop private or public land adjacent to a Street, or the general contractor or other person acting on behalf of such a person, shall not allow mud, dirt or other construction debris to be tracked by motor vehicles from said lands onto a Street.

Material is defined as "any object or article, animal waste, ashes, building waste, dry refuse, garbage, industrial chemical waste, refuse and yard waste as defined in *The Waste Bylaw*, and includes sand, gravel, earth and building products."

Section 29: "A person authorized under permit to develop private or public land adjacent to a Street, or the general contractor or other person acting on behalf of such person, shall not allow mud, dirt, or other construction debris to be tracked by motor vehicles onto a Street."

2.4.3 Sewer Service Bylaw 24M96

Note: This Bylaw is currently under review and subject to changes.

The *Sewer Service Bylaw (24M96)* regulates the quality of wastewater discharge streams to protect the wastewater collection system and treatment plants Under **Section 6(1)**, the discharge of storm drainage into the wastewater collection system (sanitary sewer) is prohibited. Under special circumstances, the Director, Water Resources may permit certain activities such as the discharge of treated groundwater to a sanitary sewer (**Section 8(4)**). Please contact 3-1-1 for further information.

2.4.4 Community Standards Bylaw 5M2004

The *Community Standards Bylaw (5M2004)* was implemented in 2004 and regulates neighbourhood nuisances, safety and liability issues.

Section 42 of the *Bylaw* states: "No owner or occupier of a Premises shall engage in an activity likely to allow smoke, **dust** or other airborne matter likely to disturb another Person, to escape the Premises without taking precautions to ensure that the smoke, dust or other airborne matter does not escape the Premises."

Section 51 of the *Bylaw* states (under **Part 13: Excavations and Ponding Water**):

(1) No owner or occupier of a Premises shall allow an excavation, drain, ditch or other depression in the ground to become or remain a danger to public safety.

(2) If, in the opinion of the Chief Bylaw Officer, a water-course, pond or other surface water becomes or remains a nuisance or poses a danger to public safety, the Chief Bylaw Enforcement Officer may declare the water-course, pond or other surface water a nuisance and require the owner or occupier of the Premises to eliminate the nuisance or danger.

This is important to keep in mind when planning and constructing sediment traps or ponds on construction sites, especially for locations accessible to the public.

2.4.5 Corporate Substance Release Reporting Program

In consideration of the AENV Release Reporting Regulation under EPEA (see Section 2.3.1.1), The City of Calgary has a Corporate Release Reporting Program. City staff and agents of The City (including contractors working on City-owned projects and operations) are responsible for completing Substance Release Reports (X-217 form) and submitting them to the Calgary Fire Department, HazMat Division, immediately. City staff are also responsible for ensuring reporting of substance releases on private sites that they observe, or are made aware of.

Note that discharges of sediment and turbid water from construction sites to storm sewers and/or water bodies are considered reportable releases.

For more information, refer to the Corporate Substance Release Reporting Procedures document. If you are unsure about reporting requirements on your job site, contact Calgary HazMat at 403-974-4800.

Table 2-3: Summary of Applicable Municipal Legislation (City of Calgary)

Note: Legislation is subject to change. Please be sure to consult the applicable bylaw, regulation, act, or enactment. The City of Calgary is not responsible for the accuracy of this information.

REGULATORY AUTHORITY	LEGISLATION	RELEVANT SECTIONS	KEY POINTS	FINES
CITY OF CALGARY ***Tel: 3-1-1*** ***www.calgary.ca***	**Drainage Bylaw 37M2005**	Section 4(1) – Discharges to Storm Drainage System, Prohibition	No person shall release or allow to be released any prohibited material into the Storm Drainage System unless permitted by the bylaw.	➢ $3000 ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail.
		Section 4(2)- Release Impounded Water	No person shall release impounded water either passively or actively into the storm drainage system.	➢ $1500 ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail.
		Section 4(3) – Discharges to Storm Drainage System, Permitted	Water may be discharged in accordance with a permit or written approval from the Director, Water Resources. A failure to obtain a permit is an offence.	➢ $1500 ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail.
		Section 5(4) – Unauthorized Discharges	Any person who releases, or causes or allows any prohibited materials to be released into the Storm Drainage System, shall immediately take all reasonable measures to notify the appropriate authorities and mitigate the discharge.	➢ $500 (failure to notify) ➢ $3000 (failure to mitigate discharge) ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail.
		Section 7 – Directing Storm Drainage	Except in an emergency, no person shall direct impounded water from a parcel to the Storm Drainage System without the consent of the Director, Water Resources. A Drainage or Dewatering Permit is required from The City.	➢ $1500 ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail.
		Section 11 – Restricting access or flow or altering the storm drainage system	No person shall restrict access or flow to or within the storm drainage system or alter, remove or change the storm drainage system without prior approval	➢ $1500 ➢ Summary Conviction: up to $10,000 and/or not more than 1 year in jail
		Section 15 – Authority of Director	The Director, Water Resources has the authority to require testing, monitoring, reporting and water treatment of water released to the Storm Drainage System.	➢ N/A
	Street Bylaw 20M88	Section 17 – Unauthorized Material on the Street	Do not store any material on any portion of a street. Material stored on private property must be stored so as not to enter the street.	➢ $500 (first offence) ➢ Summary Conviction: up to $10,000 or in the event of non-payment not more than 90 days in jail.
		Section 18 & 18.1 Material entering Street	Material entering the street by natural forces from a person or a landowner.	➢ $250 (first offence) ➢ Summary Conviction: up to $10,000 or not more than 90 days in jail.
		Section 19 – Tracking Mud onto Street	Mud and other construction debris may not be tracked by vehicles onto the street.	➢ $250 (first offence) ➢ Summary Conviction: up to $10,000 or not more than 90 days in jail.

REGULATORY AUTHORITY	LEGISLATION	RELEVANT SECTIONS	KEY POINTS	FINES
		Section 20(1) No Permit	Use of Street without permit	➢ $300 (first offence) Summary Conviction: up to $10,000 or in the event of non-payment not more than 90 days in jail.
		Section 20(2) Permit Conditions	Failure to comply with permit conditions	➢ $500 (first offence) Summary Conviction: up to $10,000 or in the event of non-payment not more than 90 days in jail.
		Section 37 Excavation	Excavation of street surface	➢ Mandatory court appearance Summary Conviction: up to $10,000 or in the event of non-payment not more than 90 days in jail.
	Sewer Service Bylaw 24M96	Section 6(1) – Storm Drainage	Do not allow any storm drainage to be placed in the wastewater collection system, except as authorized by a permit.	➢ $350 ➢ Summary Conviction: up to $10,000 or not more than 1 year in jail.
		Section 8(1) – Prohibited Material	No person shall release or discharge, or permit the release or the discharge of any waste described in Schedule "A" into the wastewater collection system.	➢ $600 ➢ Summary Conviction: up to $10,000 or not more than 1 year in jail.
	Community Standards Bylaw 5M2004	Section 42 – Nuisances Escaping Property, Smoke and Dust	No owner or occupier of premises shall engage in an activity likely to allow smoke, dust or other airborne matter likely to disturb another Person, to escape the Premises without taking precautions to ensure that the smoke, dust or other airborne matter does not escape the premises.	➢ $300 ➢ Summary Conviction: up to $10,000 or not more than 6 months in jail.
		Section 51(1) – Hazardous Excavation, Drain, Ditch or Depression	No owner shall allow a excavation, drain, ditch or other depression in the ground to become or remain a danger to public safety. This includes ponded water.	➢ $300 ➢ Summary Conviction: up to $10,000 or not more than 6 months in jail.

2.5 RESPONSIBILITIES

Companies and personnel responsible for the design and construction of all projects that disturb soil, as well as operational activities such as underground utility repairs, must be able to demonstrate planning and implementation of all reasonable steps to prevent an offence from occurring. These “reasonable steps”, are known as the standard of care.

Proper design, implementation, inspection, and maintenance of suitable erosion and sediment control practices (temporary and permanent) are required at all stages of projects or operations that disturb soil. Utilizing trained and experienced staff, timely communication and common sense to plan and implement appropriate best practices is a relatively small cost versus very large costs that can be incurred through clean-up, stop work orders, project delays, contractual penalties, fines and other enforcement actions.

- Develop and implement a company environmental policy/statement. Make all staff (and sub contractors) aware of the policy.
- Ensure erosion and sediment control reports and drawings are developed by (or under the supervision of) experienced professionals specializing in ESC/construction stormwater management.
- Allocate the responsibility of timely implementation, inspection and maintenance of erosion and sediment control practices to properly trained personnel on-site.
- Maintain records (reports, photos, etc.) detailing the implementation, inspection and maintenance of all temporary and permanent erosion and sediment control practices.
- For all projects, implement standard best management practices to protect stockpiles, prevent mud-tracking, contain run-off on-site, control dust, etc. (known as “good housekeeping practices”).
- Plan contingency measures and be prepared to implement them.
- Ensure all employees (including sub-contractors) are properly trained and aware of responsibilities.
- Immediately report releases/incidents as per requirements in legislation.

2.6 CONTACT INFORMATION

Government of Canada

Canadian Environmental Assessment Agency
61 Airport Road NW
Edmonton, AB, T5G 0W6
Phone: (780) 495-2037
Fax: (780) 495-2876
www.ceaa-acee.gc.ca

Environment Canada
Rm 200, 4999-98 Avenue,
Edmonton, AB, T6B 2X3
Phone: (780) 951-8600
Fax: (780) 495-2615
www.ec.gc.ca

Fisheries and Oceans Canada
7646 - 8 Street NE
Calgary, AB, T2E 8X4
Phone: (403) 292-5160
Fax: (403) 292-5173
www.dfo-mpo.gc.ca

Transport Canada
Canada Place
1100 – 9700 Jasper Avenue
Edmonton, AB, T5J 4E6
Phone: (780) 495-8215
Fax: (780) 495-8607

Province of Alberta

Alberta Environment
#303 Deerfoot Square Building
2938 11 Street, N.E.
Calgary, AB, T2E 7L7
Phone: (403) 297-5959 or
1-800-222-6514 (24 Hr Complaint/Emergency)
Fax: (403) 297-6069
www3.gov.ab.ca/env

Alberta Infrastructure & Transportation
2nd floor, Twin Atria Building
4999 98 Avenue
Edmonton, AB, T6B 2X3
www.transportation.alberta.ca

Sustainable Resources Development
8660 Bearspaw Dam Rd., NW
Calgary, AB, T3L 1S8
Phone: (403) 297-8800
Fax: (403) 297-8803
http://www3.gov.ab.ca/srd

City of Calgary

P.O. Box 2100, Stn. M.
Calgary, AB, T2P 2M5
Telephone: 3-1-1
www.calgary.ca
Water Services: www.calgary.ca/wqs

SECTION 3.0

EROSION AND SEDIMENT CONTROL REPORTS AND DRAWINGS: TECHNICAL REQUIREMENTS

3.0 TECHNICAL REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL REPORTS AND DRAWINGS

3.1 OVERVIEW

Erosion and sediment control documents typically consist of both a report and a set of drawings. For projects on smaller sites with moderate to low erosion potential, a set of drawings may suffice. On projects with a low risk of erosion and sedimentation, some simple procedural best management practices (BMPs) known as 'good housekeeping practices' may be all that is required (refer to Section 7.0 for more details).

1. Erosion and Sediment Control Report: The report component provides useful background and supporting information (i.e. site conditions such as soil types and critical areas, soil loss calculations, selection of erosion and sediment control temporary and permanent practices). On some smaller sites, drawings are all that may be required.
2. Erosion and Sediment Control Drawings: Drawings provide information that can be easily understood and followed by contractors (i.e. cut/fill drawings, contours, drainage divides as well as the location, types and dimensions of erosion and sediment control practices).

Erosion and sediment control reports and drawings must identify the location, design and timing of appropriate BMPs. Where possible, responsibility for implementation, inspection and maintenance of practices should be assigned. As construction schedules and conditions will change, it is likely the report and/or drawings will need to be amended from time to time to remain effective. Therefore, initial erosion and sediment control reports and drawings are generally limited to providing an assessment of erosion potential and providing prescriptions for preventative practices which have to be re-assessed during construction.

In order of priority, the goals of the erosion and sediment control report and/or drawings are to:

1. Reduce erosion by providing more effective planning and procedures, including construction site run-on and run-off control and soil stabilization practices (source control).
2. Identify sediment control measures (insurance) to prevent offsite sediment releases in the event of sediment mobilization

Note: Erosion and sediment control reports and drawings must be easily understood by contractors. Drawings should clearly identify where, when and how to implement practices to manage water, control erosion and control sedimentation. Effective planning and implementation requires the cooperation of the engineering consultant, erosion and sediment control designer, project manager, contractors, regulators and other project stakeholders.

3.2 SUBMISSION REQUIREMENTS

Note: The City of Calgary, Water Resources, has developed templates for completing reports and drawings, as well as drawings only submissions and erosion control drawings submissions with engineering drawing circulations. At the time of writing, a copy of the current template for reports and drawings is included in Section 3.4. This template is also available as an electronic fill-able template on our website at www.calgary.ca/wqs. To ensure you are working from an up to date copy of the template, visit our website to download a copy.

The City of Calgary requires an erosion and sediment control (ESC) report and drawings be submitted for all projects which involve soil disturbance on sites with overall land area greater than or equal to two (2.0) hectares. In addition, an ESC report and/or drawing(s) may be requested for smaller sites (overall land area greater than one acre or 0.4 ha) if The City deems the project to have a moderate to high erosion potential, or there is potential for impact to an adjacent area such as an environmental reserve, water body, or any other potential high impact areas.

The Water Quality Services Division of The City's Water Resources Business Unit is responsible for review and approval of erosion and sediment control reports and drawings for all construction projects and operations that disturb soil and/or require a component of erosion and sediment control. In January, 2010, Water Resources took over the role of subdivision erosion and sediment control regulation from the Urban Development Division of the Development and Building Approvals Business Unit. Further details on processing and technical requirements is provided in Section 4.0.

Table 3-1 provides a summary of activities the Water Resources Business Unity is responsible for. The flowchart in Figure 3.1 shows that submission requirements for ESC reports and/or drawings are partly triggered by a combination of site size and other risk factors.

3.3 AMENDING/UPDATING REPORTS AND DRAWINGS

The City of Calgary, Water Resources, recognizes that erosion and sediment control reports and/or drawings need to be updated or amended from time to time to capture changing project schedules, field conditions or a change of practices being implemented. To avoid project delays and ensure updates are effectively communicated, the project owner`s designate (project manager, consulting engineer or ESC designer) is responsible for notifying The appointed City ESC inspector of changes/amendments before they are implemented. The appointed City ESC inspector is responsible for ensuring a timely review and approval process for updates and amendments.

Major Changes: these represent a major departure from what was approved in the site report/drawings (for example; replacement of a specified erosion control blanket with a hydroseeding specification) and generally require an amendment to existing drawing(s) and an addendum letter to be added to the report. The City typically requires a few days of turnaround time to review these requests and may request a site meeting. Except in the case of emergency practices being installed, changes must not proceed until The City and project owner's designate have discussed and agreed to the changes.

Minor Changes: these represent a minor change in erosion and sediment control implementation (for example; substitution of triangular silt dike with fibre rolls in a channel) and can usually be approved via a phone call or e-mail, plus the submission of a sketch or simple drawing. These types of changes should be approved by the appointed City of Calgary ESC Inspector within one or two business days.

Table 3-1: Summary of City of Calgary ESC Review, Approval and Inspection

The City of Calgary, Water Resources Business Unit
Water Quality Services Division: Erosion and Sediment Control

1. **City of Calgary Capital Construction Projects**:
   e.g.; review/approval and compliance inspection of ESC for projects owned or operated by:

   Transportation Infrastructure
   Parks – unless in a subdivision under Development Permit
   Roads – unless in a subdivision under Development Permit
   Calgary Transit
   Water Resources
   Water Services
   Waste & Recycling
   Corporate Properties
2. **Stripping & Grading under a Development Permit, Development Agreement or Development Liaison** (review/approval and compliance inspection of ESC)
3. **Construction Drawings (ESC) Review for Residential, Commercial and Industrial Development** (review/approval and compliance inspection of ESC)
4. **Cash Prepayment Sites**
5. **Indemnification Agreements** (underground utilities and surface construction)
6. **Standard Development Permits, Development Liaisons and Airport Development**
7. **Drainage & Dewatering Permits** (Review applications and issue drainage/dewatering permits allowing temporary discharge of impounded water from construction sites and facilities to the storm sewer system. Additional application and processing information can be found at: www.calgary.ca/wqs)
8. **Complaints:** Complaints associated with any of the above

Contact:

Water Resources
Erosion Control Coordinator: Tel: (403) 268-2655, Fax: (403) 268-4557
Website: www.calgary.ca/waterservices/esc
Corporate Call Centre: 3-1-1

EROSION AND SEDIMENT CONTROL REPORT AND DRAWING(S) WATER RESOURCES DECISION FLOWCHART FOR **ALL** CONSTRUCTION/DEVELOPMENT PROJECTS INVOLVING SOIL DISTURBANCE

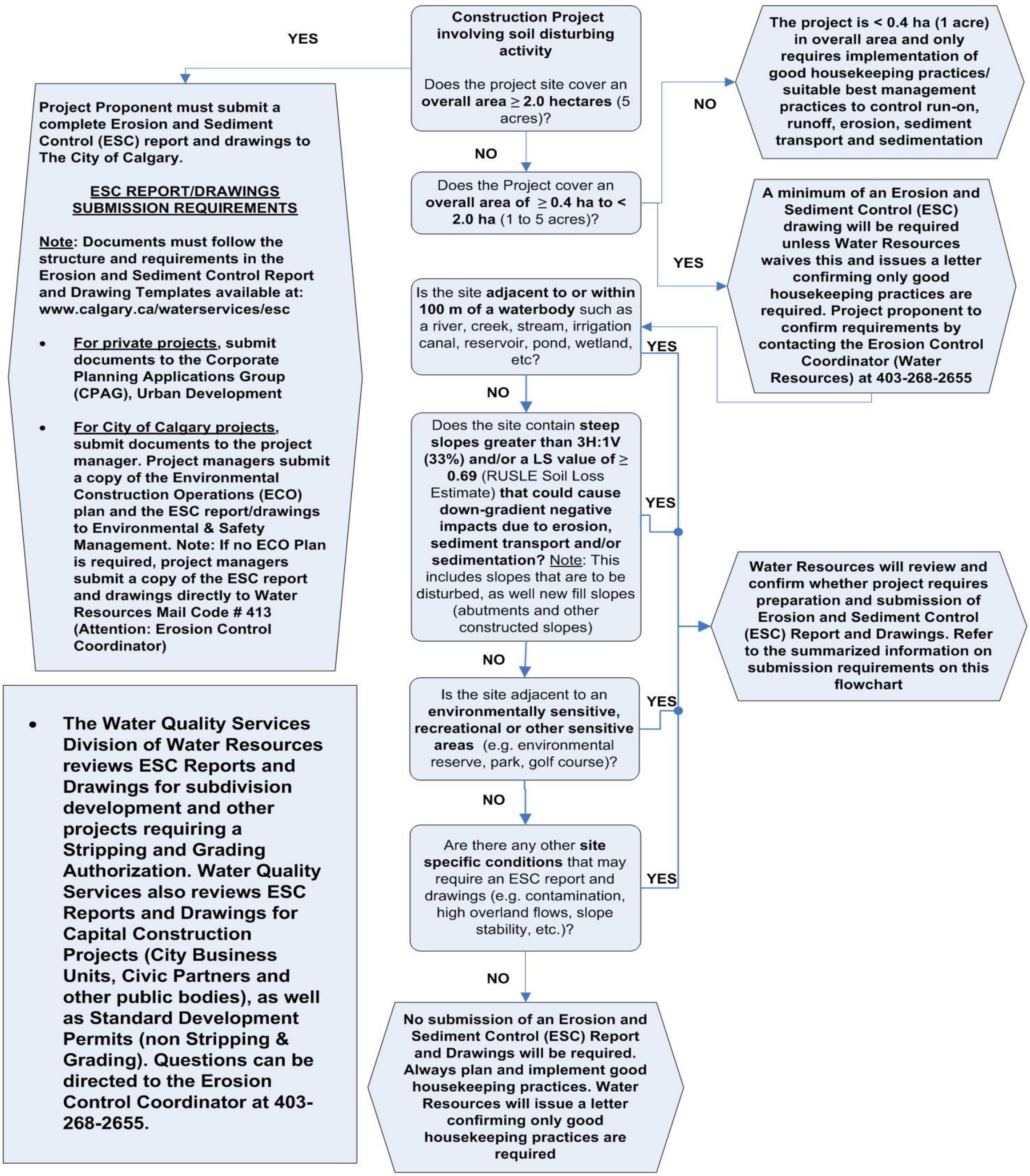


Figure 3-1: Report & Drawing Requirements for Construction/Soil Disturbing Projects

What is the RUSLE-FAC LS Value?

Slopes that are to be disturbed or slopes created during construction are of concern if they are (or will) be up-gradient of storm sewer inlets and/or infrastructure, property or water resources that could be negatively impacted. Where the LS value for such slopes in 0.69 or greater, this is a trigger for an erosion and sediment control report and/or drawings. Slopes that are not going to be disturbed, as well as disturbed slopes where there is no risk of down-gradient negative impacts are not a trigger for a report and/or drawings.

The LS-value is a parameter in the Revised Universal Soil Loss Equation for Application in Canada (RUSLE-FAC). The LS-value is related to the topographic factors specific to the length of the overland flow path times the steepness of the overland flow path. In the past, sites over 0.4 ha (1 acre) in overall area would trigger the requirement for an ESC report if there was the presence of slopes equal to or greater than 33%. A 2 m slope with a 33% grade has an LS value of 0.69. This number is used in a RUSLE-FAC calculation to determine the predicted soil loss from a construction site.

It is important to note that a 2 m, 33% slope has almost the identical LS value as a 50 m, 4% slope: Long shallow slopes have a similar topographic effect on erosion as short steep slopes. For this reason the use of an LS value of 0.69 to trigger the requirement for an ESC report is more accurate than the use of a ≥33% slope gradient.

Table 3-2 shows how LS values are calculated.

LS Values for High Ratio of Rill: Inter-Rill Erosion, such as highly disturbed soil conditions and freshly prepared Construction Sites, with little or no cover (not applicable to thawing soils)

	Slope Length in meters													
Slope %	**1**	**2**	**4.57**	**5**	**10**	**15**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**
0.20%	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
0.50%	0.07	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13
1.00%	0.09	0.09	0.09	0.09	0.11	0.12	0.14	0.17	0.19	0.20	0.23	0.24	0.26	0.27
2.00%	0.13	0.13	0.13	0.14	0.18	0.21	0.26	0.34	0.40	0.44	0.52	0.58	0.64	0.68
3.00%	0.17	0.17	0.17	0.17	0.24	0.29	0.37	0.52	0.63	0.72	0.88	1.01	1.12	1.22
4.00%	0.20	0.20	0.20	0.21	0.30	0.38	0.49	0.71	0.88	1.03	1.28	1.49	1.67	1.84
5.00%	0.23	0.23	0.23	0.24	0.36	0.46	0.61	0.91	1.14	1.35	1.70	2.01	2.28	2.53
6.00%	0.26	0.26	0.26	0.28	0.42	0.54	0.73	1.11	1.42	1.68	2.15	2.56	2.93	3.27
7.00%	0.29	0.29	0.29	0.31	0.48	0.61	0.85	1.31	1.69	2.03	2.62	3.14	3.61	4.05
8.00%	0.32	0.32	0.32	0.34	0.53	0.69	0.96	1.51	1.97	2.38	3.09	3.73	4.31	4.86
9.00%	0.35	0.35	0.35	0.37	0.59	0.78	1.09	1.73	2.27	2.75	3.61	4.37	5.08	5.73
10.00%	0.35	0.36	0.40	0.42	0.68	0.90	1.27	2.04	2.69	3.28	4.32	5.26	6.13	6.94
12.00%	0.36	0.40	0.49	0.53	0.86	1.14	1.64	2.67	3.56	4.36	5.80	7.11	8.32	9.46
14.00%	0.38	0.44	0.58	0.62	1.03	1.38	2.00	3.30	4.43	5.45	7.32	9.01	10.59	12.09
16.00%	0.39	0.47	0.67	0.72	1.20	1.62	2.36	3.93	5.31	6.57	8.86	10.96	12.92	14.79
20.00%	0.41	0.53	0.84	0.90	1.53	2.08	3.07	5.20	7.07	8.81	11.99	14.92	17.69	20.32
22.00%	0.43	0.57	0.92	0.99	1.69	2.31	3.42	5.82	7.95	9.93	13.56	16.92	20.09	23.11
25.00%	0.45	0.62	1.04	1.12	1.92	2.64	3.93	6.75	9.26	11.59	15.91	19.91	23.70	27.32
30.00%	0.48	0.69	1.24	1.33	2.30	3.18	4.77	8.26	11.40	14.33	19.77	24.84	29.65	34.27
40.00%	0.53	0.83	1.59	1.71	3.01	4.19	6.34	11.13	15.46	19.53	27.15	34.30	41.11	47.67
50.00%	0.58	0.95	1.91	2.06	3.65	5.09	7.75	13.72	19.17	24.29	33.93	43.00	51.68	60.05
60.00%	0.63	1.07	2.19	2.36	4.21	5.89	9.01	16.04	22.48	28.55	40.00	50.82	61.18	71.20

Table 3-2: Values for topographic factor (LS) for a high ratio of rill:inter-rill erosion

Source: RUSLE-FAC Handbook, Agriculture Canada (modified by: Joe Buchner, CPESC)

3.4 STANDARD REPORT AND DRAWINGS APPLICATION TEMPLATE

EROSION AND SEDIMENT CONTROL REPORT AND DRAWING APPLICATION GUIDELINE

Note: Visit www.calgary.ca/wqs for a current, electronic copy of this guideline and associated application template, or contact the Water Resources ESC Coordinator at 403-268-2655.

The application guideline was developed to assist consultants preparing erosion and sediment control (ESC) reports and/or drawings for construction projects within The City of Calgary. The corresponding application template must be completed and submitted to The City of Calgary with all supporting documentation. Failure to include the application at the time ESC documentation is submitted to The City of Calgary may result in return of your documents and delay the review process.

If any of the required information does not apply or is not available at the time of the application please provide justification and make a note, if applicable, on when it will be provided.

SUBMISSION INFORMATION

Please ensure that you submit your ESC documentation to the correct location based on the project type. Failure to submit your application to the correct contact may result in your submission being sent back or delayed.

For Development Permits, including Stripping & Grading Development Permits:

Mailing Address:
Attention: DPXXXX-XXXX File Manager
The City of Calgary
Development & Building Approvals #8108
P.O. Box 2100, Station M
Calgary, Alberta
T2P 2M5

Courier/Applicant drop-off:
Attention: DPXXXX-XXXX File Manager
The City of Calgary
Development & Building Approvals
3rd Floor, Calgary Municipal Building
800 MacLeod Trail, SE
Calgary, Alberta
Hours: 8:00 a.m. – 4:30 p.m., Monday – Friday
Tel: 403-268-5311

For Development Agreements (Stripping & Grading):

Mailing Address:
Attention: Urban Development Generalist
The City of Calgary
Development & Building Approvals #8032
P.O. Box 2100, Station M
Calgary, Alberta
T2P 2M5

Courier/Applicant drop-off:
Attention: Urban Development Generalist (#8032)
The City of Calgary
Development & Building Approvals
3rd Floor, Calgary Municipal Building
800 MacLeod Trail, SE
Calgary, Alberta
Hours: 8:00 a.m. – 4:30 p.m., Monday – Friday
Tel: 403-268-5311

For City of Calgary Projects:

Attention: Project Manager
The City of Calgary
City Business Unit Mail Code # XXXX
P.O. Box 2100, Station M, Calgary, Alberta, T2P 2M5

EROSION AND SEDIMENT CONTROL REPORT REQUIREMENTS

1. General Information

Provide the following general information within the application provided:

- Project name
- Estimated project start-up date
    - Can be month and year
- Legal land location
    - Meridian-range-township-section
    - e.g. NW-27-25-02-W5
- Development permit, agreement or liaison number
- Community name
- Overall site size (ha)
- Proposed and existing storm pond
    - Where the water from your site will end up
    - e.g. WP113 (this indicates wet pond 113)
    - Check with the developer to obtain the appropriate information
- Receiving water body
    - e.g. Bow River
    - Check with the developer to obtain the appropriate information
- Outfall
    - e.g. B71 (this indicates outfall 71 on the Bow River)
    - Check with the developer to obtain the appropriate information
- Municipal site address(es)
- Date(s) the project was visited to gather the ESC information
- Limitation of field investigation
    - e.g. snow covered, restricted access, ongoing construction
- List referenced documents
    - e.g. environmental site assessment, geotechnical report
- Inspection and maintenance requirements for each erosion and sediment measures by filling out and including **Appendix A**
- Populate the Inspection document located in **Appendix B** to be specific to the site

2. Contact Information

Within the application, provide the company & contact name, office telephone #, cellular telephone # and e-mail for:

- Owner/Developer/Project Manager
- Engineering Consultant
- ESC Consultant
- Site Superintendent
- ESC Implementation, Inspection & Maintenance Contact
- City Contact for ESC Review, and
- City Contact for ESC Inspection

City Contact for ESC Review:

- North of 17 Avenue S: Katherine Mitchell 403-268-4966
- South of 17 Avenue S: Amber Toivanen 403-268-5271

City Contact for ESC Inspection:

- North of 17 Avenue S: Robert Wills 403-268-4913
- South of 17 Avenue S: Bobby Chong 403-268-1847

3. Project Overview

- Provide a brief description of the nature and extent of the construction project
- This section will clarify what will be present on the site after the construction project is complete

4. Existing Site Conditions

- Provide a description of which areas are vegetated and which areas are stripped
- If applicable, provide information on the type(s) and density of the vegetation present
- Include any information on existing stockpiles, berms, and existing ESC practices

Attach: *Photos of the site and a map that shows which location and direction the photo was taken from.*

5. Soil Types

- Provide data on soil structure and texture for soils that will be disturbed during construction, including existing soils on site, and texture data for soil being imported as fill. As a minimum, include a copy of the most recent site geotechnical report and any soil survey information available at the time of the report development. This should include representative soil texture data (sieve analysis); the number of samples collected being at the discretion of the geotechnical engineer and/or consulting engineer. If organic matter information is not available, 0% should be used when determining K-value.
- Soil erodibility (known as the K value in the Revised Universal Soil Loss Equation) is a major factor in soil erosion prediction, and the selection of suitable temporary and permanent erosion and sediment control practices

Attach: *Title page, copies of boreholes and maps from the geotechnical report including sieve analysis data along with the nomograph(s).*

6. Critical Areas

- Discuss any critical areas located within and adjacent to the proposed development site that could be negatively impacted by erosion, sediment-laden run-off or sedimentation.
- Critical areas may require extra protection and need to be covered in your RUSLE calculations.
- e.g. steep slopes, highly erodible soils, water bodies, infrastructure, Low Impact Devlopements (LID)

7. Appendix A – ESC Product Information

Include details on run-on, run-off controls, temporary, permanent stabilization practices, stockpile information and all erosion and sediment controls used on site within Appendix A.

- Examples include, but are not limited to, protective cover such as top soiling, seeding, mulching, tackifiers, rolled erosion control products, sediment ponds and traps, compost berms and socks, silt fence, ditches, berms, stabilized/gravelled construction exits and temporary storm inlet protection.

- Please note that inspection requirements are specifically what your inspector is looking for and requires more detail than inspection frequency.

8. **Appendix B – Inspection Sheet**

- Provide data that is known at this time including, but not limited to, project, project location address, ESC inspector, developer, contractor, list of controls specific to your project with locations.

9. **Appendix C – RUSLE**

Fill out RUSLE information in Appendix C

- In Calgary, the soil loss for sites that have access to storm drainage infrastructure, including ditches is **2 tonnes/ha*yr.**
- All site that do not have access to storm drainage infrastructure must meet **4 tonnes/ha*yr.**
- In order to justify that the selected erosion and sediment controls are adequate to stabilize the site and protect downstream resources, an appropriate calculation to show predicted soil loss is required.
- e.g. Revised Universal Soil Loss Equation for Application in Canada, RUSLE-FAC.
- As construction sites are very dynamic and not all erosion and sediment control practices are in place for the entire duration of the project, more than one erosion prediction calculation is required.
- Provide the appropriate number of erosion prediction calculations for the site that take into account different slopes and drainage areas as well as construction stages.
- Examples of construction changes that could trigger the need for a separate RUSLE calculation are:
    - Site stripping and grading exposes soil and/or causes changes slope gradient and/or slope length
    - Inability to continue to use a certain erosion or sediment control (e.g. loss of sediment basin or trap due to continued construction or connection of permanent storm conveyances to future storm pond temporarily used as a sediment basin)
    - Change of soil type (e.g. placement of fill materials)

Note: Contact our office prior to submitting your report if you wish to use an alternate method for calculating soil loss.

10. **Appendix D – Ponds**

If ponds are used, fill out information in Appendix D

- If your site is > 4 hectares, a minimum of 250 cubic meters is required to obtain a value for RUSLE.
- For sites < 4 hectares, a minimum of 150 cubic meters is required to obtain a value for RUSLE.
- Use the drop down boxes to assist in determining the appropriate RUSLE P-value.

11. **Stockpile Control and/or Haul Routes with Off Site Stockpile Locations**

- Where possible, spill piles should also be placed on the up-gradient side of the trench.
- Indicate the material being stockpiled (e.g. topsoil, till overburden, sandy silt subsoil), the volume and the estimated length of time stockpiles will be in place.
- Different soil types have different erodibility and will therefore pose different levels of concern (e.g. subsoil will often have a higher K-value than top-soil which contains more organic matter)

Attach: *If soil is being hauled off site, a detailed map showing the location where soil will be stored and the haul routes.*

12. **Winter Operations/Site Shutdown**

- A pre-winter inspection will be required to locate any concerns that need to be addressed in a winterization plan. The need for additional ESC practices to ensure protection of the site and downstream areas over winter and during spring thawing/run-off should be identified in this plan.
- Items that should be addressed in a winterization plan may include, but are not limited to:
  - Removal of storm inlet sediment controls.
  - Long-term stabilization of exposed slopes by methods appropriate for the steepness and length.
- Pre-winter inspection and maintenance of all ESC practices. Examples include, but are not limited to:
  - Ensuring sediment basins/traps have adequate storage capacity
  - Removal of sediment and repair of structures and controls designed to capture sediment
  - Checking for adequate stabilization of all exposed areas and inspecting erosion controls to ensure proper installation and condition
- A review of potential run-on areas should be conducted to see if additional measures will be required.
- Regardless of whether a project site is subject to winter shutdown or construction is continuing regular inspection and maintenance of sites is required through the winter.

13. **Construction Schedule & Phasing**

- If this information is not available at the time of ESC report and drawings preparation it may be submitted as a report amendment.
- It is important for the contractor to be clear on when each specified ESC practice is to be implemented.
- Provide a construction schedule for each stage of the proposed development within the table outlined in the application. The schedule may include the following stages: pre-construction, stripping and grading, underground installations, above ground (e.g. paving, build-out, etc) and post construction (e.g. landscaping, etc). If dates are not available provide the type of controls that will be present with a note that dates will be provided when construction commences.
- Describe when each control is to be implemented and how long temporary controls should be in place.

DRAWING REQUIREMENTS

Please note the following:

- Information must be located on the erosion and sediment control drawings in the format outlined below
- Include a legend and scale, between 1:500 to 1:1000, for all drawings
- Drawings must be provided on A1 size paper, folded and attached to the report

- Ensure the drawings are labelled to match this guideline, including each item listed below
- If everything does not fit onto one drawing, the additional drawings must be labelled e.g. ESC 01 a, ESC 01 b, etc.
- ESC practices must be identified on a drawing legend and clearly marked on the drawings
- Guidance on installation, inspection and maintenance must be provided
- The applicant must include a copy of Appendix A on a separate sheet
- The City reserves the right to reject drawings that contain too much extraneous information or are difficult to read

Failure to follow the following format may result in the return of your documents and delay the review process.

ESC 01 – General Information

1. Construction details and schematics for each erosion and sediment control measure that is anticipated to be installed during the project
    - Refer to the current City of Calgary ESC Guidelines or your local manufacturer for the details
2. Insert the applicable mandatory notes from below.

The following good housekeeping and general notes are <u>mandatory</u> and must be cut and pasted directly onto at least one drawing in the set, keeping the numbering the same.

Good Housekeeping Practices Items:

1) Proper placement and protection of stockpile soils and materials. Placement of materials on a City Street or where wind/water could transport material off-site is prohibited under the City of Calgary Street Bylaw. Stockpiles are to be properly placed and protected on site so material will not be eroded to off-site areas, including storm inlets.
2) Control of mud track out during construction, usually by means of a well maintained construction entrance/exit on all access locations, supplemented with periodic street sweeping if required.
3) Dust control must be implemented on site, when required.
4) Install down-gradient perimeter protection (such as silt fence, compost socks or fiber rolls) to protect off-site areas from stormwater runoff and sedimentation during construction.
5) Temporary sediment control at any storm inlets requires prior written approval. One of the forms of written approval is approved ESC drawings. When installing inlet protection make sure that they match what is shown on the approved drawings. For most sites, the only location where inlet protection would be approved is directly adjacent to a gravel pad or stockpile. Failure to obtain approval can lead to fines under the Drainage Bylaw. Please contact our office for more information if you wish to use inlet protection on or near your good housekeeping site.

Add any additional good housekeeping items that are unique to your construction site.

General Items:

1) A preconstruction meeting must be called with the Water Resources (City) ESC Inspector after controls have been put in place but prior to the commencement of construction. Provide at least two business days notice when scheduling your meeting.
2) The following information must either be available on site or be made available to a City ESC inspector the business day following a request for information (that latter applies to projects such as residential subdivisions where the documentation may need to be obtained from the consulting engineer), and filed for a minimum of two years following final site stabilization:
    - The Erosion and Sediment Control Report and/or Drawing(s), including all amendments;

- Documentation (including photos and up-to-date written records) detailing implementation, inspection and maintenance of ESC practices.

3) Inspections of all ESC practices must be completed and documented at least every 7 days and at critical times when erosion or sediment releases could occur. Inspections must be completed and documented during, or within 24 hours of, heavy snowmelt and heavy and/or prolonged rainfall (defined as >12 mm precipitation within any 24 hour period, or precipitation or snowmelt on wet or thawing soils).
4) Inspection must be done by a qualified person who has training in ESC or by someone who is directly under the supervision of a qualified person whom they have received assistance from in understanding the purpose and requirements of the required ESC inspections.
5) The approved Erosion and Sediment Control Report and/or Drawing(s) must be updated when there are changes to the erosion and sediment control practices or implementation. **The City** ESC Inspector responsible for approving the original Erosion and Sediment Control Report and/or Drawing(s) must be notified by submitting an addendum letter and updated drawing(s).
6) Deficiencies documented during inspection of ESC practices must be corrected promptly, and maintenance documented. Any off-site releases of sediment-laden water or other contaminants to a storm drainage system or the environment must be immediately reported by calling 1-800-222-6514 and 3-1-1 (City of Calgary staff and contractors follow the Corporate Substance Release Reporting Procedure), and The City ESC Inspector notified.
7) Prior Authorization (a Drainage or Dewatering Permit) is required from The City of Calgary prior to pumping or directing impounded surface water and/or groundwater into a storm sewer. More information on permits is available at www.calgary.ca/wqs or by contacting 3-1-1.
8) Longer term stockpiles (in place more than 30 days) must be covered or stabilized with mulch and tackifier, vegetation cover or other suitable measures. Stockpiles in place less than 30 days must have functional sediment control practices on the down-gradient side of the pile that will contain sediment (silt fence, fibre rolls, compost socks, etc.). Soil windrowed during utility excavations should be placed up-gradient of the trench; in the absence of other specific regulatory or project requirements, maximum length of open excavation prior to backfilling and stabilization is 150 m.
9) Should all or part of the site be left in a state where active construction is not occurring for a period greater than six months the following conditions must be met:
   a) The inspection frequency listed in #3 must be maintained unless you have written approval from the Water Resources (City) ESC Inspector that states otherwise,
   b) Documentation associated with the site must be maintained but these may be kept at an alternate specified location via an amendment,
   c) The area of land that is to remain inactive is capable of passing RUSLE calculations, and
   d) Both the request to keep documents at an alternate location and the new RUSLE calculations must be submitted to The City ESC Reviewer responsible for approving the original Erosion and Sediment Control Report and/or Drawing(s)

The following stripping and grading notes are **mandatory for stripping and grading projects and must be cut and pasted directly onto relevant drawing(s)**:

Stripping and Grading Items:

Add the following additional notes if your application is for a Stripping and Grading Development Agreement or Permit

1) Where the developer transfers ownership of a piece of property it must be properly stabilized, from an ESC perspective.

2) Thirty days notification to the Manager of Urban Development is required to obtain a stockpile

extension for stripping and grading Development Permits or Development Agreements if you wish to extend the stockpile beyond the length of time noted in the permanent conditions.

3) All inlet protection must be removed at Final Acceptance Certificate. Any inlet protection that remains in place after this point must have a separate authorization, other than this report and drawing, under the *Drainage Bylaw*, or the responsible party will be subject to fines.

4) Inlet protection associated with phases on engineered drawings will be authorized on those circulations. Only socks and donuts associated with the initial stripping and grading phase will be authorized in this report and/or drawing.

ESC 02 – Present Conditions

1. Adjacent properties
   - e.g. streams, lakes, residential and commercial areas, reserves, parks and named roadways
2. If applicable, the location of any trees, shrubs, grass and unique vegetation both on and adjacent to the construction site
   - If not applicable, please note
3. Contours of existing areas
   - Contours of 0.5 metres or less
   - Ensure contours are legible if less than 0.5 m are provided
4. Slopes with slope lengths and LS values marked
   - e.g. 25m @ 6% = LS of 0.72
   - Include a direction arrow
   - Length of the arrow should correspond with the length of the slope
5. Present patterns for overland drainage and drainage divides
   - Include run-on and run-off locations
6. The location and dimensions of existing storm infrastructure onsite and for the surrounding area
   - e.g. catch basins, low impact development (LID) structures,storm pipes, drainage swales, trap-lows, stormwater ponds
7. The location of critical areas within and near the development
   - Adjacent critical areas may include, but are not limited to, areas that are environmentally sensitive (e.g. environmental reserves, waterbodies, natural areas), established residential areas, and/or recreational areas
   - On site critical areas may include, but are not limited to, areas where drainage could enter the site, areas with erodible soils, and steep slopes (with an LS value of 0.66 or greater).

ESC 03 – Intermediate / Final Conditions

1. Contours or final grades
   - Contours of 0.5 metres or less
   - Ensure contours are legible if less than 0.5 m are provided
2. Slopes with slope lengths marked
   - e.g. 25m @ 6% = LS of 0.72
   - Include a direction arrow
   - Length of the arrow should correspond with the length of the slope
3. Intermediate and/or final flow directions and drainage divides
   - Include run-on and run-off locations
4. For each stage of construction indicate on your drawing which controls will be in place and when they will be removed
5. The location and dimensions of existing and proposed permanent storm drain inlets, pipes, outlets and other permanent drainage facilities onsite and for the surrounding area
   - e.g. concrete and swales, waterways, trap-lows, stormwater ponds etc.
6. Show the location of the foot print of the construction project
   - e.g. building footprint, overpass, storm main
7. Long term stockpile staging areas (both on and off site)
   - If soil is being hauled off site provide a separate map showing the haul routes

ESC 04 – Cut and Fill

Include a cut and fill drawing where there are areas in the project with cut and/or fill of more than two metres depth

ESC 05 – Landscape / Permanent Stabilization

Submit a drawing providing details for implementation of landscaping and other practices required for permanent site stabilization

- e.g. erosion control blankets, turf reinforcement mats, seeding, sodding, retaining walls, riprap, and paving
- The landscaping/permanent site stabilization drawing should also identify any temporary measures required to be installed, inspected, and maintained in the period between project completion and final stabilization
- Identify the company/person responsible for inspection and maintenance during this period, as well as who is responsible for removal of any temporary controls such as silt fence and storm inlet controls

Note: A landscaping drawing is not required for stripping & grading under a Development Permit or Development Agreement; however, areas that will be permanently stabilized at the stripping & grading stage, including but not limited to Municipal Reserves, Municipal School Reserves and Environmental Reserves, should be addressed on the drawings).

ESC 06 – Phasing Plan
If the construction project in question will be done in phases please provide a phasing plan • If this the project will consist of one phase please provide a note to this regard in lieu of a phasing plan

The documents, including drawings, are to be signed and stamped by a professional with experience in the design and implementation of erosion and sediment control (i.e. CPESC, P.Eng, P.Ag.)

ESC REPORT AND DRAWINGS APPLICATION: APPENDIX A
RUSLE CALCULATIONS

Location (referenced on Drawings)	Construction Stage	Slope and Slope Length (worst case LS Value for area)	R – Value	K – Value	LS – Value	Description of Control Practices	C – Values	P – Values	A – Value Tonnes/ha*yr
Note: download a current, fillable electronic version of application template available at www.calgary.ca/wqs or by calling 403-268-2655									
e.g. Area 1	Stripping and grading	20% @ 50 metres	320	0.048	5.17	- Sediment pond at 250 cubic metres/ha - Mulch at 4.5 tonnes/ha	0.1	0.1	0.79

Note: For construction sites in Calgary the soil loss for sites that contribute to underground servicing is and/or surface improvements is **2 tonnes/ha*yr**. All sites that do not have access to underground servicing and/or surface improvements must meet **4 tonnes/ha*yr**.

ESC REPORT AND DRAWINGS APPLICATION: APPENDIX B
SEDIMENT TRAPS AND BASINS DATA

Location (referenced on Drawings)	Pond Identifier	Pond Volume in Cubic Metres	Area Pond Serves in Hectares	P – Value
Note: download a current, fillable electronic version of application template available at www.calgary.ca/wqs or by calling 403-268-2655				
e.g. Area 1	Pond A	500 cubic metres	1.5 ha	0.1

Note: The use of values less than 250 cubic metres per hectare is only acceptable if the entire site size is less than 4.0 ha.

ESC REPORT AND DRAWINGS APPLICATION: APPENDIX C

ESC PRODUCT/PRACTICE INFORMATION

Type of Control	Detailed Description of Control	Location (referenced on Drawings)	Description of Where used	Construction Stage When Used	Installation Method Include details on seed mix, application rates for products such as mulch and tackifier, blanket specifications etc.	Inspection Requirements	Maintenance and Removal Requirements
e.g. Temporary Erosion Control	Hydraulic Mulch at 4.5 tonnes/ha Tackifier at 10 kg/ha	Area 1	On all 3:1 slopes	As soon as underground installation is complete the area will be graded and track packed. This control will be installed as soon as Above Ground work commences.	Mulch & tackifier will be installed using a pneumatic blower truck at 4.5 tonnes/ha. The mulch will be blown onto the site from a minimum of two separate angles to prevent shadowing. Due to the slope the mulch will be anchored.	Ensure the landscape contractor is applying the rate of mulch & tackifier specified. Inspect the application for consistent coverage. Ensure there has been no over-spray of slurry to roads, sidewalks, watercourses, existing vegetation. Verify supplied materials and application meets site-specific specifications. Keep certification tags available for inspection. Ensure that the mulch is not preventing vegetation establishment. Except during freeze-up and until permanent vegetation cover is established, inspect a minimum of every seven days and after significant rainfall or snowmelt likely to cause erosion or damage to mulch.	Replace mulch carried away by wind or flowing water and ensure new application is crimped/tackified. Mulch & takifier may need to be reapplied after 6 months – 1 year for continued temporary erosion control. Areas where erosion is evident should be repaired as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs. Ensure that the integrity of the mulch is sufficient to provide the required period of temporary control.

APPENDIX D
INSPECTION SHEET

Project Name:	

Inspection Date:	**Weather (including past 48 hours):**
Project Location/ Address:	**Site Conditions:**
ESC Inspector:	**Developer:**
Other Attendees:	**Contractor:**

Inspection Checklist (Mark the appropriate boxes with a ✓ or a note)	**YES**	**NO**	**N/A**	**NOTES**
Are the approved and up to date ESC report, drawings & inspection sheets available on-site?				
Are appropriate measures in place to control overland run-on and run-off?				
Are all stockpiles adequately located and stabilized?				
Are construction exits properly stabilized and maintained?				
Does contractor have a valid drainage permit and are all permit conditions being adhered to?				
Are all entry points to the underground storm drainage system adequately protected (on-site and adjacent to site)?				
Are all perimeter controls properly installed and maintained to ensure sediment does not leave the site?				
In dry conditions, is dust adequately controlled on stockpiles and exposed areas?				
In areas where construction is complete, are permanent stabilization measures adequate?				
Have all temporary controls that are no longer needed been removed?				

Control	Location	Observation (effectiveness of the measure used) Include Deficiencies or Noted Concerns Deficiencies or Concerns Noted	Maintenance Requirements or Changes Required for the ESC Report and/or Drawings	When and What Repairs/Maintenance were done and by Whom	Optional Photo

3.5 ENSURING EFFECTIVE IMPLEMENTATION OF REPORTS/DRAWINGS

The following are some suggestions to make the process of erosion and sediment control planning and implementation more effective:

- The initial erosion and sediment control design should be completed at the pre-tendering (or early planning) stage of projects, where possible, and implementation must be integrated with all stages of construction planning and implementation, including the project design and tendering stage.
- Except for small, simple good housekeeping sites, it is important to retain a qualified, experienced consultant, with several years of experience in construction site erosion and sediment control.
- A **pre-construction site meeting** to discuss erosion and sediment control is an effective way to start ongoing communication between ESC designers, regulators, project managers, contractors, homebuilders, landscapers, and others. Some projects also benefit from weekly or bi-weekly environmental meetings (can be combined with the site safety meeting)

  Implementation, inspection and maintenance of ESC practices is often incomplete or overlooked, especially where the contractor is not familiar with the ESC report/drawings, or the prescribed practices cannot be well integrated with construction scheduling. The ESC Designer should be retained during construction to work with the contractor to address these challenges.

3.6 PLANNING AND IMPLEMENTATION RESPONSIBILITIES

3.6.1 Regulators (including City of Calgary)

- The responsibility of regulatory agencies is both to review projects to ensure activities will be compliant with legal requirements and to provide education, inspection and enforcement components that are fair and un-biased.
- The City of Calgary is responsible for reviewing erosion and sediment control reports and drawings in a consistent, timely and efficient manner, including updates and addendums submitted during construction projects. City ESC staff are responsible for clearly communicating submission and review requirements for erosion and sediment control reports and drawings to City Business Units and the private construction and development industry, as well as maintaining open communication with project proponents at all times.
- To ensure erosion and sediment control practices are being properly implemented, monitored and maintained, City ESC staff conduct inspections on private sites, City capital project sites and at other City and private utility operations. It is the responsibility of staff and City management to ensure inspections and enforcement are thorough and fair, with any enforcement for non-compliance following established compliance assurance principles.
- The City of Calgary recognizes that, even with the best standard of care, construction sites and operations may release some fine sediment to a storm sewer or receiving waters. Where inadvertent situations arise, it is the responsibility of City ESC staff to work with contractors and project managers in a fair and constructive manner.

3.6.2 Project Owner

- Although the owner (could be a private developer or a City of Calgary Business Unit) may contract out the responsibility for the erosion and sediment control report and drawings development to a specialist, and implementation to the contractor(s), **the owner is ultimately responsible for ensuring compliance with regulations**.

- The owner must adequately budget for erosion and sediment control report and drawings development and implementation. This will often require consulting closely with the erosion and sediment control designer to discuss project risks, costs and suitability of controls and the necessary level of effort required. To ensure the erosion and sediment control report and drawings are clearly understood, and recommendations properly implemented, it is usually wise to retain the services of the ESC designer during construction.
- The owner must be notified immediately of erosion and sediment control failures and off-site sediment releases.
- At the end of the project, the owner is responsible for ensuring the site is stabilized and for approving the timely removal of temporary erosion and sediment control practices.

3.6.3 Consulting Engineer

- In developing site plans, and assuming the erosion and sediment control designer is different than the consulting engineer, the owner or consulting engineer must communicate with the erosion and sediment control designer (this may include providing the erosion and sediment control designer with useful site data and project design information).
- The owner or engineering consultant must work with the erosion and sediment control designer to incorporate strategies such as construction site phasing and vegetated buffer strips into the project. Minimizing the length and steepness of final slopes and utilizing existing drainage ways are also project design considerations.
- When the consulting engineer is responsible for the erosion and sediment control design, they must update and submit revisions to the erosion and sediment control documents to The City and project owner.

3.6.4 Erosion and Sediment Control (ESC) Designer

- The ESC designer must be qualified and experienced. Except for simple projects that have a low potential for erosion, sedimentation or negative impacts, The City requires that erosion and sediment control report and drawings are prepared by (or overseen and signed and stamped) a P.Eng., P.Ag. (Agrologist) or CPESC (Certified Professional in Erosion and Sediment Control), with several years of experience in erosion and sediment control.
- During the development of the initial site erosion and sediment control report and/or drawings, the erosion and sediment control designer must visit the project site to conduct a thorough site evaluation and risk assessment. The erosion and sediment control designer must develop documents that meet regulatory requirements, can be integrated with project scheduling, and can be clearly understood and implemented by the contractor(s).
- The erosion and sediment control designer has the primary responsibility for the selection, placement and design of erosion and sediment control practices, subject to ongoing advice and feedback from the owner, engineering consultant, regulators, contractors and inspection staff.
- The erosion and sediment control designer must emphasize that the erosion and sediment control report and drawings is an initial ‘appraisal’ and will need to be frequently reviewed (and updated). The designer is responsible for submitting updates/revisions to The City and project owner. Field inspections and communication with contractors and project managers will be necessary to ensure the implementation of erosion and sediment control is continually reviewed.

3.6.5 Contractor

- The contractor is responsible for ensuring they understand the erosion and sediment control report and/or drawings, and their responsibility to prevent stormwater pollution during construction.
- Contractors can be a valuable source of advice and information through project planning and implementation phases. Frequent opportunities for contractor feedback should be provided by the project owner or manager.
- The contractor must implement the practices prescribed in the erosion and sediment control report and drawings (including approved updates), then inspect and maintain them.
- Where practices do not function as intended, the contractor must communicate observations to the project manager and/or erosion and sediment control designer.
- When the contractor has concerns with the erosion and sediment control practices selected or wishes to propose alternate measures, they must discuss concerns or suggestions with the project manager and/or the erosion and sediment control designer. The contractor must ensure any required updates have been made to the erosion and sediment control report and drawings and regulators and other relevant parties notified.
- Contractors must cooperate with site erosion and sediment control inspectors and regulators from government agencies. In the event of a non-compliance incident, including a spill or release, the general contractor is responsible for immediately notifying the project manager or owner. The general contractor and project manager/owner must work to ensure spills and releases are immediately reported to regulatory agencies (e.g. Fisheries and Oceans Canada, Alberta Environment, City of Calgary).
- Depending on contractual agreements, contractors may also be responsible for the removal of temporary erosion and sediment control practices once the contributing area is stabilized.

3.6.6 Site/Project Erosion and Sediment Control Inspector

- Site ESC inspectors must clearly understand the erosion and sediment control report and drawings and have experience in construction, inspection and maintenance of ESC practices. This knowledge and expertise will enable inspectors to recognize the effective application of controls and practices and to communicate concerns to the contractor.
- The site ESC inspector must understand the importance of documentation (photos, inspection and maintenance records, and addendums to the report/drawings) and follow documentation requirements.
- The site ESC inspector must be given the authority to direct work to mitigate or stop erosion, sedimentation or stormwater pollution. This should include the ability to quickly access equipment and supplies to implement contingency measures.

SECTION 4.0

STANDARD DEVELOPMENT PERMITS, DEVELOPMENT LIAISONS AND AIRPORT DEVELOPMENT: TECHNICAL REQUIREMENTS

4.0 TECHNICAL REQUIREMENTS FOR STANDARD DEVELOPMENT PERMITS, DEVELOPMENT LIAISONS AND AIRPORT DEVELOPMENT

4.1 OVERVIEW

A **Development Permit (DP)** is required for all construction sites having a land use designation above R2 development. Within the existing development permit review process, site erosion and sediment control requirements will be reviewed and applied as conditions of the development permit.

Capital construction projects on City-owned land (managed by City Business Units or civic partners) also follows a parallel process, either via a standard development permit process or a **development liaison (DL)**. Environmental and Safety Management requirements on City of Calgary capital construction projects are generally required to be addressed in an **Environmental Construction Operations Plan** (ECO Plan) prepared and submitted to The City of Calgary, Environmental and Safety Management Business Unit, for review. Both the ECO Plan and the erosion and sediment control (ESC) report/drawings are submitted to Environmental and Safety Management by the project manager prior to construction start-up. A joint ECO Plan/ESC pre-construction meeting is also a requirement for capital construction projects.

It is the responsibility of Project Managers to ensure that erosion and sediment control design requirements are addressed and reviewed prior to project start-up. **Except where erosion potential is low and measures will simply consist of good housekeeping practices, the development of the erosion and sediment control report and drawings should not be left to the contractor**. Erosion and sediment control reports and drawings must be developed, signed and stamped by a qualified professional (P.Eng., P.Ag., or CPESC), preferably at pre-tender stage.

The City also provides more limited review of erosion and sediment control for development applications within the Calgary Airport lands (known as **Airport Developments, AD**).

Erosion and sediment control report/drawings requirements for these types of projects is determined using the flowchart in Figure 3-1 (Section 3.0).

The flowchart in Figure 4-1 illustrates how applications for Development Permits, Development Liaisons and Airport Development are processed.

4.2 EROSION AND SEDIMENT CONTROL REVIEW

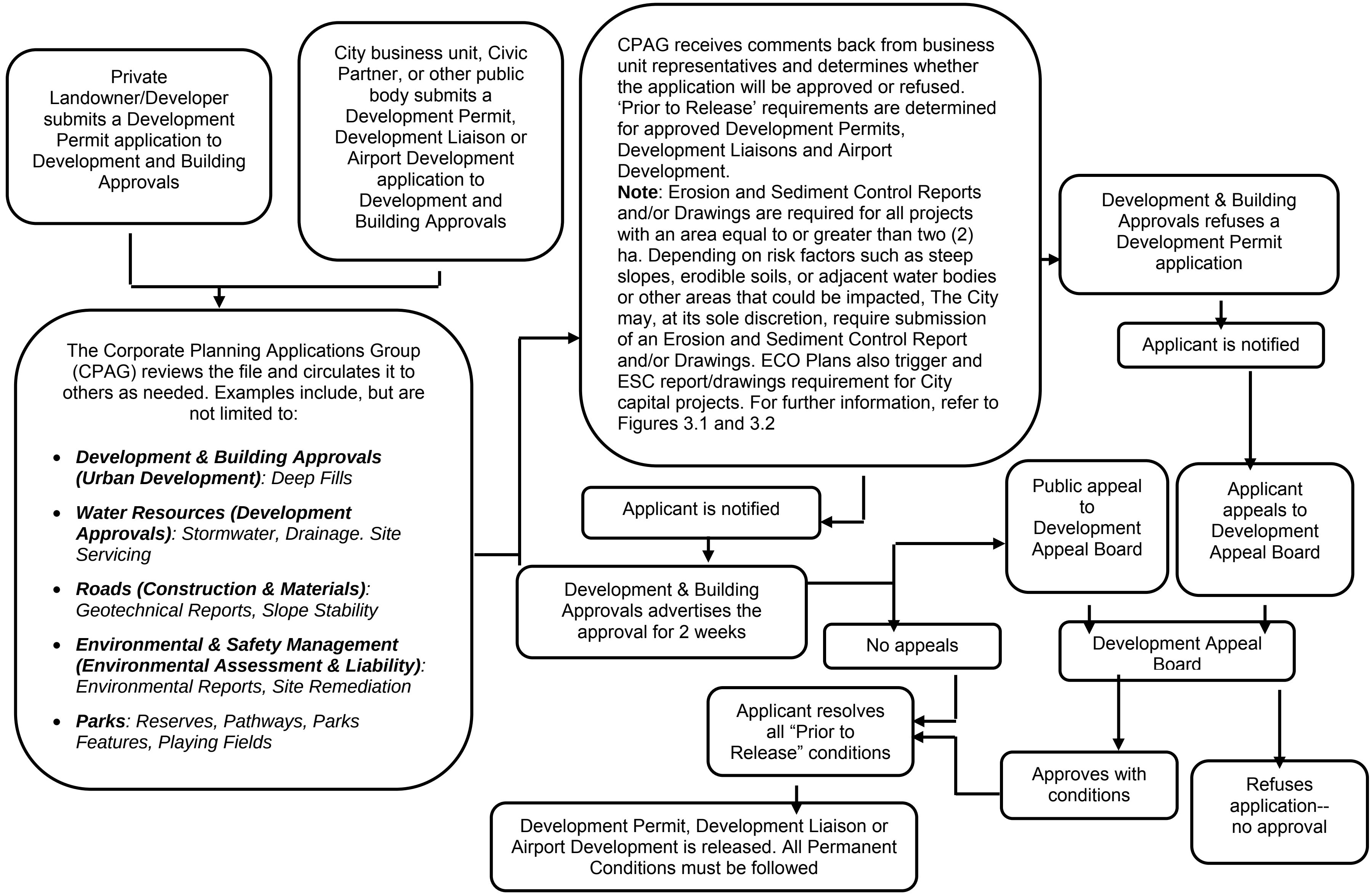
To obtain written permission under a Development Permit, Development Liaison or Airport Development, the following terms must be addressed:

1. In some cases, a prior to release condition requires the submission of an erosion and sediment control **report** and/or **drawings** to The City of Calgary for review. This requirement is a condition of all Development Permit (DP), Development Liaison (DL), and Airport Development (AD) applications for sites with an overall project area greater than or equal to 0.4 hectares in overall size. On-sites less than 2.0 ha in overall project area, only a drawing or drawings are typically required, but a report and drawings may be required if Water Resources deems the site to have moderate to high erosion potential and/or the site is adjacent to a sensitive area. Two (2) copies of documents are to be submitted.
2. **All sites where there is soil-disturbing activity, regardless of site size, must follow erosion and sediment control 'good housekeeping practices'** (including: protecting the site perimeter, protecting storm sewer inlets, controlling the tracking of mud off-site, stockpile management, and construction dewatering control).

3. An erosion and sediment control report is the written portion of the submission and it must include descriptions of pre-disturbance site conditions, details of the proposed construction project, construction phasing details, temporary and permanent erosion and sediment controls, etc. For more details, refer to the technical requirements for reports in the erosion and sediment control report and drawing template in Section 3.0.
4. A set of erosion and sediment control drawings must be submitted with the report. Drawings must include pre-construction and post-construction contours, major stockpile locations, erosion and sediment control construction details, locations of proposed erosion and sediment control practices, and a legend. For more details, refer to the technical requirements for reports in the erosion and sediment control report and drawing template in Section 3.0.
5. Once reviewed, the Applicant or Applicant's Representative shall be notified, in writing, if additional information is required or if there are no objections to the erosion and sediment control documents. The Corporate Planning Applications Group (CPAG) shall be copied on such communications. Where possible, the Applicant or Applicant's Representative should provide an e-mail address, fax number and contact name to speed up the communication process. Once there are no objections to the contents of the erosion and sediment control report and drawings, the CPAG Engineering Generalist will clear the erosion and sediment control Prior to Release (PTR) Condition. The Applicant will be required to meet permanent conditions (implement, inspect and maintain the erosion and sediment control practices described).
6. Where additional information is requested for the erosion and sediment control report and/or drawings, The City shall notify the applicant. Two (2) copies of the revised report and/or drawings shall be submitted to The City. Once the review of the documents is complete, The City will provide written notification that there are no objections, or that further information is requested.
7. Prior to construction start-up, The City will typically require a pre-construction site meeting be set up once preliminary erosion and sediment control practices are installed (to include the applicant, contractors, erosion and sediment control designer, and any other relevant parties).

The City would like to ensure that all soil-disturbing activities that have the potential to cause stormwater pollution or dust problems are proactively and adequately controlled. Education and site meetings are key success factors. If you have questions or concerns, contact the CPAG Urban Development representative for your file, or refer to Table 3-1 in Section 3.0 for additional contact information.

Figure 4-1: Processing of Applications for Development Permits, Development Liaisons and Airport Development



SECTION 5.0

STRIPPING, GRADING, AND SUBDIVISION DEVELOPMENT: TECHNICAL REQUIREMENTS

5.0 TECHNICAL REQUIREMENTS FOR STRIPPING AND GRADING PERMITS AND SUBDIVISION DEVELOPMENT

5.1 STRIPPING AND GRADING UNDER A DEVELOPMENT PERMIT

Land is not permitted to be stripped or graded without a Development Permit or a Subdivision Development Agreement. This includes any form of land disturbing activities, and can include road grading.

A **Developer** is defined as any party undertaking stripping and grading, or any form of land disturbing activity. This can include, but is not limited to, developers, landowners, contractors, consultants, and other City departments. The City is defined as the City of Calgary.

5.1.1 General Process

The process for submission and review of erosion and sediment control (ESC) reports and drawings is the same as that outlined in Section 4.2. Refer to Figures 5-1 and 5-2 for an overview of the overall application process.

Figure 5-1: Processing Stripping & Grading Permits through the Urban Development Division (Development & Building Approvals business unit)
Stripping & Grading Under a Development Permit

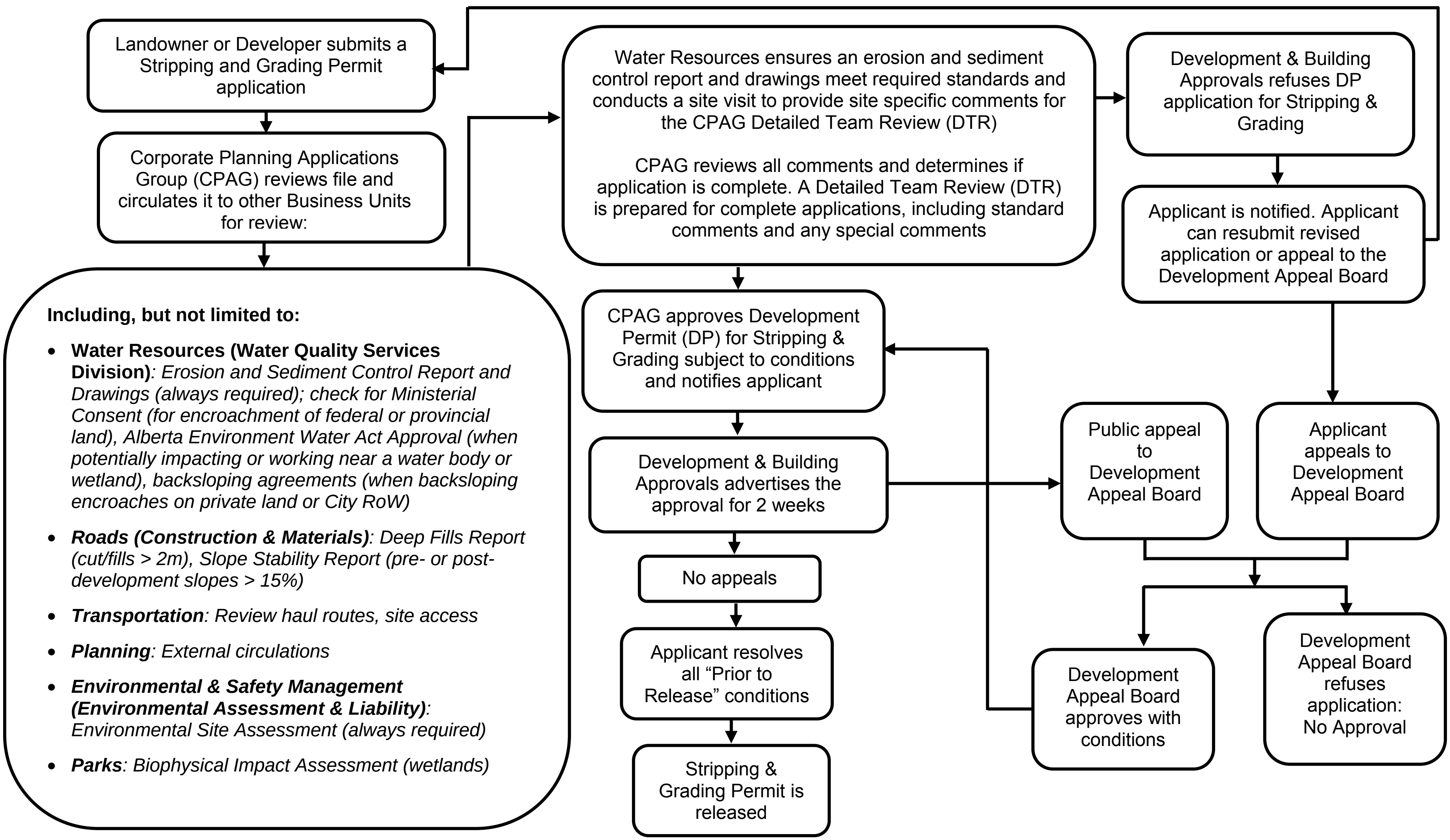
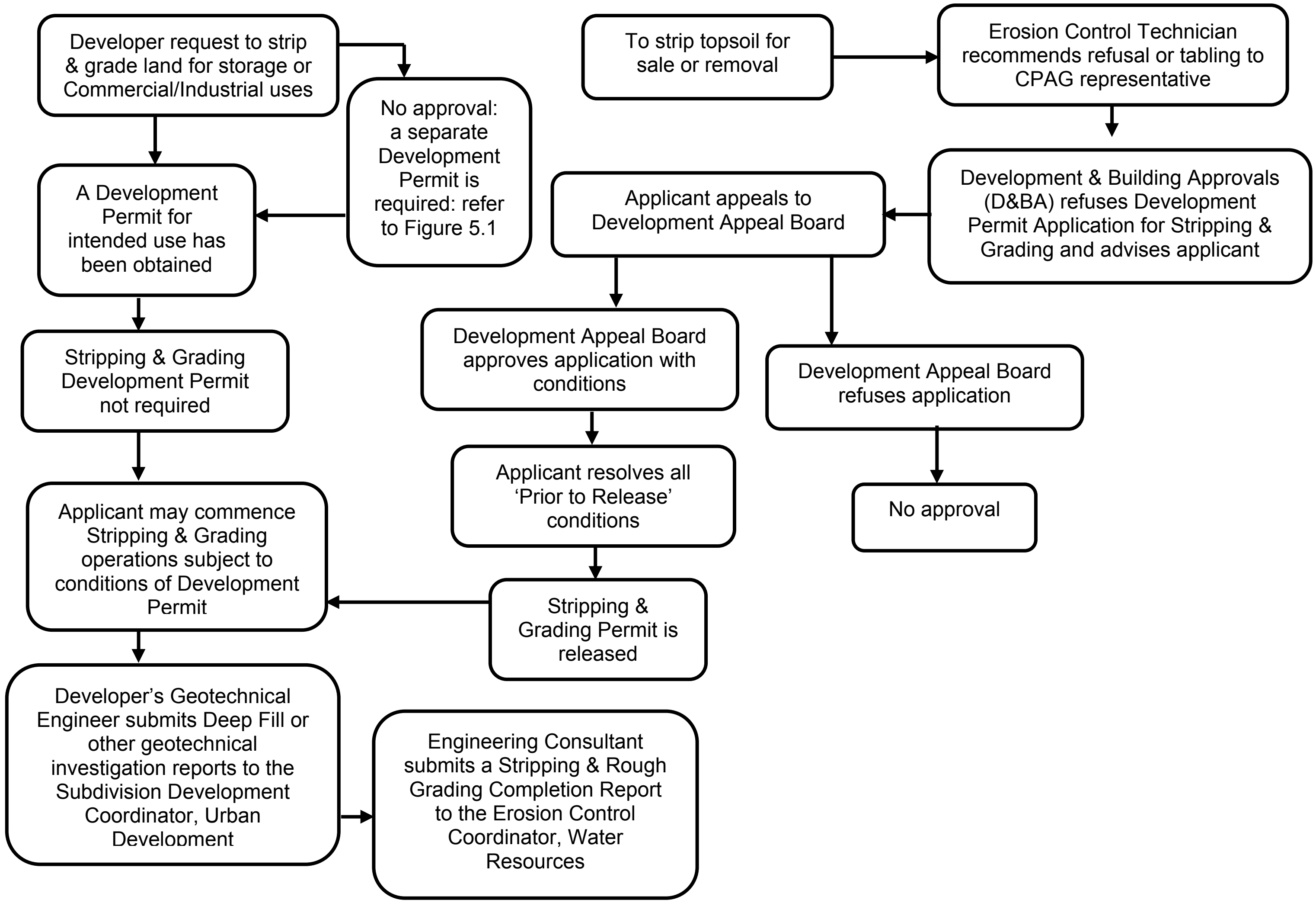


Figure 5-2: Processing Stripping & Grading Permits Through the Urban Development Division (Development & Building Approvals business unit)

For Purposes Other than Subdivision Development



5.1.2 Letter Of Credit for Stripping and Grading Permits

Developers are required to submit a $150,000 Letter of Credit to the Urban Development Division (Development & Building Approvals) prior to commencement of stripping and grading under a development permit. The Letter of Credit provides a performance security to The City in the event the developer fails to prevent or repair damage to infrastructure or adjacent areas, including damage caused by uncontrolled erosion and sedimentation or failure or erosion and sediment control practices. Performance security requirements are different for stripping and grading under a Development Agreement (refer to a current copy of the Residential, Commercial or Industrial Master Development Agreement for further details).

5.1.3 Insurance Requirements for Stripping and Grading Permits

(1) The Applicant, at his/her own expense, shall provide and maintain in full force and effect with insurers allowed by the laws of the Province of Alberta to issue insurance policies in Alberta and in form and content satisfactory to the City Solicitor and General Counsel the following insurance policies:

(a) Commercial general liability insurance policy for bodily injury (including death) and property damage in an amount of not less that two million dollars ($2,000,000.00) inclusive limit for any one occurrence and shall include:

- i) The City as an Additional Named Insured (if a third party is providing the insurance then the Applicant must also be shown as an Additional Named Insured);
- ii) a cross liability clause;
- iii) products and completed operations coverage;
- iv) a broad form of a contractual liability clause;
- v) non-owned automobile liability extension and;
- vi) an operation of attached machinery clause; and

(b) An automobile third party liability insurance policy (owner's form) for bodily injury (including death) and property damage in an amount of not less than two million dollars ($2,000,000.00) inclusive limit covering all vehicles used in the performance of this Agreement and such insurance shall include the passenger liability extension.

(2) The insurance policies mentioned in item (1) above shall include provision for The City to be given thirty (30) days written notice prior to cancellation or material change of said policies of insurance. The Applicant shall immediately advise The City should said policies of insurance lapse or otherwise be discontinued.

(3) The Applicant shall provide a Certificate of Insurance indicating compliance with item (1) and item (2) above to The City and at the request of The City shall furnish documentary evidence satisfactory to The City Solicitor and General Counsel of the renewal or continuance of such insurance.

(4) Notwithstanding, item (3) above, The City shall have the right to demand at any time and the Applicant shall be obligated to provide proof of insurance when so requested by The City and in a form satisfactory to The City Solicitor and General Counsel.

(5) In the event of the Applicant failing to provide The City any of the documents mentioned in item (3) above, or otherwise failing to prove to The City the existence of any required insurance, The City may, at its option, purchase on behalf and at the expense of the Applicant the required insurance coverage.

5.1.4 Indemnity Letter for Stripping and Grading Permits

An indemnification letter is a legal document between The City of Calgary and a developer or contractor whereby the developer or contractor assures that no legal action of any kind will be imposed on The City of Calgary as a result of the actions or activities of the developer or contractor. Use the following indemnification letter template for erosion and sediment control:

(To be sent to the Subdivision Development Coordinator, City of Calgary, Development and Building Approvals, Urban Development Division, Mail Code 8032)

DATE

The City of Calgary
Urban Development (8032)
Development & Building Approvals
Planning, Development & Assessment
PO Box 2100, Stn M
Calgary, AB T2P 2M5

Attention: Manager, Urban Development

Re: Letter of Indemnification
Stripping and Rough Grading
Development Permit #_____________

Dear Sir:

(DEVELOPER'S NAME) hereby indemnifies and saves harmless The City of Calgary and owners of adjacent properties or such other affected parties from any losses or damages which The City and owners of adjacent properties or such other affected parties may sustain as a result of the stormwater run-off, soil erosion, soil instability, sedimentation, loam stock pile, dust and any other problem that may arise from the stripping and rough grading of the Lands. In addition, *(DEVELOPER'S NAME)*, at its sole expense, shall take corrective action(s) deemed necessary to rectify the problem(s) and do so in a timely manner to the satisfaction of the Manager of Urban Development.

SIGN AND SEAL

5.2 STRIPPING AND GRADING UNDER A DEVELOPMENT AGREEMENT

5.2.1 General Process

The process for submission and review of erosion and sediment control (ESC) reports and drawings is the same as that outlined in Section 4.2. Refer to Figures 5-1 and 5-2 for an overview of the overall application process.

5.2.2 Letter Of Credit for Stripping and Grading Under a Development Agreement

The Letter of Credit requirements for Stripping and Grading under a Development Agreement are not the same as Stripping and Grading under a Development Permit. Refer to a current edition of the Master Development Agreement (Residential, Commercial or Industrial, depending on the type of development).

5.2.3 Insurance Requirements for Stripping and Grading Under a Development Agreement

Insurance requirements are based on the conditions outlined in the current Development Agreement

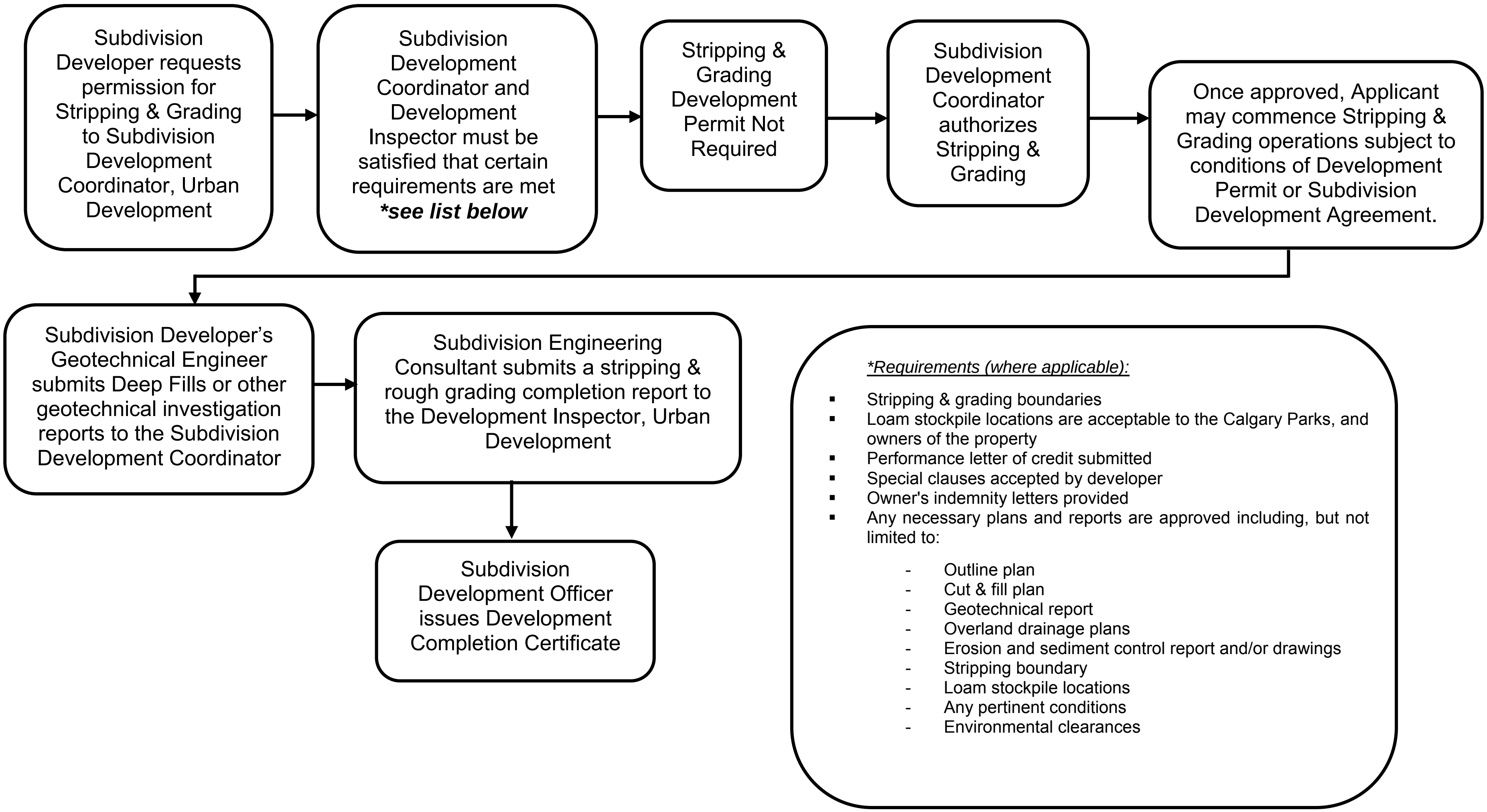
5.2.4 Indemnity Letter for Stripping and Grading Under a Development Agreement

Indemnity Letter requirements are the same as for Stripping and Grading under a Development Permit (refer to Section 5.1.4).

Figure 5-3: Processing Stripping & Grading Permits Through the Urban Development Division

(Development & Building Approvals business unit)

Stripping & Grading Under a Subdivision Development Agreement



SECTION 6.0

SITE ASSESSMENT AND EROSION POTENTIAL EVALUATION

6.0 SITE ASSESSMENT AND EROSION POTENTIAL EVALUATION

6.1 PLANNING OBJECTIVES

The objective of erosion and sediment control is to prevent pollution by limiting the amount and rate of erosion occurring on disturbed sites and by capturing eroded soil before it leaves the construction site. The best strategy for managing erosion and sediment is to direct efforts towards prevention/minimization of the problem. Prevent sediment from negatively impacting health and safety, storm infrastructure, other property and the environment by maximizing efforts to control it **at the source**.

Source controls reduce the opportunity for wind and water to detach, entrain and transport soil particles. Effective water management (diverting clean run-off away from exposed areas), controlling the amount of soil exposed at any one time, and rapid stabilization of exposed soils are all strategies for reducing the quantity of sediment generated during construction. In addition, it may be possible to time critical phases of the construction project to fall outside peak rainfall or snowmelt periods.

As 100% management of water and 0% erosion during construction are impractical objectives, it is generally necessary to plan and implement measures to retain or detain sediment-laden water (as close to the source as possible) on-site, providing a means to settle and/or filter sediment out of suspension.

> Note: Fine sediment is difficult and expensive to settle or filter. Sediment controls often fail when the need for sediment control is highest (during heavy run-off or windy conditions). Without properly planned and implemented source controls, sediment controls frequently fail, resulting in damage, costly clean-up and potential fines.

Equally important for effective erosion and sediment control is the need for **regular inspection and maintenance**.

The construction phase of a project or development is usually considered a temporary condition, which will normally be replaced by permanent structures and facilities. However, the construction work may take place over an extended period of time. Management practices and controls should be of sufficient size, strength and durability to outlast the expected construction schedule until the site is permanently stabilized.

6.1.1 Elements of Effective Erosion and Sediment Control Planning

Ten Key Elements of Effective Erosion and Sediment Control Planning

1. **Minimize needless clearing and grading**
2. **Protect waterways and stabilize drainage ways**
3. **Phase construction to limit soil exposure**
4. **Stabilize exposed soils immediately**
5. **Protect steep slopes and cuts**
6. **Install perimeter controls to filter/settle sediment**
7. **Employ advanced sediment settling controls**
8. **Ensure contractors understand the site ESC report and/or drawings and good housekeeping practices and are familiar with the implementation, inspection and maintenance of the required ESC practices**

9. Continually inspect and maintain ESC practices and update the ESC report and/or drawings during construction

10. Assess ESC practices during and after storms

6.2 RISK ASSESSMENT

Construction site erosion and sedimentation (on-site and/or off-site) can result in several potential consequences, including:

- Environmental Damage (introduction of sediment into the aquatic environment)
- Property/infrastructure damage (damage to public/private property and storm sewer infrastructure)
- Project consequences (there is a need to respond to damage, resulting in unforeseen labour and material costs and possible project delays)
- Legal consequences: Due to deposition of sediment onto streets, into storm sewers and into water bodies (fines, stop work orders, clean-up costs, lawsuits)

Assessing potential damages and consequences resulting from uncontrolled erosion and/or sedimentation is essential to assessing the degree to which ESC practices will need to be integrated into the development planning. Addressing risks during the planning stage also demonstrates that reasonable care was taken during project planning to address issues.

6.3 SOIL EROSION POTENTIAL

Site erosion potential is a measure of the erosion potential of exposed soils, where consideration is given to:

- Slope gradients
- Length of exposed slopes
- Soil erodibility (based on soil texture, structure and permeability)

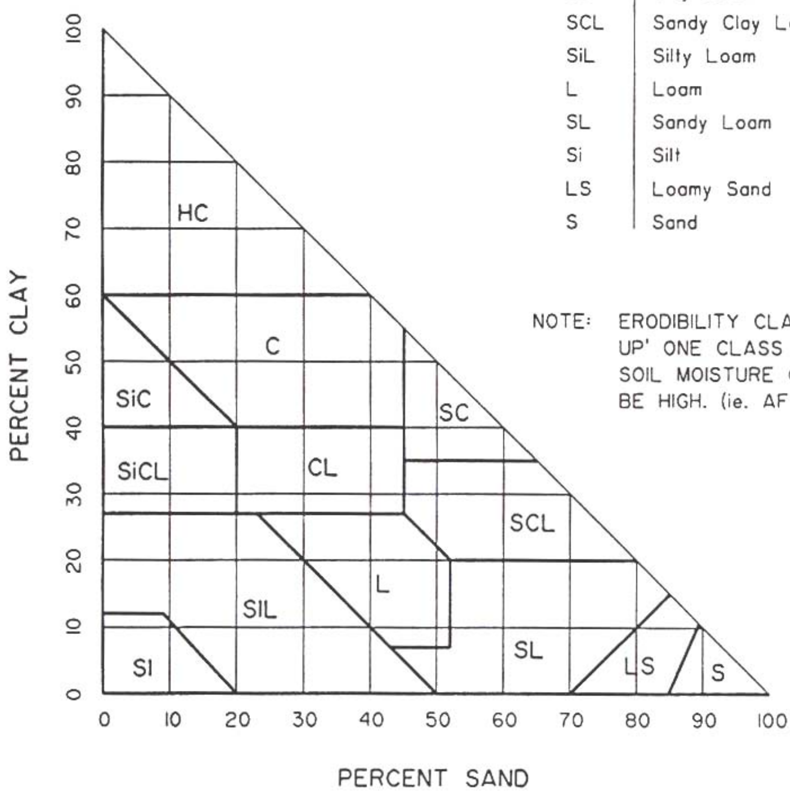
Construction activities can drastically alter site erosion potential by causing changes in soil cover, soil type, slope length and steepness. As part of the site evaluation, the ESC designer must review the following:

- **Soil Information**: Soil erodibility (RUSLE K-Factor) is affected by several variables such as soil texture (grain size distribution), organic matter, structure, permeability, and soil chemistry
- **Topographical and Drainage Information**: Including slope length and gradient (RUSLE LS-Factor), drainage areas, existing drainage patterns, flowing water and slope stability
- **Climatic Information**: Consider likely climatic conditions that will occur during the construction project (intense summer storms, winter shutdown requirements, freeze-thaw conditions, etc.). In addition to long-term local climatic data, day to day activities must consider local forecast information. ESC measures must be properly designed and implemented based on design storm durations and intensities
- **Soil Cover or Stabilization**: Such as vegetation, mulching, paving, and rock armour, as well as roughening (RUSLE C-factor and P-factor)

- **Property and Infrastructure**: Consider the consequences of erosion, sedimentation and dust impacting adjacent property and infrastructure
- **Downstream Sensitivity**: Sensitivity of downstream water resources and environmentally sensitive areas (natural areas, wetlands, etc.)

KEY	SOIL TYPE	SOIL ERODIBILITY (K)
HC	Heavy Clay	Low
C	Clay	Low
SiC	Silt Clay	Medium
SC	Sandy Clay	Low
SiCL	Silty Clay Loam	Medium
CL	Clay Loam	Medium
SCL	Sandy Clay Loam	Medium
SiL	Silty Loam	High
L	Loam	High
SL	Sandy Loam	Medium
Si	Silt	High
LS	Loamy Sand	Low
S	Sand	Low

NOTE: ERODIBILITY CLASSIFICATIONS (K) SHOULD BE 'BUMPED UP' ONE CLASS IN SITUATIONS WHERE THE INITIAL SOIL MOISTURE CONTENT OF THE SITE IS LIKELY TO BE HIGH. (ie. AFTER SNOW MELT)



SOIL TEXTURE CLASSES. PERCENTAGES OF CLAY AND SAND IN THE MAIN. TEXTURAL CLASSES OF SOIL: THE REMAINDER OF EACH CLASS IS SILT.

SOIL TEXTURE NOMOGRAPH

Figure 6-1: Soil Erodibility Estimates Based on the Soil Texture Triangle

6.4 ASSESSING SOIL ERODIBILITY

6.4.1 Soil Texture

Erosion assessment must begin with a review of the types of soils that will be disturbed during construction, as well as soil materials that may be brought onto the site as fill. Although estimates of soil texture, structure and permeability can be made from geotechnical reports, The City of Calgary requires that all project sites with an overall size ≥ 2.0 ha provide quantitative information on soil texture, obtained from soil sampling and laboratory particle size distribution data (texture). Figure 6-1 illustrates a process for roughly estimating soil texture and erodibility based on quantitative data for percent sand, silt and clay. The number of samples needed to get a rough soil texture assessment of the site is at the discretion of the geotechnical engineer and/or consulting engineer, but the sampling methodology should provide a reasonable texture assessment of the soils that will be exposed during construction for areas where source control practices will be required to control erosion and sedimentation.

6.4.2 Topographical Assessment

The topography of the construction site, including lengths and gradients of slopes (RUSLE LS-factor) must be documented, both for pre-development and post-development conditions. Table 6-1 provides a qualitative, rough illustration of erosion potential estimate based on soil texture, slope length and slope gradient for a “base case” (assumes disturbed cover and no application of ESC practices). This table can be used for small, short term projects to make a rough estimate of erosion based on these three variables. However, this approach does not take precipitation into account, nor does it consider the benefit of ESC practices. Therefore, all sites ≥ 2.0 ha of overall project are required to take a more quantitative approach using the Revised Universal Soil Loss Equation for Application in Canada (RUSLE-FAC).

Table 6-1: Erosion Potential Based on Soil Erodibility Rating, Slope Length and Slope Gradient

Slope Gradient	Soil Erodibility	Slope Length	
		< 70 m	> 70 m
0 – 10%	Low	Low	Low
	Medium	Low	Moderate
	High	Moderate	High
10 – 20%	Low	Low	Moderate
	Medium	Moderate	High
	High	High	High
> 20%	Low	Moderate	Moderate
	Medium	High	High
	High	High	High

6.4.3 Revised Universal Soil Loss Equation for Application In Canada (RUSLE-FAC)

Note: A hypothetical example of a RUSLE-FAC calculation is provided in Appendix C.

RUSLE-FAC (developed from the Revised Universal Soil Loss Equation) is a mathematical equation representing the variables that influence erosion and sedimentation, including structural and non-structural best practices that can be implemented to control erosion and sedimentation on construction sites. RUSLE-FAC was developed by Agriculture and Agri-food Canada, including the development of a handbook which was published in 2002.

More details can be found in the RUSLE-FAC handbook, available through the Agriculture and Agri-Food Canada Web Page: www.agr.gc.ca

The RUSLE equation was derived from a theory of erosion processes, more than 10,000 plot-years of data from natural rainfall plots, and numerous rainfall-simulation plots.

Note: RUSLE-FAC can be used as a tool to estimate the rate of **soil loss**, based on site-specific environmental conditions and then to select and design sediment and erosion control systems for these conditions. RUSLE-FAC does not determine when soil loss is excessive at a site or when erosion-control systems have failed. The erosion and sediment control designer user makes these decisions based upon numerous criteria, of which soil-loss and sediment-yield estimates are only one important component.

Users of RUSLE-FAC should exercise caution, understanding that RUSLE-FAC calculations are only as accurate as the accuracy of the input data. Also RUSLE-FAC is based on average storm erosivity values and not individual short, high intensity rainfalls which often occur in Calgary during late spring and summer months. Additional effort should be made to minimize exposure of soils to erosion and to control run-on and run-off, quickly stabilize exposed soils and contain sediment when high intensity, high erosivity precipitation is likely.

Limitations for RUSLE include:

(1) RUSLE provides soil loss estimates rather than absolute soil-loss data.

(2) Soil-loss estimates are long-term average rates rather than precipitation event-specific estimates.

(3) There are hill slope-length and gradient limits for which the component RUSLE equations have been verified.

(4) RUSLE does not produce watershed-scale sediment yields and it is inappropriate to input average watershed values for the computation of the RUSLE factors.

(5) RUSLE is limited to estimation of erosion and sediment yields due to sheet and rill erosion. RUSLE cannot be used to estimate erosion and sediment yields caused by gully or channel erosion.

RUSLE Equation

$$A = R * K * LS * C * P$$

A: Annual soil loss due to erosion (tonnes/(hectare/year))

R: Erosivity index at a specific climatic location (320 for Calgary)

K: Index for soil erodibility based on a specific soil's susceptibility to erosion

L: Topographic factor specific to length of the overland flow path

S: Topographic factor specific to steepness/slope of the overland flow path length

C: Cover and management factor

P: Support practices factor

6.4.3.1 A-Value

For construction sites in Calgary, the following soil loss tolerances must be achieved using suitable erosion and sediment control practices applied within the site. Additional sediment controls are also required at the perimeter of sites (which includes storm drain inlets) as a final line of defence.

A = 4 tonnes/hectare/year for stripped and graded sites without underground servicing and/or surface improvements

A = 2 tonnes/hectare/year for any construction activity with run-off contributing to underground servicing and/or surface improvements

6.4.3.2 R-value

The R-Factor is derived from probability statistics resulting from analyzing rainfall records of individual storms. Rainfall produces the erosive agents of raindrop impact and overland flow. How much it rains (rainfall amount) and how hard it rains (rainfall intensity) are the two main characteristics of rainfall that determine its erosivity. Rainfall erosivity varies by location; therefore, the R-value describes erosivity at a location. The Erosivity Index (EI) for a single storm event is the product of a storm's energy (related to storm amount and intensity) and maximum 30-minute intensity. The R-value is an average annual sum of EI_{30} for long term rainfall data. The point values of R are plotted on maps known as "isoerodent" maps.

Calgary construction sites should use ***320*** as an annual R-Factor.

6.4.3.3 K-value

Soil susceptibility to erosion is the opposite of resistance of erosion. This susceptibility is known as soil erodibility, and the index for erodibility is known as the K-value. This value is affected by variables such as soil texture and structure, organic matter content, permeability and season of the year.

A geotechnical report should be available for the site soils to be exposed, indicating the soil texture (from laboratory analysis) for each of the soils. In addition, more accurate K-values can be determined with information on soil structure and permeability, as determined during the field geotechnical investigation.

The single most important variable affecting soil erodibility is soil texture. Soil texture refers to the distribution of sand, silt and clay particles in the soil. For example, silt loam is a soil textural class that has about 20% sand, 65% silt and 15% clay.

- Fine-textured soils that are high in clay have low K-values (about 0.05 to 0.15) because the particles are resistant to detachment
- Coarse-textured soils, such as sandy soils, also have low K-values (about 0.05 to 0.2) because of high infiltration (resulting in low run-off), even though these particles are easily detached
- Medium-textured soils, such as a silt loam, have moderate K-values (about 0.25 to 0.45) because they are moderately susceptible to particle detachment and they produce run-off at moderate rates
- Soils having a high silt content are especially susceptible to erosion and have high K-values which can exceed 0.45 and can be as large as 0.65. Silt-size particles are easily detached and tend to promote surface crusting, reducing infiltration and increasing run-off
- Organic material in the soil reduces erodibility because it produces compounds that bind particles together, increasing aggregation and reducing the susceptibility of the particles to detachment by

raindrop impact and surface run-off. Organic matter also improves soil biological activity and increases infiltration rates, reducing run-off and erosion potential

Seasonal Variability

Soil erodibility varies during the year. In many areas where freeze-thaw conditions persist, erodibility tends to be high early in the spring, during and immediately following thawing, and during periods when moisture is above average for the soil.

6.4.3.4 LS-value

The effect of topography on erosion is accounted for by the LS-value, which combines the effects of steepness of the overland flow path, length of the path and profile shape of the flow path (i.e. how steepness varies along the path).
Generally speaking, as hill-slope length and/or hill-slope gradient increase, soil loss increases. As hill-slope length increases, total soil loss and soil loss per unit area increase due to the progressive accumulation of run-off in the down-slope direction. As the hill-slope gradient increases, the velocity and erosivity of run-off increases.

Note: If more than a single slope of overland flow path exists on a site that requires analysis for soil loss, then each flow path must be analyzed separately, or the worst case LS value applied (i.e. the highest LS value).

Interaction of Hill-Slope Length and Gradient

The hill-slope length (L) and gradient (S) terms are combined into a single topographic factor (LS), representing the ratio of soil loss from a given hill-slope length and gradient to soil loss from the unit plot (72.6 feet in length and 9 percent gradient). Therefore, LS-values are not absolute and are based on a value of “1” for unit plot conditions.

6.4.3.5 C-value

The C-value is one of the most important terms in RUSLE-FAC and represents a combined effect of surface cover (plants), roughness, soil biomass and non-structural management practices implemented to reduce erosion.

As with other RUSLE factors, the C-value is a ratio comparing the existing surface conditions at the site to the standard conditions of a unit plot.

The C-value is affected by:

- Canopy (leaves and branches of vegetation, which intercepts raindrops and dissipates erosive force)
- Surface covers (vegetative residue and live vegetation on the soil surface)
- Soil biomass (all vegetative matter within the soil; residue helps to improve the flow of water into the soil and the soil water-holding capacity)
- Tillage or roughening practices

C-values are important during and immediately following construction, because the topsoil is often stripped and stockpiled, causing a decrease in the incorporated biomass. Soil disturbance makes the soil more erodible because the soil is less consolidated and stable aggregates are broken up. Increasing surface roughness slows run-off, increases infiltration and traps sediment transported by overland flow. Therefore, maintaining or creating roughness can be an effective method of reducing soil erosion. Vegetation cover on long-term topsoil stockpiles helps maintain the biological integrity of the topsoil, which will help provide an improved erosion control and growing medium when the topsoil is replaced during final site stabilization.

6.4.3.6 P-value

Note: The P-value may well be the least accurate and most subject to error of all the factors in RUSLE-FAC, because of a deficient database compared to that for other factors in the equation (especially in Canada). Therefore, it is highly recommended that these values be estimated conservatively.

By definition, the support practice factor (P) in RUSLE-FAC is the ratio of soil loss with a specific support practice to the corresponding loss for slopes freshly tilled up and down the slope.

Supporting mechanical practices include tillage (furrowing, soil replacement, seeding, etc.), strips of close-growing vegetation, deep ripping, terraces, diversions, and other soil-management practices orientated on or near the contour that result in the collection and storage of moisture and reduction of run-off. In addition, many structures such as gravel filters, silt fences, continuous berms and bench terraces are used on construction sites to control or minimize sediment transport.

6.5 LEVELS OF EFFORT REQUIRED FOR EROSION & SEDIMENT CONTROL

In determining the appropriate levels of effort that are required to control erosion and sediment for various stages of construction, it is recommended that quantitative estimates of erosion potential (using defensible, quantitative input data) are combined with consideration of potential negative impacts that could be caused by erosion and sedimentation.

Again, consider the four types of consequences listed at the start of this section:

- Environmental Damage (negative impacts to water quality, fish habitat, etc.)
- Property and Infrastructure Damage (to public and private property and storm infrastructure)
- Increased Project Costs (due to construction delays, clean-up costs, etc.)
- Legal Consequences (fines, lawsuits, possible prison sentences)

These consequences form the basis of erosion and sedimentation risk assessment: Each of them must be considered at the project planning stage. Table 6-2 describes the typical levels of ESC effort that would be required based quantitative erosion potential risk (using RUSLE-FAC).

Table 6-2: Typical Required Levels of Erosion & Sediment Control Based on Risk Assessment

Source: Transportation Association of Canada. National Guide to Erosion & sediment control on Roadway Projects. 2005 (modified from The City of Calgary Erosion & Sediment Control Guidelines, 2001)

Erosion Potential (Disturbed Condition; No Controls)	Consequences of Erosion and/or Sedimentation	Level of Erosion & sediment control					
		Good Housekeeping Practices	Structural Practices to Control Erosion & Sedimentation	Water Management Practices	Staging Construction & Progressive Site Rehab.	Intensive Sediment Control Practices (i.e. sediment basins)	Water Quality Monitoring (Receiving Water Bodies: Turbidity & TSS)
Low	Low	Required	-	-	-	-	-
	High	Required	Required	-	-	-	-
Moderate	Low[a]	Required	-	-	-	-	-
	High	Required	Required	Recommend[b]	Recommend[b]	Recommend[b]	Recommend[b]
High	Low[a]	Required	Required	Required	Required	Required	Recommend
	High	Required	Required	Required	Required	Required	Required[c]

Table Notes:

As a minimum, good housekeeping practices (i.e. controlling mud tracking and dust, protecting adjacent storm sewer inlets) must be planned and implemented for all soil disturbing activities that have the potential to cause negative impacts due to erosion and sedimentation. Common sense should be used by the ESC designer, site owner/manager and regulators in reviewing the levels of controls required:

[a] For projects assessed with a low risk of consequences (such as those away from storm infrastructure, developed areas, water bodies and environmentally sensitive areas, it may be acceptable to simply implement good housekeeping practices and basic construction phasing.

[b] Recommended levels of ESC must be implemented, where practical, depending on the extent, length and timing of the project (i.e. a small, short-duration project constructed over the winter may not need to implement some of the levels of control that may be required for construction in late spring. Although a smaller site may contain soils of high erosion potential, staging construction and rehabilitating the site as the project proceeds may be largely impractical). For example, a small, short-duration may not require staged construction and progressive rehabilitation. Recommended actions may be necessary to demonstrate due diligence in the event of the release of sediment due to an extreme run-off event.

[c] Water quality monitoring provides a quantitative measurement and record of the effectiveness of controls. Work adjacent to or in water bodies must include water quality monitoring (which generally means frequent turbidity readings, observations and possible sampling for total suspended solids (TSS) measurement). Drainage and Dewatering Permits (City of Calgary) and other permits/licenses may also have conditions requiring frequent discharge and downstream water quality monitoring.

SECTION 7.0

EROSION AND SEDIMENT CONTROL PRACTICES

7.0 EROSION AND SEDIMENT CONTROL PRACTICES

Note: Specific and detailed BMP information is located in Appendix A of this document.

7.1 OVERVIEW

Once a site evaluation has been carried out to determine the combined effect of erodibility of the site and sensitivity to sedimentation, then appropriate erosion and sediment control practices can be determined.

On all urban construction sites, from small individual building sites to large subdivisions, contractors must implement, inspect and maintain the minimum set of practices in order to achieve sufficient erosion and sediment control for the specific site.

The project designer (or appointed designate) should be aware that the review of any erosion and sediment control strategy must examine the suitability of proposed control measures according to site conditions and the degree of control required as a result of the evaluation process. All areas of a site, even those rated as having low erosion potential, will require some “minimum” measure(s) unless the disturbed areas drain to an on-site depression with adequate storage capacity and an overflow outlet. Appropriate signage, warning of the hazards of the site, is required for all large sites that contain erosion and sediment control practices. Fencing may also be required.

Along with reviewing site information to assess the project site and construction activities, the ESC designer’s role is to select and design appropriate mitigation measures known as Best Management Practices (BMPs).

Note: Source control (i.e., controlling run-on/run-off and stabilizing exposed soils as soon as possible) must be the primary goal of effective ESC. It is much easier and more economical to control erosion at the source than to try to control fine sediment once it is mobilized.

This section provides an overview of BMPs that can be applied to project design, construction procedures, site water management, erosion control and sediment control. Although the primary responsibility for the proper selection and design of BMPs is that of the ESC designer, effective plan development requires the experience and input of other members of the construction team (owner, engineering consultant, contractor, site inspector, regulators, etc.).

7.2 BEST MANAGEMENT PRACTICES

A best management practice (BMP) is a practice implemented to reduce erosion and prevent and/or reduce off-site releases of sediment onto adjacent property or into stormwater infrastructure or water bodies. For erosion and sediment control, there are five general categories:

1) **Project Planning and Design**
2) **Procedural (Good Housekeeping Practices)**
3) **Water management (Run-on and Run-off Control, Site Dewatering)**
4) **Soil Stabilization Practices**
5) **Sediment Control Practices**

The following information provides an overview of the five general BMP categories:

7.2.1 Project Planning and Design

Avoiding sensitive areas such as steep slopes or highly erodible soils (where feasible) can substantially reduce erosion risk and the associated mitigation costs. Most importantly, developments must be planned to fit the site, instead of trying to alter the site to fit the development. Using this philosophy, the risk of uncontrolled erosion and sedimentation can be reduced significantly.

7.2.2 Procedural (Good Housekeeping Practices)

Procedural practices are commonly referred to as 'good housekeeping practices'. All projects or activities that disturb soil and have the potential to cause negative impacts resulting from erosion and sedimentation must implement practices to control common problems such as wind-blown dust from stockpiles and exposed areas and mud tracking onto adjacent streets. Other activities such as saw cutting concrete, disposing of chlorinated water, uncontrolled construction dewatering, and concrete washout can also be a major source of stormwater pollution. It is critical that project managers and contractors understand the importance of procedural practices and take a proactive role in implementing, inspecting and maintaining them.

- Dust: During extended dry weather, protect exposed soils (especially stockpiles and haul roads) so as to minimize wind erosion (dust problems). Many of the methods used to stabilize soils against water erosion will also effectively control wind erosion. The simple practice of regularly using a water truck to keep stockpiles and haul roads moist will minimize dust problems.
- Mud Track-out: Minimize tracking of mud onto adjacent streets by restricting traffic to stabilized construction exits, minimizing traffic entering and leaving the site when soils are wet and sweeping/scraping up any mud or debris deposited on streets by at least the end of each work day.
- Stockpiles: Locate stockpiles on pervious ground and – where possible – away from the site perimeter. Placing stockpiles on the upstream side of a utility excavation is often an effective way of capturing sediment. Perimeter protection is required around stockpiles in cases where material could migrate off-site. Long term stockpiles (in place more than 30 days) must also be covered or stabilized with mulch and tackifier, vegetation cover or other suitable measures.
- Weather Forecast: Avoid exposing soils towards the end of the work day and/or when wet weather is forecast.
- Saw cutting: Cutting concrete and asphalt can result in discharge of saw-cutting slurry into storm sewer catchbasins. Slurry containing concrete residues can have an extremely high pH (alkalinity) and contain fine sediment and heavy metals. Saw cutting slurry must not be allowed to discharge into catch basins (this requires vacuuming or sweeping up the slurry or residues and disposing of them appropriately).
- Concrete Waste: Equipment used to transport or place concrete must be washed off into a completely contained concrete washout. Washout facilities must be lined with an impervious liner or located on low permeability soils (to minimize potential groundwater contamination).
- Chlorinated Water: Concentrations of chlorine in potable water can be harmful to aquatic life. Any discharge of potable water to a storm sewer requires a drainage permit and de-chlorination measures are generally required.
- Drainage Permits: Discharge of all other impounded drainage (such as run-off impounded in an excavation) to a storm sewer or off-site requires a drainage or dewatering permit (contact 3-1-1).

7.2.3 Water Management

Appropriate management of stormwater run-on and run-off (and, in some cases, groundwater) is one of the most commonly overlooked mitigation strategies during construction activity, yet one of the most effective strategies for reducing erosion. Managing stormwater and groundwater during construction is essential to controlling erosion, off-site sedimentation and turbidity/suspended solids in water. Water management is a necessary part of almost any construction activity that disturbs soil: This is applicable regardless of project size from small utility projects to deep excavations (such as downtown multi-family developments) to subdivision development.

- Collect and convey sediment-laden run-off (convey concentrated run-off in properly designed channels) to detention or retention facilities on-site.
- Divert clean storm run-on around the site and away from exposed areas.
- Try to maintain existing drainage patterns and use natural drainage channels to the greatest extent possible.
- Ensure channels are designed and constructed to the necessary design discharge.
- Try to anticipate construction dewatering requirements ahead of time. Any discharge of impounded water to a City storm sewer requires a drainage permit. The permit includes strict conditions on water quality and quantity that can be discharged (for more information, contact 3-1-1).

7.2.4 Soil Stabilization (temporary and permanent)

Erosion caused by raindrop splash, run-off and wind must be minimized by stabilizing exposed soils as soon as possible. Detachment of soil particles (by water or wind) can be reduced by providing a suitable temporary cover and planning for long-term (post construction) non-erosive cover. Soil stabilization practices are the single most important category of BMPs. In addition, entrainment and transport of soil particles can be reduced by decreasing the quantity and/or the velocity of run-off.

7.2.5 Selecting Erosion Control Practices

The following factors should be considered in determining the suitability of specific erosion control practices (Source: Transportation Association of Canada; National Guide to Erosion & sediment control on Roadway Projects. 2005):

1) Run-off Quantity and Velocity: Dictates the suitability of products (i.e. erosion control blankets such as straw blankets are suitable for short term erosion control on some slopes, whereas a synthetic, three-dimensional turf reinforcement mat may be required for necessary shear resistance and longevity in a channel application).
2) Soil Characteristics: Soil texture and chemistry can affect the performance of many erosion control practices (e.g. successful application of anionic polyacrylamide products onto exposed soils to improve structure and reduce erosion is very dependent on soil texture and chemistry).
3) Topography: The selection and success of erosion control practices is dependent on slope length and gradient. The ease or difficulty of diverting clean run-off around the site is dependent on the terrain and drainage patterns.
4) Climate and Season: Using vegetation as an erosion control depends on local climatic conditions (affects seed mix selection, timing requirements, etc.). Soils that thaw in spring and have been left exposed prior to winter freeze-up are particularly susceptible to erosion, therefore it is essential to implement erosion controls as part of pre-winter practices.
5) Temporary vs. Permanent Controls: Some erosion control practices are intended as permanent measures (i.e. turf reinforcement mats), whereas others are temporary (i.e. mulch, tackifiers).

6) Accessibility: Some practices require access for specialized equipment (i.e. hydroseeding).
7) Cost: It is necessary to choose the most cost-effective practice that provides the necessary level of control for the required length of time.

7.2.6 Sediment Control

Sediment-laden or turbid water must not be discharged from a construction site. Maximum efforts must be made to design and implement effective source control practices to reduce entrainment of sediment into water. Since it is difficult during construction to completely control sediment at the source, it is generally necessary to provide some insurance in the form of sediment control practices.

Sediment control practices should be implemented as close to the source as possible. This will reduce the amount of water that has to be detained and treated, thereby reducing the potential for the controls to become overwhelmed and ineffective, as well as reducing maintenance requirements.

Sediment controls can generally be categorized into two categories:

1) Filtering Controls: Water is filtered through some kind of porous filter media, allowing trapping of sediment on the filter. However, it must be noted that it is very difficult to filter fine sediment while providing adequate flow rate.

Note: Silt Fence is often incorrectly referred to as a filtering control. While silt fence may provide some filtering of coarse particles, it predominantly functions by detaining run-off, thereby providing time for suspended particles to settle.

2) Settling/impoundment: Water is retained or detained, or velocity is slowed sufficiently, to allow sediment to settle out of suspension. Settling of fine sediment can often be improved by the controlled addition and mixing of chemicals known as flocculants or coagulants.

Note: **Sediment traps** are simple depressions designed to capture and contain runoff from small drainage areas. Sediment traps are only acceptable for sites smaller than 4.0 ha in overall size. Sediment traps must be sized to a minimum range of 150 – 250 m^3/ha, and volume must be maintained in between run-off events (a drainage permit will be required to drain any traps into storm sewers). When correctly constructed and well maintained, sediment traps can be an effective means of minimizing the quantity of sediment that is transported off-site. Ideally, sediment traps should be located within the site near the sediment source. Only the area exposed to erosion should drain into the trap.

Sediment basins are similar in function to sediment traps, but provide larger storage volumes. Sites 4.0 ha or greater in overall area must have properly designed sediment traps implemented and maintained during construction through to final stabilization. Sediment basins must be designed for **minimum** storage volumes of **250 m^3/ha**.

The same selection factors that were discussed for erosion control selection apply to sediment control selection. (Source: Transportation Association of Canada; National Guide to Erosion & Sediment Control on Roadway Projects. 2005):

Note: Detailed information on BMP selection, implementation, inspection and maintenance is provided in *Appendix A* of this manual. The BMPs have been split into four sections, depending on their primary application:

- Stripping, Grading and Site Preparation
- Erosion Control: Construction site Stormwater Conveyance
- Erosion Control: Temporary and Permanent Soil Stabilization
- Sediment Control

7.3 REQUIRED LEVEL OF DESIGN AND IMPLEMENTATION

All projects and activities that disturb soil and create potential for erosion and/or sedimentation, regardless of size, require some degree of erosion and sediment control planning, as well as the implementation of good housekeeping practices.

The level of effort on any project is generally based on the risk of negative impacts caused by erosion and sedimentation. For projects where there is a high risk of negative impacts to stormwater infrastructure, health and safety, property and/or the environment, it is essential that a good dialogue be established with relevant regulatory agencies (Fisheries and Oceans Canada, Environment Canada, Alberta Environment, City of Calgary, etc.).

Effective control of erosion and sediment typically requires designing and implementing a system of source controls and sediment controls. Designing a system of control practices based on-site erosion potential and likely water management needs is cost effective (avoids excessive spending on labour and material costs for sediment controls and reduces the risk of clean-up costs associated with erosion and/or sedimentation).

7.3.1 Steps for Effective BMP Selection and Implementation

In addition to planning and procedural BMPs that should be applied to any construction project, it is often necessary to select and implement additional practices. Erosion and sediment are best controlled as close to the source as possible rather than at the perimeter of the site.

1. **Reduce exposure of disturbed soils to flowing water and wind**. The first step in effective selection and implementation of erosion control practices is to identify sources of run-on and run-off and to select appropriate practices for managing run-on and run-off during construction, and through to final site stabilization. Mitigate increased erosion potential due to grading of slopes and channels by installing appropriate erosion control practices.
2. **Select and implement appropriate temporary and permanent soil stabilization practices** to stabilize disturbed soils against detachment on a timely basis. Protecting exposed surfaces can also promote infiltration, reducing run-off quantity and velocity.
3. **Select and implement appropriate sediment controls**. It is generally impossible to achieve complete control of run-off and erosion during construction; therefore it is necessary to complement water management and erosion control practices with sediment control practices.

7.3.2 Sequence for Selecting and Implementing BMPs

1. **Identify the area to be controlled**. In addition to the construction site, it is necessary to identify adjacent areas that could be negatively impacted by construction activities (e.g. existing vegetation to be preserved, existing watercourses, and residential areas) and ensure adequate measures are in place to protect these sensitive areas.

2. **Divert clean run-on/run-off around the site and away from disturbed areas**. It may be necessary to construct temporary diversion berms and channels to divert water away from exposed slopes or to install temporary slope drains to safely convey water down exposed slopes. In addition, temporary diversions of water will likely be required when constructing water course crossings.
3. **Identify and define drainage areas and patterns** (based on pre-construction topography and construction design). Linear projects may have numerous drainage areas that have to be reviewed. Large, relatively flat grades may only generate sheet flow and will also be suitable areas for locating detention facilities. Steeper grades may be prone to concentrated flows, especially at the toe of slopes.
4. **Determine drainage channel alignments/configuration**. Work upstream from the point of discharge and base size on design discharge requirements. Consider channel tributaries that will contribute flow to the channel. Control flow velocities and quantities by slope grading and texturing or diverting run-off.
5. **Determine temporary and permanent erosion control needs for all drainage channels** (e.g. rock or grass lining, turf reinforcement mats, check dams).
6. **Determine areas and phases suitable for erosion control using vegetative and/or non-vegetative measures**. Until suitable vegetation cover can be established, it may be necessary to implement additional erosion control practices such as mulch, tackifier and rolled erosion control products (RECPs). Steeper slopes or areas with high erosion potential may require the use of other measures such as riprap or cellular confinement systems.
7. **Determine appropriate sediment control requirements for detaining and treating sediment-laden run-off**. Large drainage areas can produce a significant amount of run-off, resulting in a need for large detention or retention structures. The size of structures required can be reduced by splitting up the large drainage areas or by phasing soil disturbance.
8. **Consult manufacturer specifications**. When selecting some BMPs, manufacturer's specifications provide valuable information on application, performance, installation, inspection and maintenance of the BMP.
9. **Carefully consider the project schedule in selecting, designing and laying out practices**. This will require communication between the ESC designer, the project owner/manager and the contractor (assuming the project has been tendered and awarded). Most perimeter controls can be installed at the start of construction, followed by sediment detention facilities. The implementation of other controls and practices needs to be integrated closely with the project schedule. Complex projects have complex schedules and will require a series of ESC drawings to be developed in consultation with design and construction drawings.
10. **Consider Seasonal Shutdown Requirements (for longer-term projects)**: Select and design controls and practices for controlling erosion and sedimentation on the site during shutdown periods.

7.4 OVERVIEW OF EROSION AND SEDIMENT CONTROL REQUIREMENTS BY CONSTRUCTION PHASE

> Note: Some projects such as multi-family and commercial developments occur on land that has already been stripped, graded and has some degree of underground servicing installed, so phases may be different than those identified below.

There are typically three major phases of construction that can be identified land development activities, each with very different site conditions. To optimize BMP selection, installation and effectiveness, designers and contractors need to understand the types of BMPs to be implemented at each stage.

7.4.1 Initial Cleaning and Grubbing Phase

Trees, coarse vegetation and roots are removed from the site, allowing access for stripping and grading equipment.

- Prior to commencing site clearing and grubbing, flag the limits of clearing and all buffer areas. Properly fence off vegetation and trees that are to be protected and clearly mark with signage
- Wetlands, riparian areas, ravines, environmental reserves, and other critical areas must also be delineated and protected
- Provide stabilized construction entrances and exits at all points where vehicles, including clearing and grading equipment, will enter or exit the site. Locate entrances and exits on flat areas away from catch basins. Limit the number of entrances and exits to the site to minimize potential for off-site tracking
- Divert clean run-off away from disturbed areas
- Where required, perimeter controls and sediment ponds and traps must be installed once basic clearing and grubbing is complete, and prior to topsoil removal and rough grading
- Contain and treat sediment-laden run-off on site. Sizing and configuration of sediment ponds and traps must provide adequate detention time for run-off (to provide required particle settling time and avoid short-circuiting). Proper planning, installation and maintenance of practices are essential for effective control

7.4.2 Stripping and Grading Phase

This phase results in significant exposure of soil and generally has the highest potential for erosion. A strict schedule of BMP inspection and maintenance must be followed at this stage.

- Limit the duration of soil exposure and provide adequate soil stabilization/cover (erosion control) as soon as practicable
- Reduce the volume of sediment-laden run-off by diverting clean run-on away from work areas
- Convey run-off in stabilized channels, with velocity controls and inlet/outlet protection. Sediment-laden run-off must always be conveyed to suitable sediment trapping facilities that are frequently inspected and maintained
- Stay within the limits of the area allowed to be exposed at one time
- All stockpiles must be located within the site perimeter controls and a minimum of 30 m away from a water body or storm sewer inlet. When run-off from stockpiles cannot be contained by perimeter controls, install sediment control practices (such as silt fence or compost socks) around the down-gradient base of the piles (leaving space for ponding and sediment trapping). In addition, all stockpiles in place for more than 30 days must be stabilized with appropriate erosion control practices
- Roughen the surfaces of all exposed slopes (e.g. horizontal cat tracking, contour furrowing, and scarification) to promote infiltration, reduce run-off velocity and provide a microclimate for seed germination
- Reduce slope length by intercepting run-off along the contour on steep slopes (e.g. fibre or brush wattles, terracing, compost socks and berms)

- Stabilize all exposed soils by providing cover (i.e. temporary seeding, sod, rolled erosion control products, riprap lining). Timely stabilization of soils significantly reduces erosion potential
- Install check dams to control water velocity and channel erosion in channels receiving concentrated flows (e.g. rock check dams, synthetic barriers, geotextile triangular dike, rolled fibre logs, compost socks)
- As a last line of defence, protect storm drain inlets (where necessary). There are several options available depending on the type of inlet: wood or plastic frames with geotextile filter fabric, curb inlet filters and weirs, block and gravel. Practices require frequent inspection and must not cause downstream flooding due to diversion or excessive ponding of water on streets. Inlet protection is the last opportunity (with very limited effectiveness) to control sediment before it leaves the site: It is not intended as a replacement for proper site erosion & sediment control
- Protect channel/culvert inlets and outlets: Areas that are prone to scouring are generally protected with riprap aprons or other energy dissipaters, level spreaders or stilling basins

7.4.3 Underground, Above Ground and Post-Construction Phases

During these phases, underground utilities and permanent drainage structures are installed and construction grading is largely completed. Construction of buildings is underway. In the case of subdivision development, homebuilders and small site developers may start working in newly developed phases. Homebuilders, small site managers (i.e. multi-family, commercial and industrial sites) and contractors must implement planning and procedural practices to control erosion and sedimentation on building lots (for further information, refer to Section 8.0).

- Upon completion of this phase, all areas must be permanently stabilized
- Establish permanent vegetation cover after topsoil is applied to landscape areas
- Stabilize all stormwater conveyances with non-erosive materials
- All outlets must have permanent energy dissipation installed to prevent scour erosion
- Maintenance of sediment trapping facilities is required until all disturbed areas have established cover
- Once final stabilization is complete, all remaining temporary controls must be removed and all affected areas stabilized

<u>SECTION 8.0</u>

EROSION AND SEDIMENT CONTROL REQUIREMENTS FOR SMALL SITES

8.0 EROSION AND SEDIMENT CONTROL REQUIREMENTS FOR SMALL SITES

8.1 OVERVIEW

In this document, small sites are defined as:

- Sites with an overall area < 0.4 ha (1 acre), including:
  - Single family residential and duplex developments, and;
  - Many small commercial, industrial and multi-family sites

Uncontrolled construction activity on relatively small sites can result in large quantities of sediment and other stormwater pollutants moving off-site and into storm sewers and water bodies. In Calgary, on-site control of stormwater, erosion and sediment is critical during the construction of single family homes, multi-family developments and small commercial and industrial developments.

Erosion control is important on any construction site, regardless of size. The large number of small construction sites and the challenge of controlling erosion and sedimentation within the confined areas typical of these sites can make small sites a major contributor to construction site stormwater pollution.

The principles and methods of controlling erosion and reducing off-site sedimentation from small sites are relatively standard and simple. The guidance in this section is intended to assist small parcel owners, developers and contractors implement the necessary standards of erosion and sediment control on small sites. In addition to the relatively simple practices and controls prescribed, it must be noted that every site is unique and poses its own restraints and potential erosion hazards. Because of this, additional measures may be required in the following circumstances:

- Sites adjacent to, or within 100 m, of a water body
- Sites Containing steep slopes
- Sites receiving run-on from adjacent upstream areas
- Sites having an overall area > 0.4 ha (1 acre)

It is the responsibility of property owners and contractors to ensure that they are in compliance with federal, provincial and municipal regulations, as well as municipal design guidelines regarding construction site erosion and sediment control and stormwater pollution prevention. Erosion and sediment control practices for small construction sites (including single-family lots) must be in place before small site contractors/homebuilders commence any grading activities, utility installation or building construction.

8.2 BEST MANAGEMENT PRACTICES FOR SMALL SITES

Note: Refer to **Appendix A** in this document for more detailed information on erosion & sediment control measures for small sites.

As with larger sites, there are four general categories of controls and practices for controlling erosion and sediment during development and construction activities on small construction sites.

1. Stripping, Grading and Site Preparation

As with larger sites, it is important that construction is scheduled and phased so as to minimize the potential for erosion and off-site transport of sediment and other pollutants. Additional controls may be required during periods of high erosion potential (i.e. heavy rainfall events in summer and rapid snowmelt). Preserving vegetation during site preparation, especially at the perimeter of the site, and correctly placing and protecting soil stockpiles are critical. All construction sites with vehicles entering and exiting the site should have stabilized entrances/exits. Where possible, vehicles should be parked on adjacent streets to minimize mud track-out.

Suitable Best Practices (refer to Appendix A):

- Construction Scheduling & Phasing
- Preserve Existing Vegetation or Vegetative Strips
- Soil Salvage, Placement & Stockpiling
- Stabilized Construction Entrances/Exits (i.e. gravel pads, coarse woody slash, plywood sheeting)

Note: Preserving vegetation cover and providing timely stabilization of exposed soils and stockpiles is also an effective way to control dust.

2. Construction Site Stormwater Management

Erosion caused by concentrated discharge of stormwater from downspouts onto exposed soils is a common problem on small sites, especially residential lots prior to landscaping. Small commercial, industrial and multi-family sites may need to implement additional stormwater controls as detailed in Appendix A.

Suitable Best Practices (refer to Appendix A):

- Energy Dissipaters or Splash Pads (gravel/rock, vegetation, commercial products)

3. Erosion Controls

Erosion controls protect the soil surface from rainfall and run-off. Prevention of erosion is the most preferable and cost-effective approach.

Suitable Best Practices (refer to Appendix A):

- Seeding and Sod
- Mulching
- Hydromulching and Hydroseeding
- Rolled Erosion Control Products (blankets/mats)
- Compost Blankets
- Straw/Fibre Wattles (used as perimeter controls known as lot logs)
- Aggregate Cover (placing gravel over exposed soils to reduce risk of soil erosion)

4. Sediment Controls

As is the case for larger sites, practices must be implemented on smaller sites to control dust. A drainage or dewatering permit must be obtained from The City prior to discharging any impounded water (surface water and groundwater) to a storm sewer or off-site. **Sediment controls must be in place to contain run-off and capture sediment on site**. Use of adjacent streets for sediment trapping and deposition is not permitted.

Suitable Best Practices:

- Dust Control
- Site Drainage/Dewatering Practices
- Sediment Traps (small V-ditch traps at the perimeter of residential lots under construction are an effective perimeter control)
- Compost berms, compost socks and other lot logs for perimeter control
- Storm Drain Inlet Protection (may be useful for small commercial, industrial and multi-family developments. Not recommended for individual residential developments)

Photo 3: Discharge from downspouts is a common cause of erosion of unstabilized soils. In this case, rock has been added in an attempt to control erosion. All downspouts are required to discharge to a suitably sized stabilized area such as vegetation or a properly installed energy dissipater (riprap or other material).

8.3 GENERAL STEPS FOR SMALL SITE EROSION & SEDIMENT CONTROL

8.3.1 Building Lot Drainage

Provide for adequate lot drainage before building construction begins and ensure grades are in accordance with The City of Calgary's *Lot Grading Bylaw 32M2004*. During subdivision development, it is necessary to ensure adequate ponding on undeveloped lots once underground utilities and surface improvements (streets and sidewalks) are constructed.

8.3.2 Prior to Construction

Wherever possible, preserve existing vegetation to help control erosion and reduce off-site sedimentation. Prior to construction, the entire site must be evaluated, marking important trees (including rooting zones) and other vegetation (especially filter strips within the site perimeter).

Place orange snow fence or other visible fencing outside of the drip-line of trees to be protected. Fence off other vegetated areas to be protected.

To prevent root damage, do not disturb land, place stockpiles or park vehicles within tree protection zones or areas marked for vegetation preservation.

Photo 4: Uncontrolled run-off and erosion from inner city infill development resulting in off-site sediment releases and sedimentation.

8.3.3 Perimeter Erosion and Sediment Control Practices

Note: **Sediment-laden run-off must be contained on-site for all small residential, industrial and commercial sites**. Stormwater catch basins on city streets are prone to bypass and flooding as a result of sediment control devices known as ‘socks and donuts’ being inappropriately installed or maintained. These devices are frequently installed in locations where they can cause bypass of run-off and result in downstream flooding. Therefore, they must strictly be considered a last line of defence. In all cases where these devices are used, they must be frequently inspected and maintained, especially during and immediately after run-off events. On public streets, storm inlet protection must be removed prior to freeze up (where ponding water could freeze and cause a safety hazard).

Identify all perimeter areas and on-site storm sewer inlets where sediment-laden run-off could leave the construction site and install on-site perimeter controls (i.e. silt fence or lot logs such as compost socks or straw/fibre wattles) to minimize the potential for off-site sedimentation. Perimeter controls must be in place before any other grading or soil-disturbing activities commence. Ensure perimeter sediment trapping devices are placed on contour and run end sections upslope 2 to 3 m to prevent bypass.

Where possible, preserve a vegetative buffer strip around the perimeter of the property. This buffer strip will help reduce run-off velocity and trap sediment before run-off reaches perimeter controls. A suitable alternative to a vegetative buffer strip is a strip of properly installed erosion control blanket.

Where a vegetative buffer strip cannot be preserved (or a blanket installed), building lot run-off must be captured by excavating, on the upstream side perimeter controls such as a lot log, a temporary sediment trap (such as a simple v-shaped ditch) at the front and rear of the lot.

Photo 5: Placement of silt fence around a temporary stockpile on a multi-family development. Note that long term stockpiles such as this one should also be stabilized with vegetation or other temporary cover.

Install stabilized construction entrances and exits and restrict all vehicle access to these points to minimize off-site mud tracking. Vehicle access to the site must be restricted during wet weather/wet soils. Where possible, limit parking of vehicles to the street. Inspect adjacent roadways at least daily and remove tracked mud prior to the end of each day.

Prior to paving, protect any on-site storm sewer drop inlets or catch basins with a silt box (silt fence installed on a square wood frame) or similar commercially available alternative.

Ensure water containing sediment or other contaminants (such as concrete fines or hydrocarbons) resulting from construction, maintenance, repair or operational activities does not enter storm sewer inlets. During the installation, maintenance or repair of streets or underground utilities, protect adjacent storm inlets and implement controls for activities such as dewatering and saw-cutting. For example, vacuum up saw-cutting slurry and dispose at an approved facility; obtain a drainage permit prior to discharge of any impounded water.

8.3.4 Small Site Preparation

Prepare the site for construction, including installation of utilities. Make sure all contractors (especially the excavating contractor) are aware of areas to be protected.

Photo 6: Uncontrolled stockpiling on a street, causing erosion of pile material and a resulting release to the storm sewer. Note that The City of Calgary *Drainage Bylaw 37M2005* provides for a specified penalty of $3,000.00 for releasing prohibited substances such as sediment to a storm sewer.

Salvage and stockpile topsoil and subsoil in separate lifts and piles. Except in special cases approved by The City of Calgary Roads, storage of stockpiles on streets (including back lanes) is not permitted (such material may be eroded by significant surface run-off and washed into off-site areas and storm sewers). Likewise, material must not be stockpiled such that it could leave a site and enter a City street (i.e. on driveways). Where possible, locate stockpiles on a pervious surface, away from driveways, sidewalks or other drainage features. Where it is necessary to store piles of gravel or soil on streets, obtain a City of Calgary Street Use Permit (contact The City of Calgary Corporate Contact Centre at 3-1-1).

To control erosion, including wind-blown dust, cover all stockpiles with tarps, plastic sheeting or other suitable cover. Divert concentrated run-off away from stockpiles and install temporary perimeter controls such as silt fence or a lot log around the downstream end of all stockpiles (place in a “smile” configuration to prevent bypass of run-off and sediment around the ends of the device).

Never store material in a concrete drainage swale or street gutter; concentrated run-off will cause significant erosion and transport sediment.

Never store material such as fertilizer or concrete mix where it could be exposed to rainfall or run-off.

8.3.5 Utility and Building Installation/ Construction

As soon as building roof gutters and downspouts are installed, there is significant potential for erosion of un-stabilized soils by concentrated roof run-off. To prevent lot erosion from roof run-off, install extenders on all downspouts that discharge to exposed soils. Run the extenders to a vegetated area or energy dissipater such as a riprap outlet (refer to Appendix A, Energy Dissipaters) or splash pad. Stabilized outlets must conform to the surrounding grade.

Note: Under The City of Calgary *Drainage Bylaw 37M2005*, it is prohibited to allow downspouts to discharge within 2 m of a City Street (including a back lane) and surface drainage facility/drainage swale.

Photo 7: Placement of wood chip filled bags as a lot log perimeter control on a steeply graded lot. Note that a temporary v-ditch sediment trap must be excavated on the upstream side of the lot log and the bags better entrenched and staked into place to prevent sediment-laden flow undermining this control.

Due to the typically lengthy periods of time required to complete construction projects in Calgary (i.e. typical house construction can last 12 to 18 months, with additional time required for permanent stabilization), it is critical that exposed soils are stabilized throughout the construction process. There are a number of practical options for temporary stabilization of exposed soils, including straw mulch, application of suitable tackifiers and installation of temporary erosion control blanket.

8.4 INSPECTION AND MAINTENANCE OF SMALL SITE CONTROLS

Frequently inspect and maintain all erosion and sediment control practices until construction is complete and the site is stabilized. In the case of residential lots, this is generally the immediate responsibility of the homebuilder or their designate. Until final acceptance (FAC) of surface improvements by The City, the developer is responsible for ensuring homebuilders in their development phases are compliant.

Inspect practices a minimum of every seven (7) days and during (or within 24 hours of) heavy or prolonged rainfall or run-off (including snowmelt). Schedule and complete necessary repairs and upgrades to practices immediately. Maintain an inspection log and photos (recording inspection and maintenance activities) on site.

By the end of each work day, remove (by sweeping or scraping) any material tracked onto adjacent streets. Never wash material onto or down a street or adjoining driveway.

Note: Refer to Section 9.0 of this document for further guidance on construction site ESC inspection/ maintenance.

8.4.1 Site Stabilization / Revegetation

Note: Where landscaping and final stabilization is being left as the responsibility of the owner, this should be clearly agreed to and specified in contract documents. In such cases, perimeter controls must left in place and fully functional and the owner will be responsible for completing final site stabilization. Once the site is permanently stabilized, temporary controls must be removed and properly disposed of.

As soon as outside construction activities are complete, redistribute stockpiled subsoil and topsoil and grade areas to final design elevations.

Immediately stabilize exposed soil with suitable sod, seed or other landscaping materials. It may be necessary to apply fertilizer and lime, as required, avoiding over-application.

Mulch all newly seeded areas with a light cover of compost, crimped straw or a suitable application of hydromulching or hydroseeding. Steep slopes and areas adjacent to environmentally sensitive sites or natural areas may require the additional protection of a suitable, properly installed erosion control blanket.

Once the site is stabilized with sod, vegetation or other erosion-resistant cover, remove any remaining **temporary** erosion & sediment control measures such as perimeter controls.

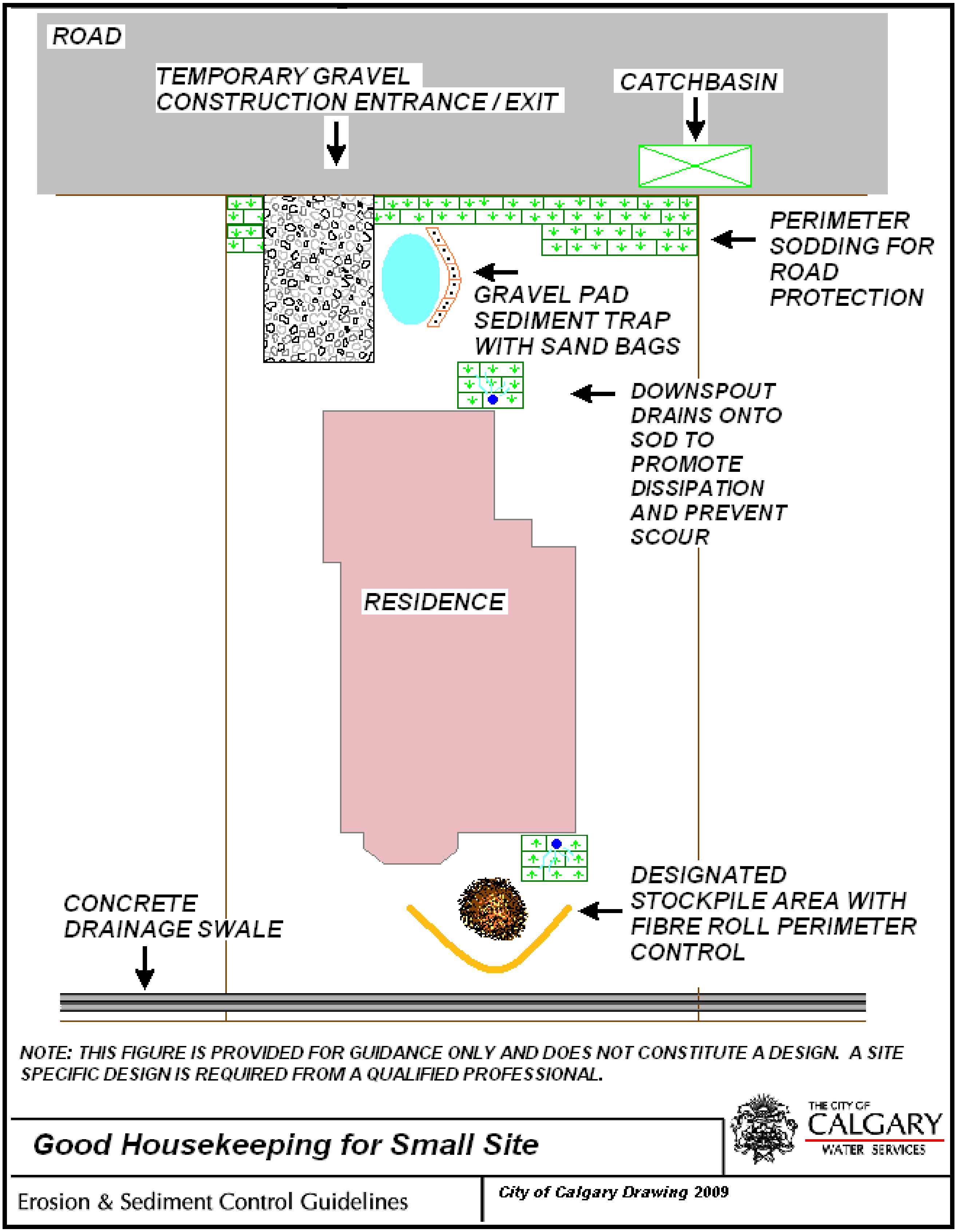


Figure 8-1: Schematic Example of Small Construction Site Practices

SECTION 9.0

IMPLEMENTATION, INSPECTION AND MAINTENANCE

9.0 IMPLEMENTATION, INSPECTION AND MAINTENANCE

9.1 IMPLEMENTATION

9.1.1 Overview

Ensuring the effective implementation of erosion and sediment control practices requires good communication between key project stakeholders (such as the landowner or developer, the project manager, the project design consultant, the erosion and sediment control designer, contractors, inspectors and regulators).

The project manager/owner should ensure stakeholders are invited to a pre-construction site meeting to discuss construction site stormwater management and erosion and sediment control practices. Frequent site meetings are essential, especially on projects that are large, complex or require significant planning and implementation of controls to manage risk.

Throughout a project, a number of important items must be addressed, including:

- Construction/implementation of erosion and sediment control practices according to the erosion and sediment control report and drawings (including addendums)
- Inspection and maintenance of erosion and sediment control practices
- Timely management of erosion and sediment control failures
- Timely removal of temporary practices once no longer required
- Documentation of installation, inspection and maintenance of erosion and sediment control practices and changes (addendums) made to the erosion and sediment control report and/or drawings

9.1.2 Communication

Successful implementation of construction site erosion and sediment control practices requires the project owner/manager, engineering consultant, erosion and sediment control designer, contractors, field inspectors and regulators to recognize the important key roles they have and to communicate effectively with each other.

Project owners commonly delegate the responsibility of erosion and sediment control design and implementation to an erosion and sediment control designer and contractors respectively. It is often the responsibility of the prime contractor constructing the project to implement, inspect and maintain the practices prescribed in the erosion and sediment control report and drawings. Therefore, *the designer must ensure reports and drawings can be easily understood and implemented by the contractor*.

- During the pre-construction meeting, and throughout the project, the erosion and sediment control designer must clearly communicate the intent and details of the report and drawings to the project manager and contractors.
- Frequent inspection of controls and practices must be undertaken by the project manager or their designate, with deficiencies noted and addressed in a timely manner.
- Components of the erosion and sediment control design which appear deficient must be discussed with the designer. Changes made to erosion and sediment control reports/drawings must be documented as an addendum and forwarded to the relevant City inspector and other stakeholders.
- If erosion or sediment control practices fail, the project manager must notify relevant City staff, as well as the erosion and sediment control designer. In many cases, it will be necessary to consult with regulators and the designer regarding repairs or required changes to the plan.

- If the contractor or any other party is to be responsible for the decommissioning/removal of temporary practices, or the continued inspection and maintenance of erosion and sediment control practices until final site stabilization, this must be written into the contract documents and agreed to, otherwise, the owner will be responsible for these items.
- All erosion and sediment control implementation, inspection and maintenance activities must be properly documented.

9.1.3 Anticipating Storm Events

It is common for Calgary to experience short, high intensity storm events during the late spring and summer months. Although the timing and intensity of such events is hard to predict, they must be expected and planned for.

Any time that significant rainfall events are forecast or possible, it is advisable to inspect erosion and sediment control practices and undertake preventative maintenance in advance of storms. Excessive stripping of vegetation and soils should be avoided when there is a high likelihood of erosive rainfall or run-off, including snowmelt.

Sufficient pre-winter practices to minimize snowmelt erosion must be implemented prior to ground freezing and accumulation of snow and ice.

9.1.4 Concurrent Critical area stabilization

Critical resources include surface waters (such as streams, rivers, wetlands and lakes) and environmental reserves. Critical resources also include areas connected or draining to surface waters such as storm pond side slopes, and any exposed soil areas within a positive slope to a stormwater conveyance system (including curb and gutter system draining to storm sewer inlets, temporary or permanent drainage ditches and other natural or man-made systems that discharge to a surface water).

These critical resource areas require rapid stabilization (temporary or permanent vegetation or non-vegetative cover) of exposed soil to be completed concurrent with stripping and grading or other soil disturbance.

9.1.5 Safety

Construction projects typically include many potentially dangerous conditions, including noise, dust, heavy equipment, excavations and slopes. Care must be taken during planning and implementation to ensure erosion and sediment control practices do not create unsafe conditions for workers and the public. In particular, areas intended to pond water and/or accumulate sediment should be clearly marked (and may require barriers around the perimeter). Temporary sediment controls on storm inlets must not cause excess ponding of water on public streets or diversion of run-off away from storm inlets.

9.2 INSPECTION AND MAINTENANCE

9.2.1 Overview

Erosion and sediment control practices implemented on construction projects are intended to control run-on and run-off, stabilize exposed soils, and reduce/eliminate the discharge of sediment/pollutants associated with construction activities. This section provides guidance on control-specific inspection and required frequencies of inspections to be undertaken by the delegated site erosion and sediment control inspector for active and inactive sites.

In addition to improper selection and installation of erosion and sediment practices, a lack of timely inspection and maintenance and lack of inspection experience are the most frequent causes of failure.

The time of year and weather conditions encountered during the construction project can greatly influence the amount of maintenance required. To ensure the continued performance of practices, it is especially critical to monitor them before, during and following significant storm events and snowmelt.

Note: Inspection and maintenance criteria and frequency specific to each erosion and sediment control practice must be included in the site erosion and sediment control report and/or drawings. Some practices require more frequent inspection and maintenance than others.

9.2.2 Inspection Frequency

Inspection and maintenance is required throughout the project, starting at the installation of preliminary controls through to final site stabilization (when permanent erosion and sediment controls/stormwater controls are in place and functional and all exposed areas have been permanently stabilized).

The frequency of site inspection depends on weather conditions, site soils, construction phase and, to some degree, the specific control/practice. **As a minimum, site inspections on active sites must be conducted at least every seven (7) days during dry weather and at critical times when precipitation or snowmelt may be capable of causing erosion** (inspection must occur during or within 24 hours of significant precipitation or snowmelt).

Note: Significant precipitation is defined as any rainfall event likely to cause run-off and erosion. For the sake of consistency, any 24 hour period with > 12 mm rainfall must be considered significant, with site inspection required.

It is the responsibility of the site owner or project manager to ensure qualified, experienced erosion & sediment control inspection personnel are conducting inspections to the frequency and standard outlined in these guidelines and as addressed in the site ESC report and/or drawings.

Winter Shutdowns and Inactive Sites

- Construction projects may be shut down by weather conditions, contractual problems, regulatory directions, etc. In the event of a work stoppage, the monitoring and maintenance of controls is still the responsibility of the project/site owner and must continue.
- **Except during prolonged winter freeze-up conditions, any site that is inactive for greater than seven days must be inspected every seven days** (this includes inspection during/after winter snowmelt conditions).

Note: All exposed areas and stockpiles must be stabilized and inspected before a site is left in an inactive or winter shutdown state.

- Frozen soils are not prone to erosion. However, surface soils may be detached by freeze-thaw cycles and thawing surface soils quickly become saturated in spring. As a result, erosion potential on many construction sites can be very high during spring thaws or prolonged chinook conditions. Therefore, it is essential to ensure effective ESC measures are installed prior to freeze-up and inspected during snowmelt.

9.2.3 Inspection Procedures

Inspections must include:

- All disturbed areas of the site
- Material and waste storage areas
- Stockpile areas

- Construction site entrances/exits
- The site perimeter
- Environmentally sensitive areas (on-site and adjacent to site)
- Discharge locations (including drainage or dewatering activities) and adjacent receiving waters (including stormwater outfalls connected to the site by an active storm sewer)

Weekly Inspection Requirements

- Walk the site to ascertain that all measures have been implemented in the field, that erosion is being controlled and that sediment/other pollutants are not being transported off-site or into critical areas on-site
- Note any improper installations, failing controls and necessary maintenance required
- Identify all critical inspection locations where control measures will need to be routinely checked for performance and checked after storm events. These critical points must include:
  1. All disturbed areas of the site
  2. Soil stockpile and material storage areas
  3. Locations where vehicles enter or exit the site
  4. The down-gradient perimeter of the site
  5. All construction stormwater diversions/conveyances and ESC measures
  6. Discharge locations and, in the case of active storm sewers, inlets and outfalls

During/After Significant Rainfall/Run-off

- During significant rainfall/run-off events (which include intense downpours, prolonged rainfall, hailstorms and heavy snowmelt), the designated site inspector must have the authority/ability to call out work crews to conduct emergency repairs. Equipment and any necessary materials may need to be kept on hand to provide a timely response

Inspect Vegetation Establishment (where applicable)

- Vegetation cover is one of the most important components of permanent erosion control. Therefore, it is especially important to ensure the success of vegetation establishment, including:
  1. The type of vegetation that is growing (compare to what was planted)
  2. Vegetation density, including percent ground cover
  3. Erosion problems on areas requiring temporary and permanent vegetation cover (sheet erosion, rilling, gullying, localized scour, etc.)

Additional measures such as re-seeding, fertilizing, erosion repairs and irrigation may be required until the vegetation is established and providing the required cover and erosion control function.

9.2.4 Follow-up/Maintenance Requirements

The inspector must record all damages and deficiencies on an erosion and sediment control inspection report. Damages and deficiencies that have the potential to cause a release must be addressed immediately. All other damages and deficiencies should be corrected as soon as possible and, in no circumstances, later than 72 hours after the inspection. Complete any required updates to the site erosion and sediment control report/drawings within seven (7) days and notify The City of Calgary erosion and sediment control inspector.

9.2.5 Inspection and Maintenance Reports

Inspection reports must be prepared during or following each inspection conducted by the designated site erosion and sediment control inspector. Reports must include information on damages and deficiencies, monitoring information (i.e. discharge turbidity readings during dewatering), vegetation establishment and a section for summarizing maintenance/repair activities. Inspection reports prepared by the designated site ESC Inspector must be kept on-site for review and for a period of three years after final site stabilization.

In addition, The City of Calgary conducts periodic compliance inspections (spot inspections, scheduled inspections and complaint investigations), which are normally documented with digital photos and field notes and, in the case of non-compliance issues or deficiencies, written documentation (such as inspection reports, field memos, notice to correct).

9.2.6 General Inspection Items

An example inspection/maintenance form is included in this section. Including photos with inspection/maintenance records provides an excellent form of documentation.

- Check to ensure up to date erosion and sediment control reports and/or drawings are available on site
- Check to ensure that required permits and authorizations (i.e. drainage permit) are in place and up to date
- Ensure all erosion and sediment control practices are being inspected and maintained by the contractor in accordance with the inspection and maintenance schedule and/or general inspection & maintenance protocol
- Observe all discharge points from the site to ensure there is no obvious sign of pollutants leaving the site. Document all visual observations (i.e. sheen, turbidity), readings (i.e. pH, turbidity) and photographs
- Ensure all perimeter controls, as required in the erosion and sediment control report and/or drawings, are in place and functional
- Ensure storm inlets draining disturbed areas are protected with temporary inlet filtration
- Ensure only designated construction entrances and exits are being used by traffic and that all are stabilized and functional. Ensure street sweeping is occurring, where required
- Ensure all sediment traps, barriers and basins are constructed in accordance with the erosion and sediment control report and/or drawings and are well maintained and functional
- Ensure all disturbed soil areas not being actively worked have been stabilized
- Ensure all other erosion-prevention measures identified in the erosion and sediment control report and/or drawings are in place and functional
- Ensure stockpiles are located in designated areas and properly protected (inactive piles must have cover or perimeter protection and dust control; active piles must be properly located away from water bodies and concentrated run-off)
- Check to ensure construction equipment and vehicles is stored in designated areas away from storm inlets or water bodies (with secondary protection, as required)
- Ensure dust control measures (i.e. water trucks, soil stabilization) are functional or being implemented during dry, windy weather
- Ensure release reporting requirements are being followed and releases properly documented

9.2.7 Project Completion

Along with other things that must be done to close out a project, don't forget important erosion and sediment control tasks. Taking care of project completion details will ensure continued protection of infrastructure and nearby environmentally sensitive resources.

- Ensure people are assigned to provide short-term maintenance of permanent erosion and sediment control practices and know their responsibilities
- Ensure all features of the permanent stormwater management system are built and functional as per design, and are stabilized
- Clean and stabilize all areas where sedimentation has occurred
- Remove all temporary erosion and sediment control practices and stabilize disturbed areas (re-seed and mulch where required

Table 9-1: Considerations for Implementation, Inspection and Maintenance of Typical BMPs

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
Stripping, Grading and Site Preparation		
<u>BMP #1</u>: Construction Scheduling and Phasing	• ESC designer failing to develop drawings and specifications that can be clearly understood/implemented by the contractor. • Not scheduling a pre-construction site meeting and frequent update meetings (to include the developer/owner, project managers, consultants, contractors, ESC installers and regulators. • Not scheduling and timing soil disturbing activities to limit soil exposure during the rainy season, significant snowmelt or forecast storms. • Not controlling the amount of area or soil disturbed • Failing to plan or implement the necessary controls and practices required for the specific phase of construction.	• ESC is everyone's responsibility: The owner/developer or their designate must ensure that there is good on-going communication between all parties. • Contractors must understand that the ESC report/drawings are only an initial "appraisal" based on-site plans and pre-construction data. Reports/drawings will likely require some updating as construction proceeds. • Consultants, project managers and contractors must continually assess the potential impacts of erosion and sedimentation relative to construction timing/scheduling throughout. • Minimize soil exposure during potentially wet periods and stabilize exposed soils as soon as possible. • Plan for periods of site inactivity or shutdown (including winter periods): stabilize all exposed soils. • Review scheduling/phasing progress during weekly site inspections and site meetings.
<u>BMP # 2</u>: Preserve Existing Vegetation	• Failure to properly fence or mark construction boundaries. • Compaction of tree root zones or other damage to trees due to failure to properly place protective fencing. • Uncontrolled stripping of vegetation and topsoil, resulting in excessive areas of exposed, highly erodible subsoil. • Failure to protect riparian areas, resulting in potential damage to aquatic habitat.	• Clearly mark construction boundaries with fencing and signage and educate all contractors on-site. • Place highly visible snow fence and signage around trees and shrubs to be protected (outside the drip line). • Vegetation is the most economical and effective method of controlling erosion and sedimentation. Avoid sediment releases and potential legal liability by preserving vegetation. • Except where permitted to do so by Provincial and Federal regulators, avoid disturbing riparian areas. • Ensure vegetation preservation requirements are being implemented during weekly site inspections.
<u>BMP # 3</u>: Surface Grading, Roughening & Texturing	• Roughening slopes in the wrong direction, resulting in concentration of run-off and potential rill and gully erosion. • Grading work often results in tracks created perpendicular to contours. This can exacerbate erosion of exposed soils.	• Roughen exposed slopes in a timely manner: Ensure tracks, grooves, furrows or terraces run perpendicular to run-off (i.e. they follow the contour). • Surface roughening loses effectiveness over time (especially during heavy rain events). Always inspect after heavy rain/run-off and assess if further roughening or additional practices are required.

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
BMP #4: Topsoil Salvage & Placement	• Topsoil on-site is poor quality and not recognized as such. • Deficient topsoil is not amended with sufficient nutrients, organic matter and micro-organisms. • Topsoil is poorly stripped and segregated from subsoil.	• Use soil survey information and skilled excavator operators to remove and store useful topsoil horizons. Avoid mixing of topsoil and subsoil. • Have topsoil analyzed for nutrient levels, organic matter, conductivity and texture. • Monitor the application of topsoil and amendments to ensure required materials, depth and quality.
BMP # 5: Stabilized Construction Exits	• Vehicles are accessing and exiting the site at random/convenient points instead of using designated stabilized access/exit points. • Gravel used at the exit is too small or too large. • Fabric is not placed under the gravel. • Exits are not inspected or maintained (topdressing may be required). • There is a well maintained stabilized exit, but mud is being tracked onto adjacent streets nonetheless.	• Regulate vehicle access/exit points, place signage/fencing and educate drivers. • 75 – 150 mm angular, durable rock generally works best. 20 – 40 mm gravel is prone to off-site tracking. • Always place a geotextile underlay under the rock. • Inspect exits daily and top-dress exits frequently. • Additional inspection and timely sweeping of streets may be required. • Minimize vehicle access during wet weather/wet soils.
Erosion Control: Construction site Stormwater Conveyance		
BMP # 6: Temporary Berms and Diversion Channels	• Diversion channels must be adequately sized to convey design flows around disturbed areas. • Berms must be adequately sized to prevent breaching. • Channels and berms must be quickly stabilized against erosion.	• Frequently inspect diversion channels for sediment and debris accumulation and remove. Repair damaged lining and replace riprap. • If erosion of diversion channels and berms occurs, assess the need for additional erosion protection.
BMP # 7: Vegetation-Lined Channels **(generally refers to grass-lined)**	• Failure to establish adequate cover of vegetation and root mass prior to erosive run-off event (i.e. failing to provide additional channel protection during seedling establishment). • Failure to correctly install, inspect and maintain turf reinforcement mats (see RECPs). • Channel run-off velocities exceed erosion control ability of vegetation and/or TRM. • Failure to install outlet protection prior to channel excavation and blanket/seeding.	• Inspect lined drainage channels at regular intervals, especially during/following heavy run-off. • Where turf reinforcement mats are used, ensure they have been correctly selected and installed (see RECPs). • Remove debris and accumulated sediment. • Repair erosion of linings or the channel substrate and assess whether erosion control measures are adequate.
BMP # 8: Riprap-Lined Channels	• Failure to correctly design or implement correct riprap grade and size. • Difficulty obtaining suitable riprap or failure to properly implement due to high cost. • Failure to over excavate channel to ensure correct riprap depth and conformity with adjacent grade. • Failure to install a geotextile or gravel	• Riprap or articulated linings to be designed by a qualified professional. • Inspect during installation to check for correct sizing and grade of riprap, stabilized outlet structure placement and over excavation and proper disposal of spoil material. • Inspect to ensure geotextile or gravel filter has been properly placed.

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
	filter before riprap application. • Failure to install outlet protection prior to channel excavation and riprap placement.	• Inspect installation during and after significant run-off to check integrity. Replace and displaced material and repair any erosion promptly.
<u>BMP # 9</u>: Temporary Slope Drains	• Designing or implementing the wrong pipe size to handle flows. • Failure to properly install a stabilize inlet (usually a compacted earthen berm & inlet structure. • Failure to anchor the slope drain adequately. • Failure to extend the slope drain to a flat area with adequate energy dissipation/erosion protection.	• Pipe size should accommodate design storm/run-off. • Check control during heavy run-off to ensure all component are functional. • Check the outlet for erosion and conduct any repairs promptly. • Check the inlet for scouring and repair any damage immediately. • Remove any accumulated debris from inlet/outlet.
<u>BMP # 10</u>: Energy Dissipaters	• Inadequate sizing or placement of material to handle design velocities. • Failure to ensure dissipater surface is same elevation as surrounding land (erosion results). • Failing to install adequate area/length of dissipater to adequately control erosive flows.	• Inspect frequently and after significant run-off: Check for piping, scouring and other erosion and stability of material. Reassess control and conduct any repairs immediately. • Pay particular attention to culvert/pipe inlets and outlets (scour erosion is a common problem).
<u>BMP # 11</u>: Check Dams	• Placing check dams or barriers such that abutments/ends are not high enough above dam centre can result in erosive flows of run-off around structure. • Common misconception that check dams are intended for sediment control (coarse sediment may be retained, but can quickly be re-suspended). • Failure to key in/anchor check dam or barrier to channel substrate, resulting in erosive undermining. • Failure to provide erosion protection downstream of check structures, • Check dams and barriers are placed too far apart.	• Ensure ends of structure are at least 150 mm higher than centre. • Frequently inspect check structures, especially after run-off. Check for erosion and repair and rectify. Ensure erosion control (such as RECP) immediately downstream of structure. • Check for undermining of structure and repair/rectify by properly entrenching or anchoring structure in channel. • To avoid scouring, ensure check structure spacing is based on channel gradient
Erosion Control: Soil Stabilization		
<u>BMP # 12</u>: Seeding and Sod	• Improper calculation of seeding rate, based on seed purity. • Improper selection of seed mix for area or soil/moisture conditions. • Failure to provide suitable protection, moisture and nutrients for seed germination and seedling development.	• Seed mixes and seeding rates must be designed by a seed specialist. • Protect seeded areas from predation (where possible) and removal of the seed by wind or flowing water. • Ensure soil nutrient and moisture regime is adequate. • Inspect seeded areas for germination and growth; reseed bare spots and assess and correct reasons for poor germination/plant establishment.
<u>BMP # 13</u>: Mulching	• Inadequate mulch application rate results in insufficient mulch coverage	• Ensure the landscape contractor is applying the rate of mulch specified.

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
	and depth. • Failure to crimp or tackify loose mulch in areas exposed to wind or run-off. • Application of mouldy or wet straw is not permitted. Avoid using hay as mulch (weed seeds).	Inspect the application for consistent coverage. • Replace mulch or seed carried away by wind or flowing water and ensure new application is crimped/tackified.
BMP # 14: Hydromulching & Hydroseeding	• Improper application of mulch (inadequate application rate or inadequate coverage). Coverage of mulch is improved by applying from more than one direction (avoids 'shadowing'). • Inadequate rate of seed, fertilizer or amendments. • Seed desiccation due to poor contact with soil. • Applying tackifiers without sufficient drying time before rainfall.	• Ensure the landscaping contractor is applying the specified rate of mulch, seed, fertilizer, tackifier and amendments. • On rough soils, consider applying seed prior to hydromulch, • Inspect germination and seedling growth. Reapply seed to bare spots and repair erosion damage. • Ensure application is avoided when rain is forecast.
BMP # 15: Rolled Erosion Control Products	• Improper site preparation. • Inadequate stapling of the RECP, resulting in movement of water beneath the product. • Stretching the RECP can result in pockets under the product and vegetation pushing product off the ground. • Improper overlapping of product sections. • Improper entrenchment at the top and sides of product.	• Ensure soils are smooth and free of clods. • Check to see staples are selected and installed as per manufacturer recommendations. • Ensure all areas of the product application have good contact with the soil. • Ensure sections are overlapped like roofing tiles. • Check for proper entrenchment and compaction at the top of the blanket (and the sides in channels).
BMP # 16: Compost Blankets	• Applied in areas of concentrated flow. • Applied at insufficient thickness. • Compost is too fine or of poor quality (does not meet CCME Class A quality).	• Ensure compost is only applied to areas subject to sheet flow. Divert concentrated run-off away from compost blankets. • Incorporate seed application with compost application. • Obtain compost quality analytical data. • Ensure compost is applied at the correct thickness using a well-graded compost (mix of coarse & fine material).
BMP # 17: Straw/Fibre Wattles	• Failure to properly entrench, overlap and stake wattles, resulting in undermining or joint failure. • Failure to inspect for and remove accumulated sediment on a timely basis.	• When used as slope interrupters, always ensure wattles are placed on contour in a small trench. Stake wattles in place and overlap end sections at least 300 mm (12"). • Remove accumulated sediment when it reaches half the height of the wattle. Use in combination with upstream run-off and erosion control. •
BMP # 18: Aggregate Cover	• Using aggregate that is not durable/weather resistant. • Using sources of aggregate containing contaminants.	• Using only durable aggregate material that can withstand construction traffic. • Check roadways and parking areas periodically to determine if topdressing

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
		is required. • Only use aggregate from a clean source.
BMP # 19: **Riprap**	• Using material that is not durable/weather resistant. • Improper design/selection of riprap. • Failing to use specified design size or gradation of riprap. • Failing to install a suitable geotextile or filter layer below the riprap.	• Ensure critical applications of riprap are designed by a qualified professional. • Check riprap applications to ensure required design depth, rock size and uniformity. • Check riprap applications following heavy run-off and repair any damage.
BMP # 20: **Cellular Confinement Systems/Articulating mats**	• Choosing the wrong product for the specific application. • Poor installation.	• Prior to establishment of vigorous vegetation cover, inspect installations frequently, especially following heavy rainfall/run-off.
BMP # 21: **Live Staking, Wattles & Brush Layering**	• Toe erosion can cause loss of the structure. • Failure to collect plant materials during dormancy. • Failure to soak materials prior to installation.	• For bank stabilization work, ensure the toe of the bank is protected with riprap or other suitable armouring to bank-full discharge. • Biotechnical stabilization only works with certain species and only during plant dormancy.
Sediment Control		
BMP # 22: **Construction site Dewatering**	• Discharging impounded water from a parcel to a City storm sewer, or where it will enter a City storm sewer, without obtaining a drainage or dewatering permit. • Failing to follow the conditions of a permit (such as water quality, water quantity and erosion control). • Failing to have adequate source control measures in place. • Discharging water containing concrete residues or other contaminants. • Failing to monitor the discharge and maintain a log (turbidity readings, pH, etc.)	• Avoid fines/legal action by applying for and obtaining a valid permit prior to dewatering. If water quality or quantity is not suitable for storm sewer discharge, explore other options. Keep copy of permit on-site. Keep permits up to date. • Avoid discharging pollutants such as sediment, concrete and hydrocarbons into a storm sewer, sanitary sewer or receiving water by controlling at the source and implementing treatment controls. • Monitor the discharge at least hourly and be prepared to stop the discharge or implement mitigation or contingency measures if there are problems with water quality or quantity.
BMP # 23: **Sediment Traps & Basins**	• Constructing a trap/basin with insufficient length or storage volume to provide adequate detention. • Failure to implement run-off and erosion controls in the contributing upstream area or to consider soil erodibility. • Failing to frequently inspect structures and remove accumulated sediment.	• Ensure correct length:width ratio (it may be necessary to include baffles to promote sediment settling and reduce short-cutting. • Consider installing a skimmer device to control basin dewatering. • Inspect traps/basins at least weekly and during/after significant rainfall/run-off. Maintain capacity by removing sediment when it reaches no more than 1/3rd of the settling volume. Dispose of sediment to a suitable area not subject to heavy run-off.
BMP # 24:	• Failure to allow sufficient space for	• Leave some space between the toe of

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
Compost Berms & Socks	ponding behind the device. • Failing to install on contour and to run ends upstream. • Failing to use a well graded mix of coarse to fine particles.	slopes and the device. Inspect to ensure devices are installed on contour. • Remove sediment after major storms or at no more that 1/3rd the height of the device. • Repair any damaged sections.
BMP # 25: Silt Fence	• Failing to install silt fence on contour, using 'smile' or j-hook configurations. • Excessive length of fence installation (commonly seen around the site perimeter). • Installing fence too close to a slope toe. • Failing to adequately entrench fence. • Unsuitable or poorly spaced and placed posts. • Not removing the fence once the contributing area is stabilized. • Excessive use of wire backing. • There are very viable alternatives to silt fence (such as compost socks and berms and straw wattles).	• Unless intended as a diversion structure, ensure silt fence is placed so as to safely pond water. Silt fence must not be installed on steep slopes or in areas subject to concentrated flow (it is only suitable for detaining sheet flow). • Ensure there is safe storage volume provided behind the fence. • Ensure fence is installed in a compacted trench or sliced (using a slicing machine). Ensure posts are well staked and closely spaced. • Replace damaged fence and always remove fence once the contributing area is stabilized.
BMP # 26: Storm Drain Inlet Control	• Over-reliance on storm inlet protection; failing to control run-off and sediment at the source. • Failing to use or maintain measures that provide detainment and filtering of storm run-off, resulting in flooding during heavy run-off (including downstream diversion). • Bypassing of inlet protection during heavy flows or due to inadequate installation. • Abandonment of devices, lack of maintenance and ice build up in winter months.	• Always control erosion and run-off at the source: inlet protection is generally only effective at removing some coarse sediment during low flow run-off events. • Ensure inlet controls mainly function by filtering out coarse sediment. Avoid excessive ponding and bypass. • Inspect all devices at least weekly, remove sediment and replace damaged or worn devices. Reassess the effectiveness of devices during run-off events. • Ensure devices are removed once the contributing area is stabilized. • Prior to winter freeze-up, ensure site soils are stabilized and remove any off-site inlet controls (in public areas) that could cause ponding and ice.
BMP # 27: Flocculants & Coagulants	• Failure to review product toxicity testing (aquatic life toxicity) or get approval for use from relevant regulators. • Product not applied as per manufacturer	• There are an enormous variety of chemicals/products marketed for soil stabilization, flocculation and coagulation. Many are ineffective or

BMP	Common Planning/Implementation Mistakes	Inspection & Maintenance Guidance
	specification. • Failure to obtain data on soil texture, pH, jar tests, etc. • Over application of product, resulting in soil dispersion. • Improper mixing of product (for sediment settling).	even toxic: Including cationic polyacrylamides (cationic PAM): Buyer beware. • Product effectiveness can be limited by soil properties such as texture, pH and conductivity as well as application rates. Optimal application rates may need to be determined using jar tests. • Never apply products adjacent to water bodies.

Table 9-2: Example Inspection and Maintenance Record

Date (yyyy/mm/dd): ______________ Project/Location: ____

Developer: ________________________ Contractor: _______________________
Consultant: ________________________

Inspector Name (Print): _________________________ Weather (current & last 48 hours):______________________

STAGE OF CONSTRUCTION FOR INSPECTION/PROJECT AREA

Inspection Checklist (**Mark the appropriate boxes with a ✓ or a note**)	**YES**	**NO**	**N/A**	**NOTES**
Are the approved and up to date ESC report and/or drawings available on-site? Is an inspection/maintenance log being maintained for the site?				
Are appropriate measures in place to control overland run-on and run-off? (Clean run-on/run-off diverted around disturbed areas and dirty run-off contained)				
Are contractors staying within the approved construction limits?				
Are all stockpiles adequately located and stabilized (i.e. located on flat areas, with containment and application of temporary cover if pile exists > 30 days)?				
Have all disturbed areas requiring temporary or permanent stabilization been stabilized with appropriate erosion controls?				
Where possible, is sediment intercepted and controlled close to the source?				
Drainage/Dewatering of impounded water to a storm sewer: Does contractor have a **valid** drainage permit and are all permit conditions being adhered to?				
Are all entry points to the underground storm drainage system adequately protected (on-site and adjacent to site)?				
Are all perimeter controls properly installed and maintained to ensure sediment does not leave the site?				
Are soil and mud being kept off all adjacent roadways? Are construction exits properly stabilized and maintained?				
In dry conditions, is dust adequately controlled on stockpiles and exposed areas?				
In areas where construction is complete, are permanent stabilization measures adequate?				
Have all temporary controls that are no longer needed been removed within 30 days of final site stabilization?				

TYPE OF CONTROL	General Condition Of ESC Measure	General Performance Of ESC Measure	Maintenance Required?	Completion Date	Notes (locations, photos)
Run-on/Run-off:					
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
Erosion Controls:					
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
Sediment Controls:					
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		
	poor/fair/good	poor/fair/good	Yes/No		

INSPECTOR SIGNATURE:______________________________ DATE (YYYY/MM/DD):____________________________

NOTE: Please keep this completed record on-site with your ESC Inspection Records. Records should be kept for three years after final site stabilization.

APPENDICES

APPENDIX A

BEST PRACTICES FOR CONTROLLING EROSION AND SEDIMENTATION ON URBAN CONSTRUCTION SITES

Note: Appendix B (Section 11.0) provides an overview of some common best practices and controls that can be applied to stormwater run-off control, erosion control and sediment control on construction sites. Given the wide range of best practices and products available, new innovations and site specific conditions, this information simply provides some guidance on some of the more common techniques. Consultants, contractors and project managers should have the flexibility to try alternative methods adapted to their specific site needs.

10.0 APPENDIX A: BEST PRACTICES FOR CONTROLLING EROSION AND SEDIMENTATION ON URBAN CONSTRUCTION SITES

Note: These Best Practices are organized by section based on their primary application. Many of these controls and practices provide more than one function (i.e. check dams are primarily used to modify channel gradients and control erosion, but they may also provide some sediment control).

BMP SECTION 1: STRIPPING, GRADING AND SITE PREPARATION

BMP 1: Construction Scheduling and Phasing
BMP 2: Preserving Existing Vegetation
BMP 3: Surface Grading, Roughening and Slope Texturing
BMP 4: Topsoil Salvage and Placement
BMP 5: Stabilized Construction site Exits/Entrances

BMP SECTION 2: EROSION CONTROL: STORMWATER MANAGEMENT

BMP 6: Temporary Berms and Channels (Run-off Diversion And Storage)
BMP 7: Grass-Lined Channels
BMP 8: Riprap-Lined Channels
BMP 9: Slope Drains
BMP 10: Energy Dissipaters/Outlet Control
BMP 11: Check Dams

BMP SECTION 3: EROSION CONTROL: SOIL STABILIZATION

BMP 12: Seeding (Temporary and Permanent) and Sod
BMP 13: Mulching
BMP 14: Hydromulching and Hydroseeding
BMP 15: Rolled Erosion Control Products (Blankets and Mats)
BMP 16: Compost Blankets
BMP 17: Straw/Fibre Wattles (Rolls)
BMP 18: Aggregate Cover
BMP 19: Riprap
BMP 20: Cellular Confinement Systems
BMP 21: Soil Reinforcement Using Live Staking, Wattles and Brush-Layering

BMP SECTION 4: SEDIMENT CONTROL

BMP 22: Dust Control
BMP 23: Construction Dewatering Practices
BMP 24: Sediment Traps and Basins
BMP 25: Compost Berms and Socks
BMP 26: Silt Fence
BMP 27: Storm Drain Inlet Protection
BMP 28: Flocculants and Coagulants

BMP CONSTRUCTION DETAILS/DRAWINGS

Figure **Detail Description**

10.1 OVERVIEW OF BEST MANAGEMENT PRACTICES

BMPs are intended to reduce site erosion potential by stabilizing soils or reducing the velocity of run-off. As it is impossible and impractical to completely control erosion during construction, it is necessary to complement these measures with sediment controls (sediment capture by settling or filtration). For the purpose of understanding the different types of BMPs, they have been split into four general categories of practice. Many BMPs can fit into more that one category (for example, rock check dams can provide both an erosion control and sediment control function), so the individual BMPs are included with their primary category of control. Refer to Table 13 for more information on the suitability of the various best practices detailed in this document for various construction applications.

Stripping, Grading and Site Preparation

Careful planning for construction scheduling and phasing, preservation of vegetation, salvage and protection of topsoil and the protection of sensitive areas should be planned and implemented at the start of any project and continued through the duration of the project until final site stabilization.

Erosion Control: Stormwater Management

Diverting clean run-on away from exposed areas and diverting sediment-laden run-off to sedimentation controls is critical. The velocity of run-off must also be controlled by modifying slope surfaces and reducing slope gradients.

Erosion Control: Soil Stabilization

Exposed surfaces must be protected from the erosive energy of raindrops, surface run-off and wind. Providing rapid and protective cover on all exposed soil surfaces is the single most important practice for minimizing erosion. Cover may include topsoil application, used in conjunction with seeding, mulching, hydroseeding and erosion control blankets. Cover for steep slopes and areas prone to heavy surface run-off includes turf reinforcement mats, riprap, gabion mats, aggregate cover and paving.

Sediment Control

It is essential to ensure adequate practices for settling/filtering sediment from stormwater are in place before sediment-laden water leaves a site. Sediment Controls BMPs can generally be classed as filtering/entrapment methods or impoundment/gravity settling methods.

Table 10-1: Suitability of ESC Practices for Various Construction Stages

BMP \ Activity	Clearing & Grubbing	Stripping& Grading	Temporary Haul Roads	Borrow Areas	Excavation & Underground	Stockpiles	Slopes	Construct Roads, Sidewalks	Stormwater Conveyance	Stormwater Inlet/Outlet	Landscaping	Small Commercial, Industrial, Multi-Family	Small Sites: Residential
Stripping, Grading and Site Preparation													
1. Construction Scheduling and Phasing	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Preserve Existing Vegetation	✓	✓	✓				✓		✓		✓	✓	✓
3. Surface Grading, Roughening & Texturing		✓			✓	✓	✓		✓		✓	✓	
4. Topsoil Salvage & Placement	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓
5. Stabilized Construction Exits	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓
Erosion Control: Stormwater Management													
6. Temporary Berms and Diversion Channels	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓
7. Grass-Lined Channels		✓						✓	✓		✓		
8. Riprap-Lined Channels		✓			✓			✓	✓		✓		
9. Temporary Slope Drains		✓	✓				✓	✓	✓	✓	✓		
10. Energy Dissipaters		✓			✓			✓	✓	✓	✓	✓	✓
11. Check Dams		✓						✓	✓		✓		
Erosion Control: Temporary Soil Stabilization													
12. Seeding and Sod				✓		✓	✓	✓	✓		✓	✓	✓
13. Mulching	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓
14. Hydromulching & Hydroseeding				✓			✓	✓	✓		✓	✓	✓
15. Rolled Erosion Control Products				✓			✓	✓	✓	✓	✓	✓	✓
16. Compost Blankets							✓	✓	✓		✓	✓	✓
17. Straw/Fibre Wattles		✓		✓		✓	✓	✓	✓	✓	✓	✓	✓
18. Aggregate Cover		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
19. Riprap					✓		✓	✓	✓	✓	✓		
20. Cellular Confinement Systems							✓	✓	✓	✓	✓		
21. Live Staking, Wattles & Brush Layering							✓		✓	✓	✓		
Sediment Control													
22. Dust Control	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

BMP / Activity	Clearing & Grubbing	Stripping& Grading	Temporary Haul Roads	Borrow Areas	Excavation & Underground	Stockpiles	Slopes	Construct Roads, Sidewalks	Stormwater Conveyance	Stormwater Inlet/Outlet	Landscaping	Small Commercial, Industrial, Multi-Family	Small Sites: Residential
22. Construction Drainage & Dewatering		✓	✓		✓			✓	✓			✓	✓
Sediment Control (continued)													
23. Sediment Traps & Basins	✓	✓	✓	✓	✓			✓	✓			✓	✓
24. Compost Berms & Socks		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
25. Silt Fence	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
26. Storm Drain Inlet Protection	✓	✓	✓		✓			✓	✓	✓	✓	✓	✓
27. Flocculants & Coagulants		✓	✓	✓	✓	✓	✓	✓	✓			✓	

Table 10-2: Best Practices for Stripping, Grading and Site Preparation

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	CHALLENGES/LIMITATIONS
BMP 1: Construction Scheduling and Phasing	• Protect slopes • Protect vegetation • Ditches/Channels • Large, flat areas • Borrow/stockpiling • Site roads • Protect site perimeter • Protect adjacent areas	• Requires the proper selection and timely implementation of ESC practices prior to the start of construction • Timely, effective sourcing, procurement and delivery of ESC supplies to the site • Avoids/reduces the need to reactively respond to ESC problems, thereby reducing potential damage, cost over-runs and enforcement	• Scheduling and phasing uncertainty increases with project size, duration and complexity Effectiveness is likely to vary as projects proceed • Still depends on proper implementation, inspection and maintenance of ESC practices • Requires frequent re-assessment and modification.
BMP 2: Preserving Existing Vegetation	• Protect Slopes • Protect water bodies • Protect Trees • Protect sensitive vegetation and habitat • Protect site perimeter • Combine with phasing	• Far more effective than all other ESC measures • Native vegetation is adapted to the site, drought tolerant, and will provide shade and erosion protection • Buffer strips around the perimeter of a site can reduce or eliminate off-site sedimentation • Especially suitable to multi-year projects where stripping and grading can be phased	• Requires careful planning by the owner/developer, designers and contractors • Must be considered at the project design stage, otherwise inclusion of this practice is likely to be limited • For sites with diverse topography, it is often difficult and expensive to save existing vegetation due to significant site grading
BMP 3: Surface Grading, Roughening and Slope Texturing	• Exposed soils on disturbed slopes • Large stockpiles • Following topsoiling • Prior to seeding • Ripping/furrowing of flatter stripped areas along the contour reduces erosion caused by run-off and wind	• Decreases run-off velocity and surface wind speed (decreased erosion potential) • Increases infiltration • Traps and retains sediment and seed detached by water and/or wind • Provides beneficial 'seedling-safe' sites for germination/establishment of seedlings • Enhances the performance of topsoiling, mulching and hydroseeding	• Generally impractical for short slopes, very steep slopes or non-cohesive soils • May cause water build-up and sloughing in wet/seepage areas • Provides short-term benefit (may need re-done) and works best when used as part of a system of practices • Grading costs are increased • Long term maintenance requirements (such as mowing) may limit the choice of suitable texturing methods
BMP 4: Topsoil Salvage and Placement	• Preserve soil seed bank and biological, chemical and physical integrity • Ensure timely application of topsoil to slopes and large flat areas immediately following final grading • Ditches/channels	• Useful where it is desirable to establish native plants and indigenous grasses from seeds "banked" in the topsoil • Placing topsoil provides an enriched organic medium and nutrients for plant development • Topsoil absorbs raindrop energy and promotes infiltration (reduced erosion potential) • Stabilized topsoil stockpiles can help shield adjacent areas from the construction site and reduce dust and noise •	• Avoid contamination with subsoil (successful topsoil stripping on large sites requires soil survey information showing topsoil locations and depth. • Topsoil must not be applied to frozen or saturated subsoil. Subsoil often needs to be scarified prior to topsoil placement • Topsoil application on slopes steeper than 2H:1V requires installation of additional erosion controls (such as rolled erosion control products)

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	CHALLENGES/LIMITATIONS
BMP 5: Stabilized Construction Site Exits/Entrances	• All construction site access/exit points	• When used in combination with regular inspection and cleaning of adjacent streets, this practice reduces the off-site deposit of sediment onto public roads and into storm sewer catchbasins.	• May be limited by space constraints • Require frequent inspection and maintenance (especially during wet conditions or clayey soils. • In some cases (wet or soft soils), gravel/rock must be placed on geotextile to prevent 'punching' of material into ground • Requires regular inspection and cleaning of adjacent public streets • May also require a vehicle wash station

BMP 1	CONSTRUCTION SCHEDULING & PHASING	Stripping, Grading and Site Preparation

When to Use

Well-planned construction phasing and scheduling can significantly reduce the amount and duration of soil exposed to erosion by wind, rainfall, run-off, and vehicle tracking.

A construction schedule is a written plan of procedure that best identifies major construction and soil disturbing activities, with an approximate time allotted to each schedule item necessary for its completion. The schedule must be sequenced into an orderly listing of all major land-disturbing activities together with the erosion and sediment control practices planned for each activity. The construction schedule must ensure that:

- **Clearing & grubbing**
- **Stripping & grading**
- **Excavation & underground work**
- **Slopes**
- **Borrow/stockpiling**
- **Site haul roads**
- **Protect site perimeter**
- **Protect adjacent areas**

- All major construction/land disturbing activities and associated erosion and sediment control/stormwater management practices are identified
- Contractors are aware of all practices to be implemented prior to and/or during each stage of construction
- Scheduling and phasing reduces both the area of disturbed soils and the length of time disturbed soils are exposed to wind, rainfall, run-off and vehicle tracking (this includes considering the effect the time of year/season has on erosion potential)
- The project complies with erosion and sediment control regulations, commitments and objectives, and that the developer/project manager and all contractors are aware of compliance requirements and responsibilities
- The schedule is frequently reviewed throughout construction and modified, as required, to meet ESC objectives

Applications and Advantages

- Improves the effectiveness of erosion and sediment control through proper selection and timely implementation of practices prior to the start of construction and during construction
- Allows timely and effective sourcing, procurement and delivery of products and equipment to the site
- Avoids or reduces the need to reactively respond to erosion or sedimentation problems. Having to deal with problems on a reactive basis can result in enforcement actions and the incorrect selection and installation of controls (due to an absence of materials on-site and a lack of time to properly select and install control measures). Reactively dealing with problems can cause cost uncertainty and project budget overrun, as well as result in enforcement for non-compliance
- Although construction scheduling/phasing may increase stripping and grading time and costs due to reduced economy of scale, effective scheduling/phasing can significantly reduce the requirement for erosion and sediment control practices (reduced time and costs for planning, implementing, inspecting and maintaining practices)

Limitations

- Scheduling and phasing requires frequent re-assessment and modification (note: scheduling and sequencing is likely to change as projects proceed, so updates will need to be made to the site erosion and sediment control documents)

- Mitigation of risk and liability not only depends on well-planned scheduling and sequencing: it ultimately depends on proper implementation, inspection and maintenance of erosion and sediment control practices
- Sites requiring a lot of excavation and balancing of soil needs (for example; storm pond construction) can be difficult to phase at stripping and grading stage

Implementation

- Scheduling and phasing must be addressed in the erosion and sediment control design. Except in the case of simple sites that only require implementation of good housekeeping practices, all erosion and sediment control reports and drawings must be prepared by a professional specializing in erosion and sediment control at the pre-tender stage. Although it will be necessary to coordinate scheduling and sequencing requirements with contractors, it is advisable to have the majority of the ESC design completed at bidding stage (to ensure a fair bidding process and successful communication and implementation)
- A construction schedule and sequence, including identification of ESC measures, must be developed for all projects. This requires communication and cooperation between all project stakeholders (developer/owner, project manager, consultants/designers, contractors, regulators)
- The construction schedule and sequence must comply with all applicable regulations, commitments and contractual obligations
- The construction schedule and sequence must be frequently reviewed and modified (when required) to meet changing or unexpected site conditions)
- Minimize the area of disturbed, exposed soil at each project stage by:

  1. Breaking the project site into project phases or smaller work areas
  2. Clearly identifying and implementing construction site boundaries (with signage and fencing/barriers) that confine construction activities within defined areas
  3. Controlling construction vehicles to minimize tracking
  4. Protecting and retaining existing vegetation, whenever possible (include vegetated buffer/filter strips at the site perimeter and to protect water bodies; develop and implement and tree and shrub protection plan that identifies all trees/shrubs and other vegetation to be protected)

Note: Whenever feasible, incorporate staged topsoiling and revegetation of graded slopes as work progresses. Do not leave topsoiling and revegetation until the end of the project!

- Minimize the time that disturbed soil is exposed to erosion and vehicle tracking by:

  1. Completing all work, including the establishment of vegetation cover/permanent erosion control, in one phase before moving to the next phase
  2. Avoiding highly erodible soils or minimizing the time such soils are exposed (stabilize immediately)
  3. Integrating erosion and sediment control implementation into construction activities
  4. Avoiding, where possible, construction activity during wet weather and wet site conditions

- Use stabilized conveyance channels to divert clean run-on and run-off away from exposed areas
- Regularly inspect and maintain all controls and practices
- Close and stabilize open trenches as soon as possible. Sequence trenching projects so that most open portions of the trench are closed before new trenching is begun
- Plan for and practice erosion and sediment control year round. Unexpected rainfall and snowmelt can cause significant erosion at any time of the year. Stabilize all exposed soils, control run-on and run-off and always maintain wet-season sediment trapping devices

Inspection and Maintenance

Routinely verify construction activities and erosion and sediment control implementation is in accordance with the schedule and take corrective action when required. Document site inspections and retain a copy on site

Erosion and Sediment Control Report/Drawings Requirements

- An approximate site-specific scheduling and phasing plan should be provided with the ESC report prepared by the ESC designer. With some projects, the scheduling and phasing plan is determined by the contractor (in such cases, this should be noted when the ESC report and drawings are submitted, with the scheduling and phasing plan submitted prior to construction start-up). The scheduling and phasing plan should be frequently reviewed and updated as required

BMP 2	PRESERVE EXISTING VEGETATION	Stripping, Grading and Site Preparation

When to Use

- **Clearing & grubbing**
- **Stripping & grading**
- **Slopes**
- **Buffer strip around sensitive areas, storm inlets and site perimeter**

Dense vegetation cover protects soil from raindrop impact and can typically reduce erosion rates by 98% compared to sites stripped of vegetation and topsoil. Existing native vegetation usually provides the best soil protection. Only disturbing areas immediately needed for construction is one of the best ways of reducing sediment yield.

The use of buffer strips around water bodies and construction site perimeters provides filtering of sediment from surface run-off. It is generally mandatory to protect riparian (adjacent to water bodies) vegetation and habitat during the planning and implementation of construction projects. Removal or damage of riparian vegetation cover can negatively impact fish habitat.

Note: The cost for preserving existing vegetation during construction will likely be less than the cost of applying erosion and sediment control practices to the disturbed area. Replacing vegetation damaged or destroyed during construction can be extremely expensive.

Applications and Advantages

- Protecting existing dense vegetation is far more effective that other erosion and sediment control practices
- Incorporate existing native vegetation into the final landscape plan. Native vegetation is adapted to the site, drought tolerant, and will provide shade and erosion protection
- Existing trees should be protected as per The City of Calgary Tree Protection Bylaw or other development requirements
- Buffer strips around the perimeter of a site can reduce or eliminate off-site sedimentation
- Protect vegetation on all areas within the site where no construction activity occurs, or occurs at a later date. This practice is especially suitable to multi-year projects where stripping and grading can be phased
- Protect all areas where natural vegetation exists that are designated for environmental reserve. Such areas often include steep slopes, watercourses and riparian habitat

Limitations

Note: The approach of stripping and grading large areas at once is often argued as more efficient and economical, or may be required to achieve dirt balance in some cases. This approach, however, must consider the higher costs of temporary erosion and sediment control practices and due diligence required to prevent the increased potential for sediment releases, liability and enforcement.

- Requires careful, ongoing planning by the owner/developer, designers and contractors.
- Preserving existing vegetation must be considered at the project design stage, otherwise inclusion of this practice is likely to be limited
- For sites with diverse topography, it is often difficult and expensive to save existing vegetation while grading the site satisfactory for the planned development

Implementation

- All vegetated areas to be protected must be clearly delineated on plans and protected prior to clearing and grubbing operations or other soil-disturbing activities.
- Areas of existing vegetation that are scheduled for preservation should be clearly marked with a temporary fence. Minimize disturbance by locating temporary roadways, storage facilities, and parking areas away from preserved vegetation.
- Notify all employees, surveyors, and subcontractors of vegetated areas to be protected.
- Keep equipment away from trees to prevent root and trunk damage. Trenching should be as far away from tree trunks as possible, typically outside the drip line. Trenches should be filled in as soon as possible to avoid root drying. Fill trenches carefully and tamp the soil to fill in air pockets. If roots are exposed to the air, cover them with soil or wet burlap as soon as possible.
- Consider the impact of grade changes to existing vegetation and the root zone.
- Aerate soil that has been compacted over a trees root zone with a mechanical aerator.
- Fertilize stressed or damaged broadleaf trees to aid recovery. Fertilize trees in the late fall or early spring.
- To avoid damage during site cleanup and stabilization, retain protective measures until all construction activity is complete.

Inspection and Maintenance

Follow inspection and maintenance timing requirements and inspect all areas of the construction sites where vegetation is to be preserved. Immediately repair any damage and ensure immediate follow-up with the parties responsible for causing damage.

Erosion and Sediment Control Report/Drawings Requirements

If a report is required, indicate vegetated areas that are to be preserved, including environmentally sensitive areas and buffer strips. On the drawings showing existing and intermediate site conditions, clearly delineate areas where vegetation is to be preserved and provide details on any fencing or other boundaries required on site.

Photo 8: Use of a vegetated buffer strip in combination with a perimeter silt fence and a topsoiled and tracked slope. BMPs work most effectively if they are implemented as part of a system of erosion & sediment control.

BMP 3	SURFACE GRADING, ROUGHENING & SLOPE TEXTURING	Stripping, Grading and Site Preparation

Description and Purpose

Note: The practices outlined in this BMP are not stand-alone measures; they must be used in conjunction with other erosion and sediment control practices.

- **Stripping & grading to Final Stabilization**
- **Slopes**
- **Stockpiles**

Texturing exposed slopes and stripped/graded areas by roughening the soil surface or installing tracks, grooves, furrows or benches that conform to contours helps interrupt the movement of sheet run-off across exposed areas, reducing effective slope lengths and decreasing potential for sheet and rill erosion. Roughening of exposed soils and tracking/grooving/furrowing perpendicular to the prevailing wind can also significantly reduce the detachment and creep/saltation of soil particles by wind.

Applications and Advantages

- These measures are suitable for all compacted stripped/graded areas and all disturbed areas, especially slopes 3H:1V or steeper (on fresh cut of fill slopes to a maximum gradient of 2H:1V)
- Surface roughening and slope texturing are temporary erosion control measures that need to be used in conjunction with erosion control BMPs. Surface roughening provides some instant erosion protection for exposed soils prior to final stabilization with vegetation or other cover
- Texturing will create pockets to entrap coarse sediment, reducing the sediment yield down-slope.
- Good suitability for freshly cut or filled slopes (at least 8 m in length) with a maximum slope of 2H:1V, with reasonably cohesive soils
- Benching/terracing can be used to reduce the effective length of long slopes (break up slopes)
- Decreasing run-off velocity and surface wind speed decreases erosion potential
- Increases infiltration of run-off into the soil
- Traps and retains seed detached by water and/or wind
- Provides beneficial ‘seedling-safe’ sites for germination/establishment of seedlings
- Enhances the performance of topsoiling, mulching and hydroseeding

Limitations

- Generally impractical for short slopes with insufficient room for machinery to manoeuvre
- Generally Not suitable for excessively steep slopes and/or non-cohesive soils
- May cause water build-up and sloughing in wet/seepage areas (obtain geotechnical advice)
- These practices provide limited, short-term benefit and work best when used as part of a system of practices/controls
- Grading costs may be increased

Installation

- Do not run heavy equipment on excessively wet soils as this will increase compaction

Surface Roughening/Furrowing

- Always leave exposed soils in a rough-graded condition; do not smooth grade soil

- On large, relatively flat stripped and graded areas, reduce wind erosion potential by furrowing or ripping the soil perpendicular to the prevailing wind direction (using the ripper teeth on a grader is very effective; depth should be 0.15 to 0.30 m). When furrowing sloped areas, ensure that the furrows run perpendicular to the fall of the slope

Surface Tracking (also known as cat-tracking or track-walking)

- Use tracked construction equipment to move up and down the slope, leaving depressions perpendicular to the slope direction. Limit machine-tracking to one or two passes to prevent excessive compaction
- Avoid this practice on excessively wet or clayey soils
- Tracked depressions in the soil will decrease run-off velocities, trap sediment, improve seedling development and increase infiltration of water
- For topsoiling and surface tracking, be sure to immediately seed and mulch roughened areas to obtain optimum seed germination and seedling growth. Establish good soil and seed contact

Terracing/Benching

- Construct narrow, flatter sections of terrain on the slope, perpendicular to slope direction
- Benches/terraces should be to be reviewed by a qualified geotechnical engineer for slope stability
- Benches/terraces must be graded back towards the slope and drain with a gentle gradient to a stable outlet
- This practice should be carefully considered as benching increases local slope gradients and, where positive down-slope gradients and drainage is not provided for all areas, can result in ponding, gully formation and slope instability

Inspection and Maintenance

- Inspect a minimum of once every seven (7) days and during or within 24 hours of rapid snowmelt, rainfall events of 12 mm or greater in a 24 hour period, or rainfall on saturated soils
- Areas damaged by rilling or erosion should be re-graded and re-seeded

Construction Details

Refer to:

Figure 9: *Surface Roughening*
Figure 10: *Stepped or Terraced Slopes*
Figure 11: *Grooved or Serrated Slopes*

Erosion and Sediment Control Report/Drawings Requirements

- If a report is required, describe locations that will require surface roughening/furrowing, surface tracking and/or terracing, and outline the various stages of construction where these practices are to be implemented. On the drawings, clearly delineate areas to receive this treatment and provide construction details, including notes on timing, inspection and maintenance

1994 JOHN McCULLAH
Surface Roughening
FILE: srfrough.dgn
TRACKING
CONTOUR FURROWS
Source: Salix Applied Earthcare - Erosion Draw 5.0
'
WATER SERVICES

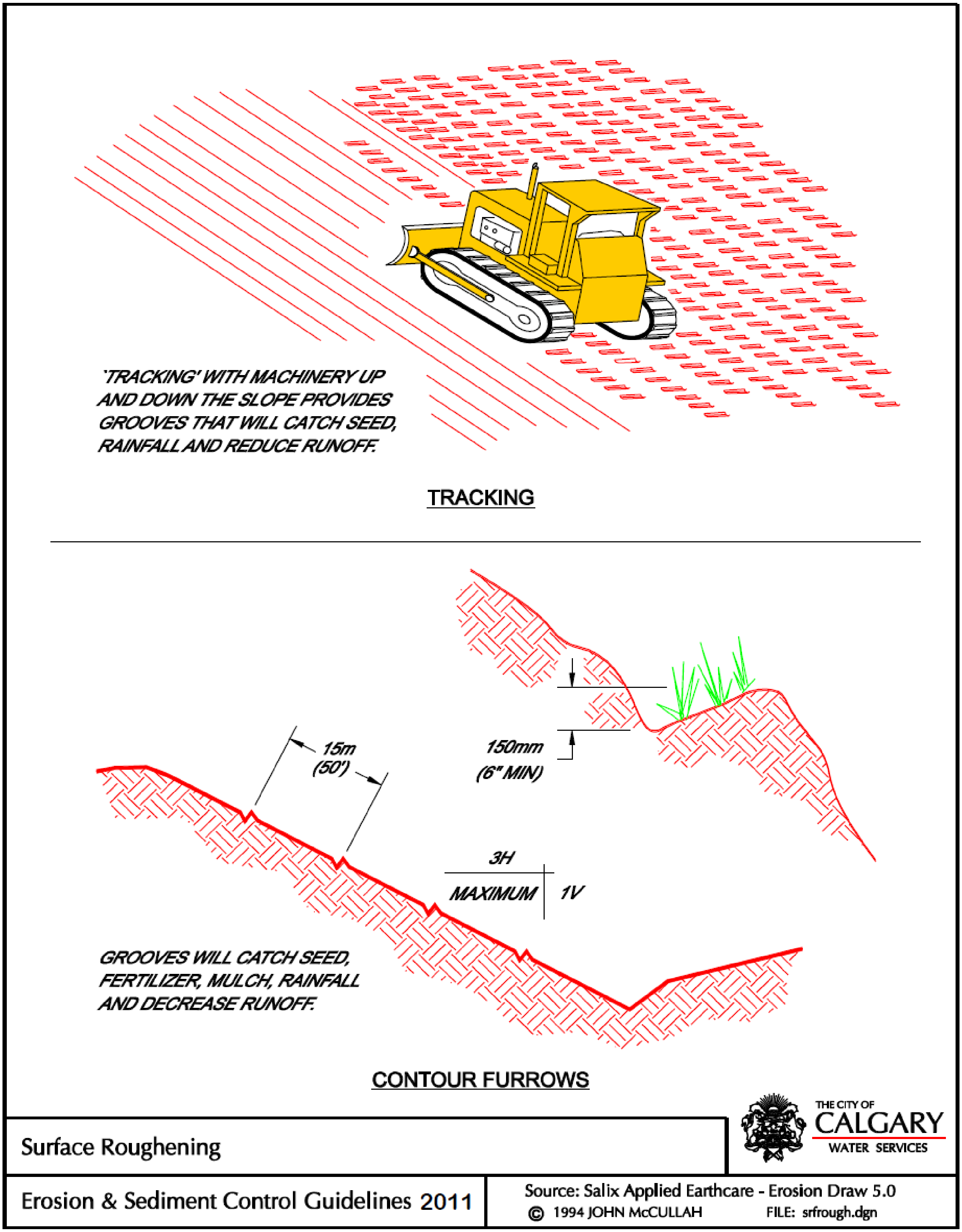
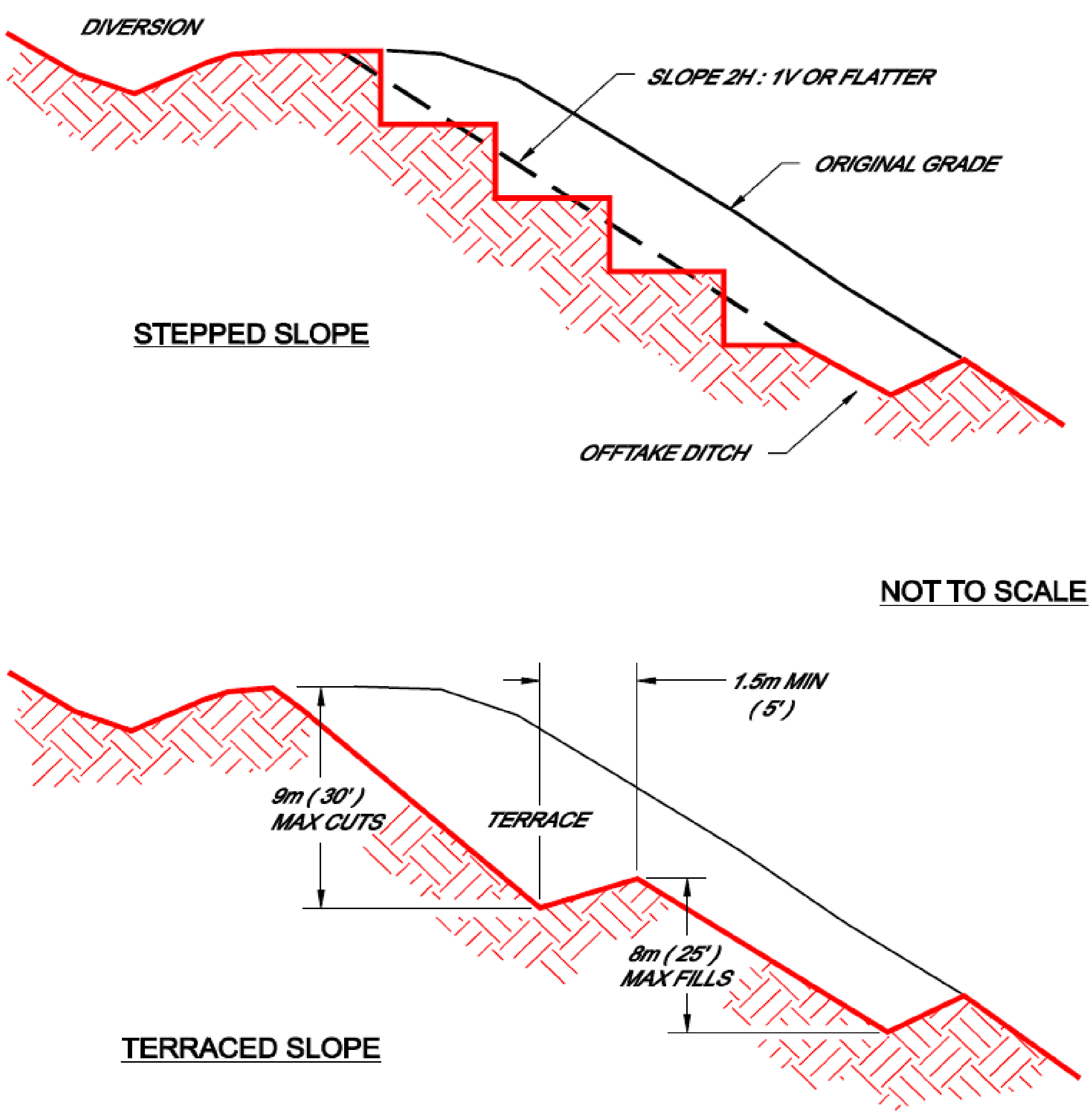


Figure 10-1: Surface Roughening



NOTES:

1. VERTICAL CUT DISTANCE SHALL BE LESS THAN HORIZONTAL DISTANCE.
2. VERTICAL CUT SHALL NOT EXCEED 0.6m (2') IN SOFT MATERIAL AND 0.9m (3') IN ROCKY MATERIAL.

Stepped or Terraced Slope

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
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Figure 10-2: Stepped or Terraced Slopes

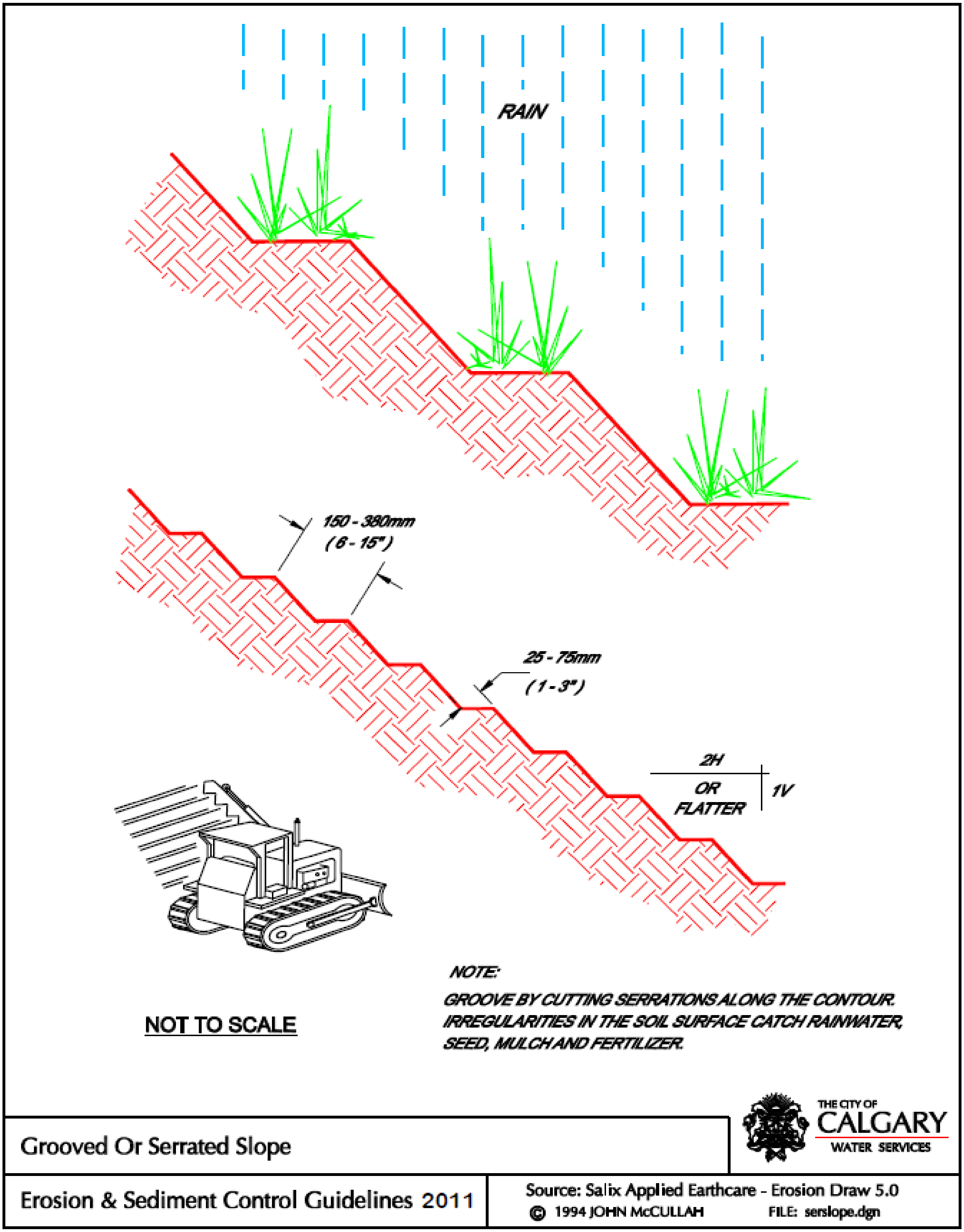


Figure 10-3: Grooved or Serrated Slopes

BMP 4	TOPSOIL SALVAGE AND PLACEMENT	Stripping, Grading and Site Preparation

Note: Subgrade preparation, topsoiling, sodding and seeding within land designated as a **City Park** is subject to the requirements detailed in the most current edition of the City of Calgary Parks' "Development Guidelines and Landscape Specifications, Landscape Construction".

Description and Purpose

- **Clearing & grubbing**
- **Stripping & grading**
- **Slopes**
- **Borrow Areas**
- **Haul Roads**
- **All Sizes of Sites**

The preservation and use of topsoil enhances final stabilization of construction sites with vegetation. Topsoil is the surface horizon (A horizon) of the soil profile, generally characterized as being darker than subsoil due to the presence of organic matter. The A horizon constitutes the major zone of root development and microbial activity, providing much of the nutrients and water available to plants.

Calgary Parks defines topsoil as "a fertile, friable, natural loam, containing not less than 4% organic matter for clay loams and not less than 2% organic matter for sandy loams to a maximum of 15%. Topsoil should be free of rocks >50mm in diameter, subsoil contamination, roots and weeds and have a pH within 7.0 – 8.5. Native soils should be used for restoration of natural areas and environmental reserves (by stripping and stockpiling the A horizon)".

The **timely** placement of topsoil (which typically has a coarser texture and better structure than subsoil) over mineral soil can significantly reduce raindrop and sheet erosion potential and increase infiltration.

Topsoiling may involve bringing in soils from off-site or merely replacing fertile topsoil that was stripped and stockpiled during earlier site development activities. The salvage and placement of topsoil can provide a suitable growth medium for the establishment of sustainable vegetation cover and a supply of native or locally occurring seeds/propagules.

Applications and Advantages

- A sufficient supply of topsoil is required (salvaged and/or suitable imported material).
- Topsoil application is recommended on slopes 2H:1V or flatter.
- This practice is especially useful where it is desirable to establish native plants and indigenous grasses from seeds "banked" in the topsoil.
- Topsoil is usually placed prior to seeding, mulching and installation of rolled erosion control products (RECPs) or planting of trees/shrubs.
- Topsoil stockpiles can help shield the construction site from the neighbouring developments and help to reduce the amount of dust and noise coming from the site.
- Placing topsoil provides enriched an organic medium and nutrients for plant development.
- Topsoil absorbs raindrop energy and promotes infiltration (reduced erosion potential).

For construction sites, salvaging or importing suitable topsoil is required where the subsoil or existing soil has:

- Texture, pH, or nutrient balance that cannot be modified by reasonable means to provide an adequate growth medium;
- Material that is too unsuited to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth, and/or;
- Substances potentially toxic to plant growth.

Limitations

- Successful topsoil stripping on large sites requires soil survey information showing topsoil locations and depth.
- Topsoil must not be applied to frozen or saturated subsoil.
- Topsoil is generally not appropriate for slopes steeper than 2H:1V, unless additional erosion controls (such as rolled erosion control products) are installed.
- Storage stockpiles of topsoil must be carefully located to avoid double handling.

Implementation (stockpiling and placement)

Note: The following notes are provided for guidance only. Always consult a professional specializing in erosion & sediment control to ensure appropriate planning, implementation, inspection and maintenance of erosion & sediment controls and practices.

- Do not apply topsoil that has significantly contrasting texture to the subsoil (for example: placement of sandy topsoil over clayey subsoil can cause lateral movement of water between soil layers and resulting slumping).
- Working the topsoil into the subsoil layer to a depth of at least 150 mm can improve bonding and water infiltration.
- All surface run-off control structures must be in place prior to soil stripping.
- Care must be taken to avoid contamination with undesirable subsoil when stripping/salvaging topsoil.
- Topsoil should be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). It should be free of debris, garbage, stumps, rocks, roots, and noxious weeds, and should be able to support healthy plant growth.

Topsoil Stockpiling

- First, determine if the quality and quantity of topsoil available will justify selective handling and will be suitable for reapplication (loam, sandy loam and silt loam topsoil is ideal; sandy clay loams, silty clay loams, clay loams and loamy sands are reasonable; heavy clay topsoil and organic peats and mucks are not suitable).
- Use soil survey/geotechnical information to determine the depth of topsoil stripping (it is likely to be variable across the site).
- Implement sediment basins/traps, diversions, and other temporary controls before stripping.
- Only strip topsoil from areas to be disturbed by excavation, road building or compaction.
- Topsoil stockpiles must be located in flat areas, away from overland drainage.
- Topsoil stockpiles must be located so as not to interfere with construction activities.

- A number of strategically placed small stockpiles allow for more economical, easier replacement during final site stabilization.
- All subsoil and topsoil stockpiles in place for more than seven days must be protected with temporary erosion control such as mulch/tackifier or covered. Stockpiles that will be in place more than thirty days must be vegetated.

Topsoil Placement

- Prepare the ground surface to final grade by removing large rocks and debris.
- Loosen the subgrade by discing or scarifying to a depth of at least 75mm (or to 200mm where subsoil compaction exceeds 95% standard proctor).
- Topsoil must be uniformly distributed to a depth of at least 150mm for seeded areas to 600mm for shrub planning.
- Apply topsoil with a dozer or light track equipment to the design thickness.
- Topsoil must be applied in a moist condition and kept moist to reduce wind erosion.
- Do not apply topsoil in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may be detrimental to proper grading or proposed sodding or seeding.
- Machine track walk upslope or down slope (do not over compact topsoil by heavy equipment; only track walk with one pass) to provide contour tracking (erosion control practice).
- If seeding or sodding over topsoil, work must be completed as soon as possible following topsoil placement.
- Until vegetation is established the topsoil should be regularly moistened during prolonged dry weather to reduce wind erosion and promote germination and seedling establishment (application of tackifier/mulch may be required to provide temporary erosion control).

Inspection and Maintenance

Prior to final stabilization, inspect areas that have received topsoil application at least once per week and after significant storm events (sufficient to cause erosive run-off) and snowmelt.
Areas damaged by washouts or rilling must be re-graded, re-topsoiled and seeded immediately.

Photo 9: Providing vegetation cover on this soil stockpile controls erosion and helps preserve the biological, chemical and physical integrity of the soil. Perimeter control (silt fence) was installed around the pile to control migration of sediment during stabilization.

Photo 10: Timely final grading and site preparation, followed by application of topsoil reduces the exposure of highly erodible subsoil to erosion. Upon completion of topsoil application, additional erosion control measures detailed in the Erosion & Sediment Control Plan should be implemented.

BMP 5	STABILIZED CONSTRUCTION ENTRANCE/EXIT	Stripping, Grading and Site Preparation

Definition and Purpose

Note: Gravel or rock can be prone to tracking off-site, especially where large vehicles are leaving the site. Coarse woody slash material offers a good alternative to gravel where rock is being tracked onto adjacent streets.

- **Clearing & grubbing**
- **Stripping & grading**
- **Haul Roads**
- **Borrow Areas**
- **All Sizes of Site**

Site access/exit points must be stabilized so as to reduce the tracking/flowing of sediment off construction sites by vehicles. Stabilization traditionally consists of application of a geotextile/gravel Placement of a layer of coarse woody slash (such as chipped woody material from construction site clearing) also provides an excellent option for controlling track-out. There are also manufactured portable products available for temporary construction entrance and exit control. When used in combination with regular inspection and cleaning of adjacent streets (as necessary), this practice reduces the off-site deposit of sediment onto public roads and into storm sewer catchbasins.

Tracking pads must be installed at all locations where vehicles enter or exit a construction site. In addition, it may be necessary to include a wash station with a water supply and wash water containment & detention for excessively muddy vehicles.

Note: Construction plans must limit traffic to properly constructed and stabilized entrances/exits at all times. Construction exit sediment control is limited by the effort to control sediment at the source: Where possible, keep traffic off wet or clayey soils and that do not have to be on-site on the street. Conduct frequent inspections for mud-tracking and implement a street cleaning program where tracking of mud continues to be a problem.

Limitations

- May be limited by space constraints.
- Tracking pads require frequent inspection and maintenance (such as top-dressing), especially during wet conditions or tracking of clayey soils.
- Gravel/rock must be placed on geotextile to prevent ‘punching’ of material into the ground and reduced effectiveness.
- A properly constructed wash station may be required for washing of excessively muddy vehicles along with regular inspection and cleaning of adjacent public streets.

Implementation

- Optimal rock size for gravel pads is 50–75 mm (ensure rock is hard, durable and angular). Erosion control drawings must indicate the specific grade and dimensions of the rock to be applied.
- The thickness of the pad must not be less than 150 mm. The width and length of the pad must be as required, but a minimum width of 3.6 m (12 feet) and a minimum length of 13 m (50 feet).

- Locate construction entrances and exits to limit sediment leaving the site and to provide for maximum ease of use by all construction vehicles. Avoid entrances which have steep grades and entrances to curves in public roads.
- The entrance must be maintained in a condition that will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional rock and repair/ maintenance of any measures used to trap sediment.
- All sediment spilled, dropped, washed or tracked onto City streets must be removed immediately.
- When necessary, vehicle wheels/tires must be washed to remove sediment prior to entrance onto City streets. When washing is required, it must be done on an area stabilized with crushed stone that drains into an approved sediment trap.

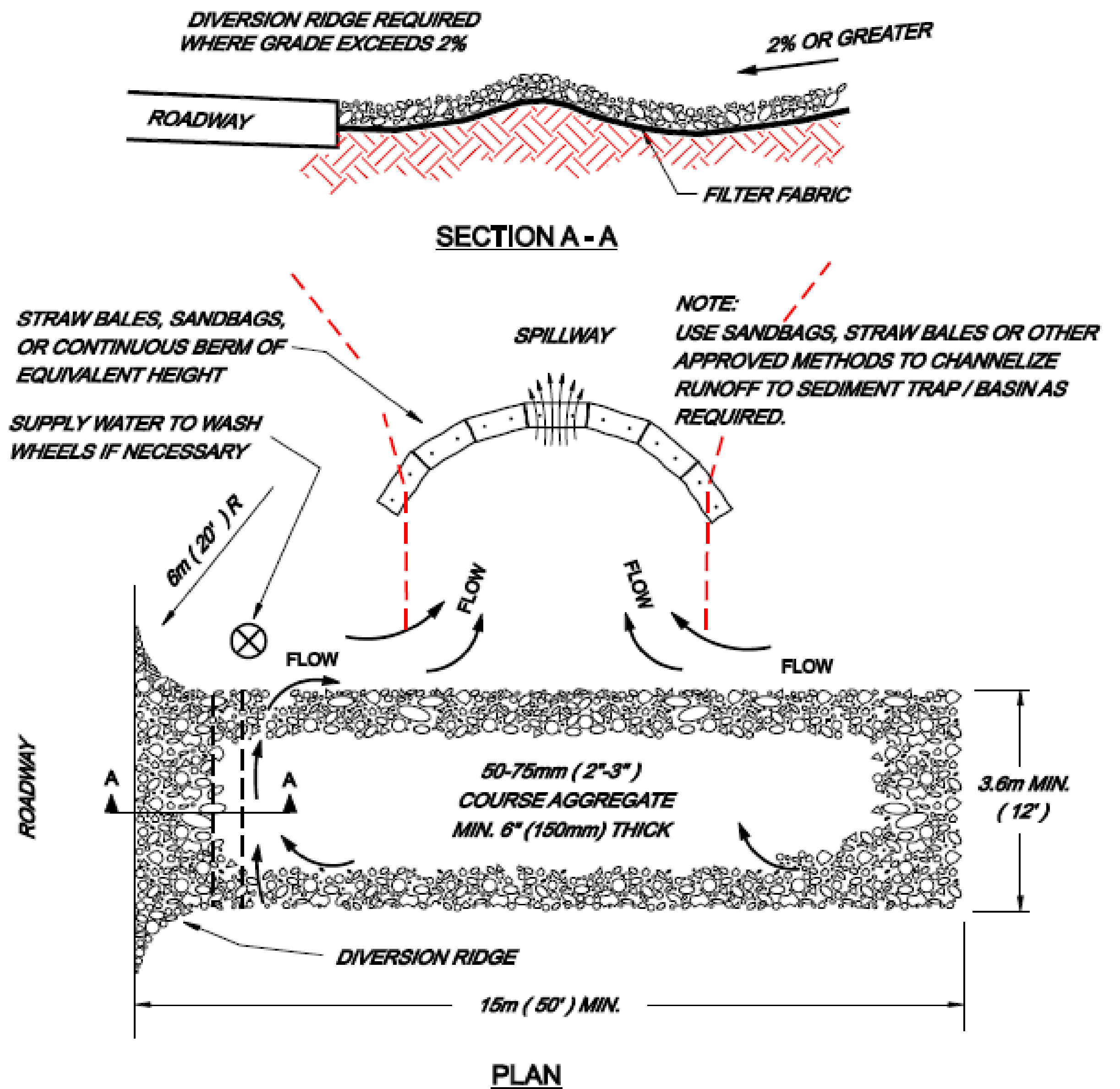
Inspection and Maintenance

- Maintain the gravel pad in a condition to prevent mud or sediment from leaving the construction site (frequently inspect and top-dress with clean rock as required).
- After each rainfall, inspect any structure used to trap sediment and clean it out as necessary.
- Immediately remove all objectionable material spilled, washed or tracked onto public roads.

Construction Details

Refer to:

Figure 12: Temporary Gravel Construction Entrance/Exit



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 CLEAN OUT 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.*

Temporary Gravel Construction Entrance / Exit

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0

 FILE: entrance.dgn

Figure 10-4: Temporary Gravel Construction Entrance/Exit

Table 10-3: Best Practices for Erosion Control: Stormwater Conveyance

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	CHALLENGES/LIMITATIONS
BMP 6: Temporary Diversion Berms and Swales	• To contain and divert clean run-off away from disturbed soils. • To contain and divert sediment-laden run-off to sediment controls. • To protect adjacent property, buildings and structures from flooding. • Used in conjunction with slope drains.	• Minimizes erosion caused by excessive sheet flow over exposed slopes. • Simulate natural flow conditions more than paved or enclosed stormwater conveyances. • Open channels are usually less expensive to construct than other types of conveyance. • Open channels are easy to inspect and maintain.	• Channels may have to be lined to minimize erosion. • Channels must be designed by a geotechnical engineer/hydrologist if flow velocities and/or volumes are large. • Berms greater than 1 m in height should be designed by a geotechnical engineer. The consequences of failure must be considered. • Channels must be located on stable slopes and must maintain positive drainage to avoid water ponding and breaching. • May need to remove accumulated sediment from channel.
BMP 7: Grassed/ Vegetated Channels	• Suitable for channels with maximum grade $\leq$ 5%. • Construct at 2 – 5% grade to convey drainage at low velocities.	• Resemble natural channels and should be the preferred option where low gradients and design velocities are possible. • Generally less expensive to install than curb, gutter and underground storm drainage. • Relatively easy to construct. • Provide reduced flow volume by allowing infiltration and reduce outlet velocities by providing surface roughness. • Can provide some pre-treatment of run-off prior to discharge to another treatment system.	• Vegetation establishment can be slow in Calgary's climate: Additional temporary stabilization measures may be required. Vegetation will not survive in sections of channels subject to sustained flow. • Soils should be suitable to establish a vigorous stand of vegetation. If dense vegetation cannot be maintained in the swale, its effectiveness will be severely reduced. • Channel excavation will produce a significant amount of spoil material.
BMP 8: Riprap-Lined Channels	• Generally used as a permanent erosion control measure for channels. • Riprap or similar linings can be installed relatively easily using heavy construction equipment. • Channels with highly erodible soils on gradients > 2% and flow velocities ranging from 2 – 5 m/sec).	• Permanent erosion control • Can provide a durable, flexible and low maintenance erosion resistant lining.	• Generally need to be designed and specified by a qualified professional. • Riprap or similar linings are expensive (dependent on rock size, local availability, transportation and handling costs). • Channel/ditch must be excavated and prepared prior to riprap placement (this includes over excavation of the channel to accommodate the required riprap thickness and the disposal or excavated spoil). • Always require the replacement of an extra-strength, non-woven filter fabric or a gravel blanket underlay to prevent the entrainment and displacement of erodible material from the

<table>
<tr><th rowspan="2">BMP</th><th rowspan="2">APPLICATIONS</th><th colspan="2">COMMENTS</th></tr>
<tr><th>ADVANTAGES</th><th>CHALLENGES/LIMITATIONS</th></tr>
<tr><td></td><td></td><td></td><td>underlying soil layer.</td></tr>
<tr><td>BMP 9: Temporary Slope Drains</td><td>• Cut or fill slopes: Where concentrated run-off that collects above a cut or fill slope - and cannot otherwise be conveyed around the slope - would cause severe erosion if it spilled over the slope.</td><td>• Allows temporary conveyance of concentrated run-off down a cut or fill slope without causing erosion.</td><td>• Proper sizing, installation and maintenance is critical to ensure function until permanent conveyance is installed or the slope is stabilized.
• Serious scour erosion can occur at the inlet structure if not properly installed and maintained (can cause slope drain failure).
• Outlet must have adequate energy dissipation to prevent erosion.</td></tr>
<tr><td>BMP 10: Energy Dissipaters/Outlet Erosion Control</td><td>• At outlets where concentrated run-off transitions to an erodible area.
• At inlets, to prevent scour erosion.
• In channels, to reduce scouring.</td><td>• Utilizes a non-erodible, rough surface to dissipate the energy of flowing water, thereby reducing erosion.
• Only requires a small area for construction.
• Riprap aprons are relatively easy and inexpensive to construct.</td><td>• Adequate sized material is required to handle high flow conditions.
• Many dissipaters can be expensive and labour-intensive to construct.
• Use of grouted riprap is not recommended in Calgary due to potential for freeze-thaw damage.
• Extreme discharge velocities require design by a qualified professional will be required.</td></tr>
<tr><td>BMP 11: Check Dams</td><td>• Temporary or permanent erosion control practice in channels.
• Only suitable for channels subject to periodic flow.
• May provide some limited sediment control (ponding and settling of coarse sediment) behind the structure. Note that checks dams should primarily used for erosion control and channel grade control, not sediment control.
• NOTE: Straw bales and silt fence do not work. Do not use silt fence in concentrated flows.</td><td>• Reduce flow velocities in channels (erosion control).
• Flatten the effective channel grade.</td><td>• Permanent check dams may obstruct ditch maintenance activities (i.e. mowing).
• Must withstand displacement at high flows.
• Rock checks restricted to ditch gradients less than 8%, flow velocities less than 1.5 m/sec and drainage areas less than 4 ha.
• For high flows, water must be able to flow over (not around) check dams.
• Silt fence and straw bales are <u>not</u> suitable for use as check dams.
• Provide minimal sediment control.
• Creation of turbulence downstream can cause erosion of the channel banks/base.
• Ponded water may kill grass in grass-lined channels.
• Synthetic barriers can become brittle in winter and be damaged by snow or traffic.</td></tr>
</table>

BMP 6	TEMPORARY BERMS AND CHANNELS FOR RUN-OFF DIVERSION OR STORAGE	Erosion Control: Stormwater Conveyance

Description and Purpose

- **Stripping & grading to Final Stabilization**
- **Haul Roads**
- **Stormwater Conveyance**
- **Slopes**

Temporary Diversion Berm: A temporary ridge of compacted soil constructed to divert or pond run-off (from catchment areas ≤ 2 ha / 5 acres) away from sensitive areas such as exposed slopes or water bodies. Note: Where the berm serves to divert run-off, flows must be contained in a stabilized channel (swale or ditch) to a stabilized outlet. Temporary diversion dikes are often used as a perimeter control in association with a sediment trap or basin. If properly installed in the first phase of grading, construction and maintenance costs are very low.

Continuous Berm (also see BMP… Compost Berms and BMP…Compost Filter Socks): A temporary diversion berm or sediment barrier constructed with soil, sand or aggregate encased within geosynthetic fabric. Continuous berms may be used to intercept and divert sheet flow from smaller contributing areas (≤ 0.4 ha or 1 acre), allowing sediment to settle. Continuous berms are an excellent alternative to silt fence as they provide continuous contact with the ground surface and do not require entrenchment. Continuous berms are useful for erosion & sediment control around the perimeter of a construction site. Continuous berms may be constructed as filter berms (with aggregate and permeable filter fabric) to facilitate the trapping of sediment and the drainage of stormwater.

Temporary Diversion Channel: Where a temporary berm is intended to divert run-off around sensitive areas or to a sediment-trapping facility, it will be necessary to construct a ditch or swale to convey run-off to a stabilized outlet.

Applications and Advantages

- Used as a temporary measure. Properly designed earthen berms and diversion channels may also be used as a permanent measure.
- Commonly located along the crest of exposed cut and fill slopes, around the site perimeter, as perimeter protection around material stockpiles or around water bodies or other sensitive areas.
- Can also be located below steep grades where run-off begins to concentrate.
- On moderately sloping areas, berms may be placed at intervals to trap and divert sheet flow before it has a chance to concentrate and cause rill and gully erosion.
- To protect adjacent property, buildings and structures from flooding.
- Used in conjunction with slope drains (refer to BMP).
- An effective method of intercepting, diverting and conveying surface run-off around or through a construction site to a stabilized outlet channel or sediment-trapping facility in a non-erosive manner.
- Minimizes erosion caused by excessive sheet flow over exposed slopes.
- Diversions are preferable over paved or enclosed stormwater conveyance systems because they simulate natural flow conditions. Flow velocities are kept to a minimum, some settling of solids may

be achieved, and infiltration is permitted. When included in the site landscaping plans, permanent berms and diversion channels can be attractive and functional.

- Open channels are usually less expensive to construct than other types of conveyance.
- Open channels are easy to inspect and maintain.

Limitations

- Diversion channels may have to be lined to prevent erosion.
- Diversion channels must be designed by a geotechnical engineer/hydrologist if flow velocities and/or volumes are large. Berms greater than 1 m in height should be designed by a geotechnical engineer. In addition, in determining the level of design and construction required, the consequences of failure must be considered.
- Channels must be located on stable slopes and must maintain positive drainage to avoid water ponding and breaching of channel flow.
- Accumulated sediment may require regular cleanup and channel maintenance may be difficult due to limited access
- Run-off must be directed to a stabilized outlet and channel.

Implementation

- Temporary channels must be able to handle a minimum of peak flow from a two year storm event. In cases where flooding and the resulting damage could be severe, additional practices to provide temporary storage and control of run-off must be designed and implemented.
- Care must be applied to correctly size and locate earthen berms, drainage channels and continuous berms. Excessively steep, unlined channels may be subject to erosion and gully formation.
- It is important to stabilize berms and channels with vegetation or other erosion-resistant materials as soon as possible after construction. The contributing drainage area of permanent diversions should also be stabilized as soon as possible to prevent excessive erosion and sediment deposition in the channel.
- When working on public land, always check the suitability of seed mixes and vegetation with relevant authorities.

Temporary or Permanent Diversion Berm

- Temporary diversion berms must be installed as a *first step in stripping and grading activities* and must be functional prior to land disturbance in the upstream catchment area.
- Berms must be constructed of suitable material and adequately compacted to prevent failure.
- Berms must be located so as to minimize damages by construction operations and traffic.
- Berms can usually be constructed with equipment used for site grading.
- The catchment area for a temporary berm must not exceed 2 ha.
- Construct the berm from the bottom up by placing and compacting lifts of soil (suitable material and degree of compaction to be determined by the designer).
- Typical berm dimensions are: ≥0.5 m high, with a crest of ≥0.6 m. Berms must be trapezoidal in cross section with side slopes of 2H:1V or flatter for mixed, cohesive or coarse-grained soils that can be compacted and 3H:1V or flatter for poorly cohesive fine-grained soils.

- To prevent erosion, temporary and permanent diversion or containment berms must be stabilized immediately following construction (i.e. seed and mulch, coarse aggregate cover). Sections of the berm that run-off could flow against will require stabilization with material that can withstand expected water velocity/shear.
- To ensure drainage, berms must include a diversion channel with a positive grade to a stabilized outlet, naturally stabilized channel or sediment trap/basin.

Diversion Channels

- Channels must be constructed with a parabolic or trapezoidal cross sections, with side slopes of 2H:1V or flatter for mixed, cohesive or coarse-grained soils that can be compacted and 3H:1V or flatter for poorly cohesive fine-grained soils. Prior to constructing a diversion channel, construct a stabilized outlet or ensure run-off will flow to a naturally stabilized channel or sediment trap or basin.
- The final channel must have the proper grade and shape of the cross section in order to discharge the design flow and provide positive drainage (minimum 2% slope). Where possible, channel gradient should be minimized so as to minimize erosion.
- Where channel gradient exceeds 2%, armour/stabilize the channel with material designed to withstand water velocity/shear (such as riprap, rolled erosion control blankets, vegetation or a combination of suitable practices).

Continuous Berms

- Continuous berms are generally used as a perimeter control for trapping and filtering sheet run-off from small contributing areas. As with silt fence, the contributing area draining to a berm must not exceed 0.4 ha (1 acre) and contributing slopes must not exceed 10 m in length.
- Continuous berms are constructed with a continuous berm machine (CBM). A CMB has a material feeding chamber (hopper) and fabric rolling system that creates the continuous berm by ‘wrapping’ geosynthetic material around sand, aggregate or soil.
- When employed to capture or divert run-off at the toe of a slope, the continuous berm should be constructed at least 2 – 3 m from the toe of the slope (to provide adequate storage or diversion to a stabilized outlet).
- Woven geotextile is preferred as a casing material due to higher tensile strength. Local suppliers may be able to provide biodegradable casing material for areas where it is required or desirable.
- Drainage of ponded water is dependent upon fabric flow rates and the infill material. Higher permeability material should be used to permit drainage in low lying areas.
- Removal of the berm can be accomplished by splitting the berm, spreading the fill material and removing the fabric.

Inspection and Maintenance

- Except during freeze-up, berms and channels must be routinely inspected at least once every two weeks.
- Measures must be inspected after significant rainfall or snowmelt likely to cause erosion, with immediate repairs to berms, channels, outlet or sediment traps as necessary.
- Prior to freeze-up, ensure all temporary berms and channels are adequately stabilized to handle snowmelt.
- Berms used to trap sediment must be inspected and cleaned out after every significant storm or as needed during regular maintenance.

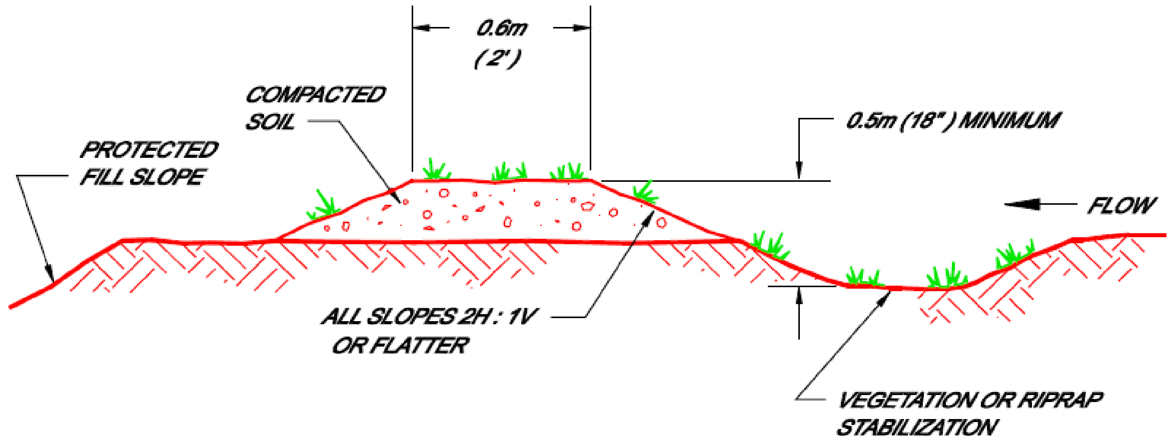
- Damages caused by construction traffic or other activity must be repaired before the end of each working day.
- Reseed areas where vegetation does not become established.

Construction Details

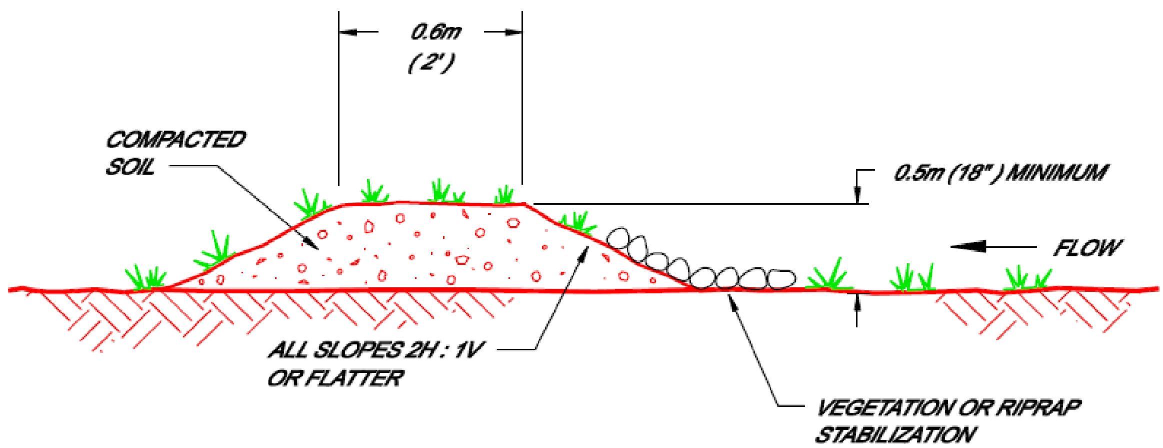
Refer to:

Figure 13: Temporary Diversion Dike

Figure 14: Continuous Berm



TYPICAL FILL DIVERSION



TYPICAL TEMPORARY DIVERSION DIKE

NOTES:

1. *THE CHANNEL BEHIND THE DIKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.*
2. *THE DIKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.*
3. *THE DIKE SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.*

Temporary Diversion Dike

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
© 1995 JOHN McCULLAH FILE: tempdike.dgn

Figure 10-5: Temporary Diversion Dike

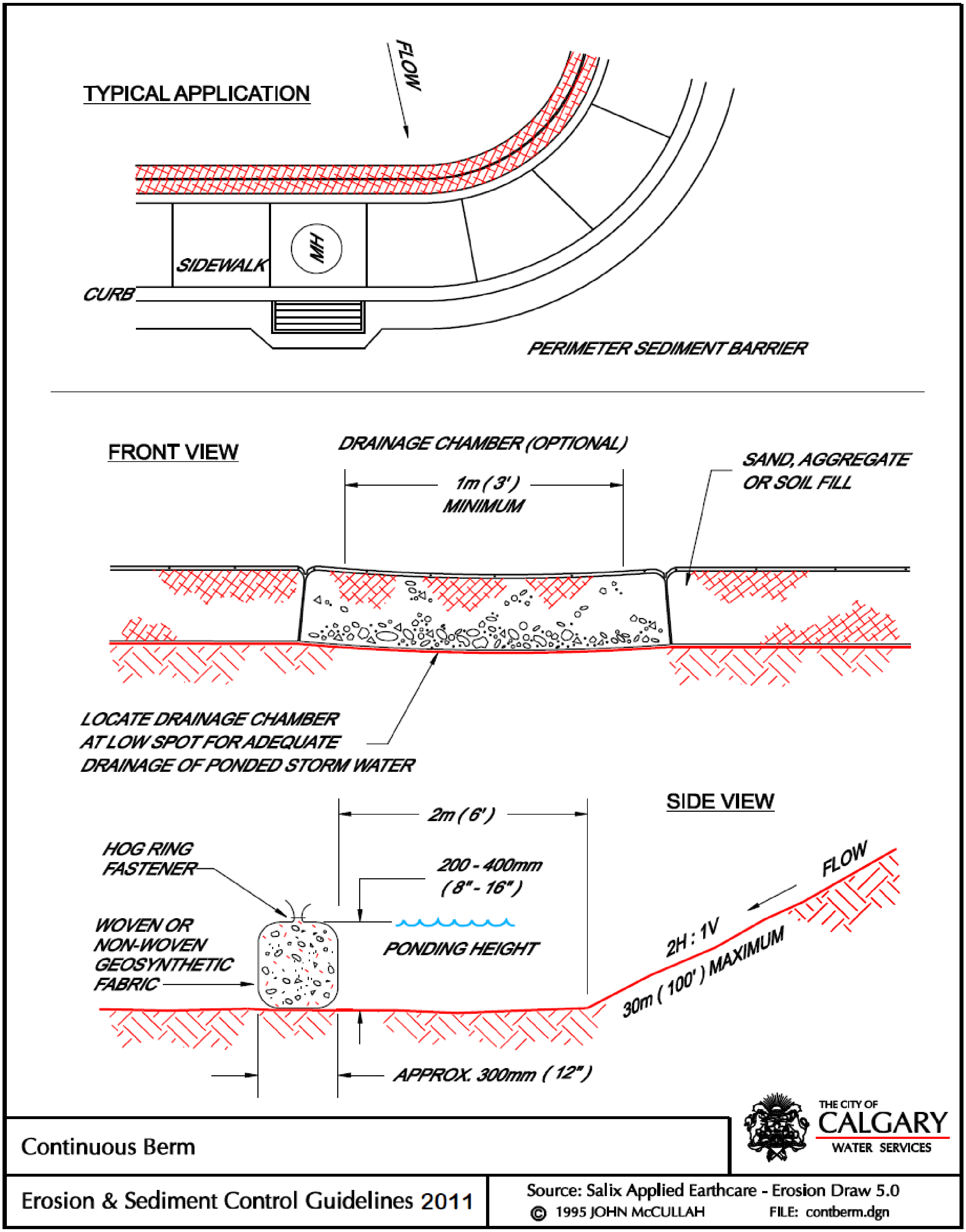


Figure 10-6: Continuous Berm Detail

BMP 7	GRASSED/VEGETATED CHANNELS	Erosion Control: Stormwater Conveyance

Description and Purpose

Vegetation can be used to line natural or constructed channels/swales to provide erosion protection. Vegetation in channels reduces erosion by lowering water velocity over the soil surface and by binding soil particles with roots. Vegetation works best in channels subject to periodic flows of relatively low velocity run-off. Grassed linings are most commonly used for channels (native species, including woody species such as willow could also be suitable for some channels).

- **Stormwater Conveyance**
- **Stripping & grading to Final Stabilization**
- **Temporary or Permanent Measure**

Applications and Advantages

- Incorporating vegetation cover into channels is suitable for channels with maximum grade $\leq$ 5%.
- Vegetated channels resemble natural channels and should be the preferred option where low gradients and design velocities are possible.
- When planning the drainage system for a development, it should be considered that vegetated swales are generally less expensive to install than curb, gutter and underground storm drainage.
- Relatively easy to construct.
- Provide reduced flow volume by allowing infiltration and reduce outlet velocities by providing surface roughness.
- Can provide some pre-treatment of run-off (reduce sediment/other pollutants) prior to discharge to another treatment system (i.e. storm ponds).
- Vegetated channels should be constructed at 1 – 5% grade to convey drainage at low velocities.
- In areas with steep slopes, vegetated channels are best suited to locations where they can be placed almost parallel to the contours.
- Ideally, channel cross sections should be wide, with relatively flat side slopes, allowing surface run-off to enter over the vegetated banks without causing erosion. Riprap may be needed to protect the channel banks in sections where flow velocities and/or turbulence could cause erosion.

Cross-section designs include:

- V-shaped Vegetated Ditches: V-shaped ditches are commonly constructed in narrow corridors (i.e. along roadsides) to convey small quantities of water. Where high flows may occur, V-shaped ditches should be avoided as they can result in high velocity flows.
- Parabolic Vegetated Channels: Parabolic channels can handle larger flow velocities, but require more space. Riprap should be considered where higher velocities are expected and where some dissipation of energy (velocity) is desired. A combination of grass lining with riprap or turf reinforcement mat centres is useful when accommodating continuous low flow in the channel.
- Trapezoidal Vegetated Channels: Used where run-off volumes are large and channel gradient is low (so that velocities are non-erosive to vegetated linings). A riprap lined centre can be included to accommodate low flows.

Limitations

- Vegetation establishment in channels can be slow in Calgary's climate. Additional stabilization measures may be required until a vigorous, sustainable vegetation cover is achieved (for example: Rolled Erosion Control Products, Cellular Confinement Systems, Hydromulching/ Hydroseeding).
- Vegetation will not survive in sections of channels subject to sustained flow. Channels in areas with a high water table or seepage may require a subsurface drain, riprap centre or other suitable means to convey base flow (since sustained wetness usually prevents adequate vegetative development).
- Soils should be suitable to establish a vigorous stand of vegetation. If dense vegetation cannot be maintained in the swale, its effectiveness will be severely reduced.
- Channel excavation may produce a significant amount of spoil material.

Implementation

- The channel shape may be parabolic, trapezoidal, or V-shaped, depending on requirements.
- Vegetated channels must be capable of adequately handling a 10 year, 24 hour design storm.
- To aid in vegetation establishment and allow for maintenance, channel side slopes must be 3H:1V or flatter.
- Late spring and summer are good times for construction of a grassed waterway as the soil can generally be easily worked and grass seed will catch easily. In areas with poor drainage, it will be necessary to work during a dry period.
- Vegetated channels must not be subject to sedimentation from disturbed areas. Sediment traps may be needed at channel inlets and outlets to prevent sedimentation.
- Established vegetated channels resemble natural drainage systems and are usually preferred if design velocities are below 5 ft/sec (1.5 m/sec).
- Outlets should function with a minimum of erosion and must be constructed prior to channel construction (see BMP…Energy Dissipaters).
- Appropriate soil-stabilization methods, such as mulch, mats or blankets, should be used before establishment of vegetation.
- For design velocities > 0.6 m/sec (2 ft/sec), line the channel with sod or install a suitable erosion control blanket or turf reinforcement mat (see BMP…Rolled Erosion Control Products). For design velocities > 1.2 m/sec (4 ft/sec), a suitable permanent erosion control blanket or turf reinforcement mat will be necessary.
- The design water surface elevation of the waterway must be equal to or less than the design water surface elevation of diversions or other tributary channels contributing to water flow.
- Following excavation and grading, the entire channel must be smoothed and compacted to prevent unequal settlement.
- Native grasses develop an extensive root system, but may take several years to become adequately established.
- Select appropriate vegetation and construct channels early in the construction schedule before grading and paving increase run-off rates.
- A stabilized outlet must be constructed prior to operation of the channel.
- It is preferable to use grading equipment to excavate or shape to line, grade and cross section as required to meet criteria.

- The waterway should be free of bank projections or other irregularities, which will impede normal flow. The entire channel should be smoothed and compacted to prevent unequal settlement. Topsoil should be stockpiled and re-spread where necessary to provide a good seed bed. Apply a suitable rate and mix of seed within 24 hours of channel construction and grading.
- Adequate fertilizer must be applied for grass establishment.
- Sodding can provide immediate protection in critical areas. However, mulch or turf reinforcement mat may be used to protect the waterway until the vegetation becomes established.

Inspection and Maintenance

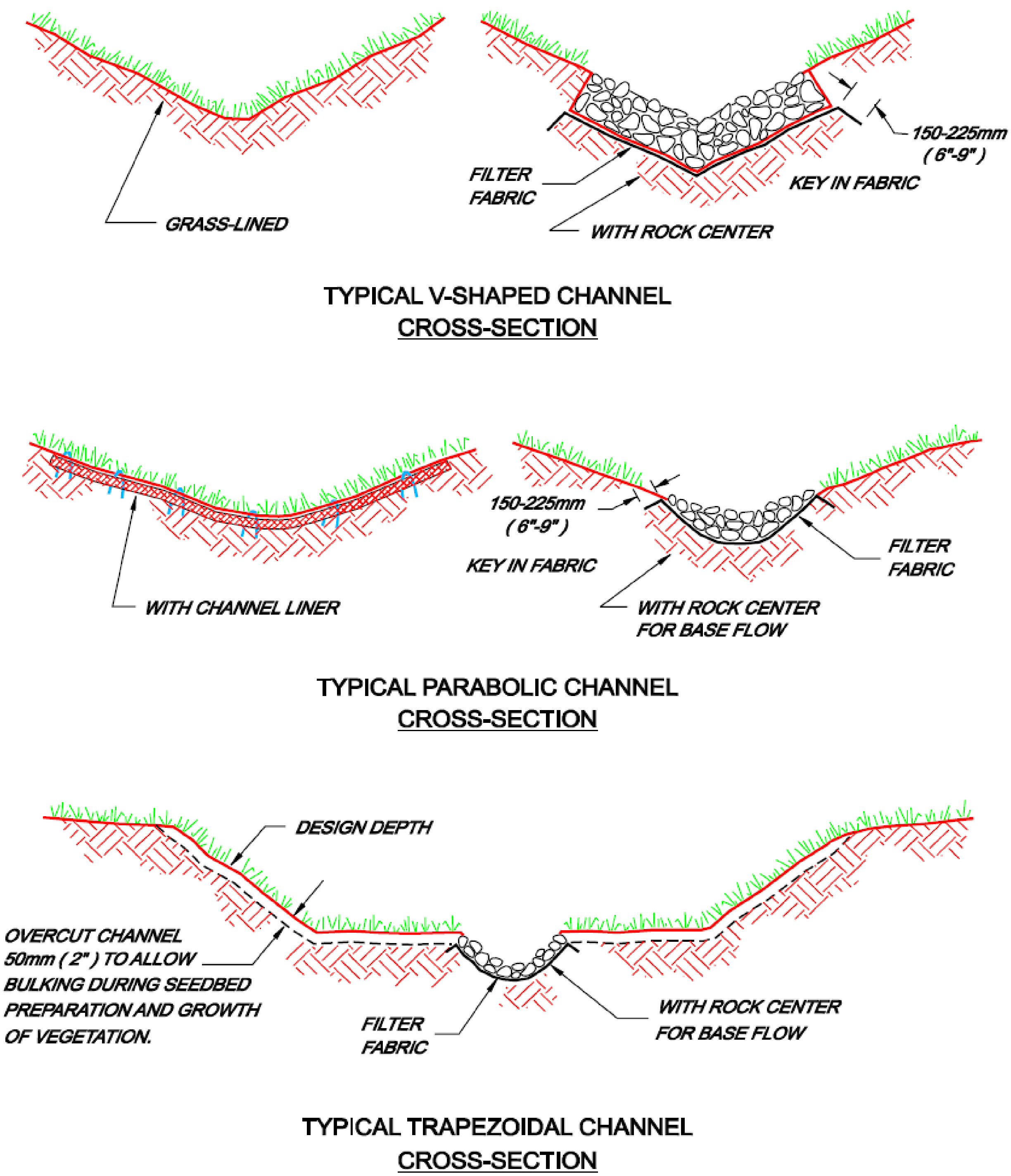
- Regular inspection and maintenance, especially during grass establishment, is important to keep a vegetated channel in good working condition. Bare or eroded spots should be quickly sodded or reseeded.
- Grass provides the primary erosion protection in grass-lined channels. Fertilizing and mowing (with the cuttings removed from the channel) should be done frequently enough to keep the vegetation in vigorous condition.
- After grass has become established, the channel should be periodically checked for debris, scour or erosion and any required repairs made immediately to determine if the channel is withstanding flow velocities without damage.
- Remove significant sediment accumulations to maintain the designed carrying capacity.

Construction Details

Refer to:

Figure 15: Grass-Lined Channels: Typical Cross Section

Figure 16: Grass-Lined Channels: Typical Installation



Grass-Lined Channel: Typical Cross Sections	THE CITY OF CALGARY WATER SERVICES
Erosion & Sediment Control Guidelines 2011	Source: Salix Applied Earthcare - Erosion Draw 5.0 © 1995 JOHN McCULLAH FILE: grass_xs.dgn

Figure 10-7: Grass-Lined Channel Cross-Section Detail

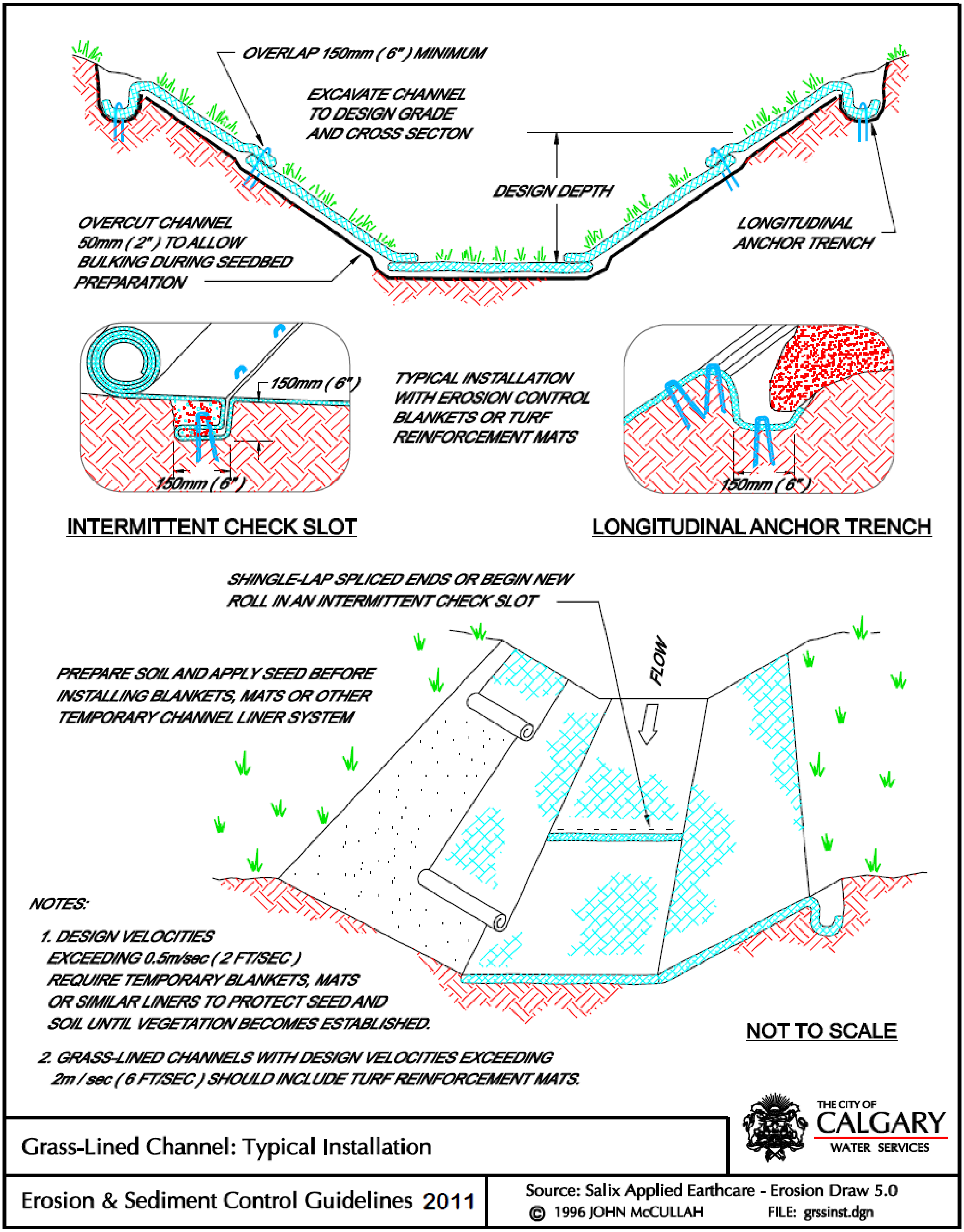


Figure 10-8: Typical Installation Detail for Grass-Lined Channel

BMP 8	RIPRAP-LINED CHANNELS	Construction Site Stormwater Conveyance

Description and Purpose

Note: This practice discusses the use of riprap or loose rock channel lining. There are also several commercially available products, many made from pre-cast concrete (i.e. grid pavers, articulating concrete mats, interlocking concrete blocks) which may be suitable alternatives and may be easier to install than riprap. Pre-cast products must be installed following the manufacturer's directions.

- **Stormwater Conveyance**
- **Stripping & grading to Final Stabilization**
- **Temporary or Permanent Measure**

Lining ditches channels with riprap (irregular shaped, angular, durable rock) or a suitable hard-armour type product can prevent erosion caused by concentrated run-off (due to turbulence and shear).

Applications and Advantages

- Generally considered a permanent erosion control measure for channels.
- Riprap or similar linings can be installed relatively easily using heavy construction equipment.
- Suitable for use in channels where the design velocity exceeds that suitable for vegetated linings (channels with highly erodible soils on gradients exceeding 2% and flow velocities ranging from 2 – 5 m/sec).
- Riprap and similar linings can provide a durable, flexible and low maintenance erosion resistant lining.

Design Capacity: Hard armoured channels must be able to handle a 24 hr, 10 year storm.

Side Slopes: 2H:1V or flatter.

Riprap Size/Thickness: Riprap size and thickness in large and critical channels must be designed by a qualified professional. For all other applications, minimum riprap diameter must be 50 mm (2 inch) and the thickness of the blanket must be a minimum 1.5 times the stone diameter (minimum thickness: 150 mm).

Underlay: Specified extra strength geotextile/filter fabric or well-graded granular underlay.

Channel Cross Section: Must conform as shown on plans for design high flow.

Outlet: must be stabilized prior to starting construction of the channel.

Limitations

- Riprap-lined channels generally need to be designed and specified by a qualified professional.
- Riprap or similar linings are expensive (very dependent on rock size, local availability, transportation and handling costs).
- The channel/ditch must be excavated and prepared prior to riprap placement (this includes over excavation of the channel to accommodate the required riprap thickness and the disposal or excavated spoil).

- Riprap and similar linings always require the replacement of an extra-strength, non-woven filter fabric or a gravel blanket underlay to prevent the entrainment and displacement of erodible material from the underlying soil layer.

Implementation

- Always construct a stabilized channel outlet prior to excavating the channel.
- Excavate the channel cross section to the grades shown on plans. Over cut the channel to accommodate the thickness of the rock and filter.
- Place geotextile or a gravel filter layer so as to provide a complete underlay (overlap upstream sections of geotextile over downstream sections).
- Always use well-graded riprap
- Place riprap or hard armour product so it forms a dense, uniform, well-graded mass with few voids. Hand placement of large riprap may be necessary to obtain good size distribution and avoid damage to the underlay.
- No over-fall of channel construction should exist at the outlet (over-falls result in erosive scour). Grass-lined channels with riprap bottoms must have a smooth contact between riprap and vegetation.

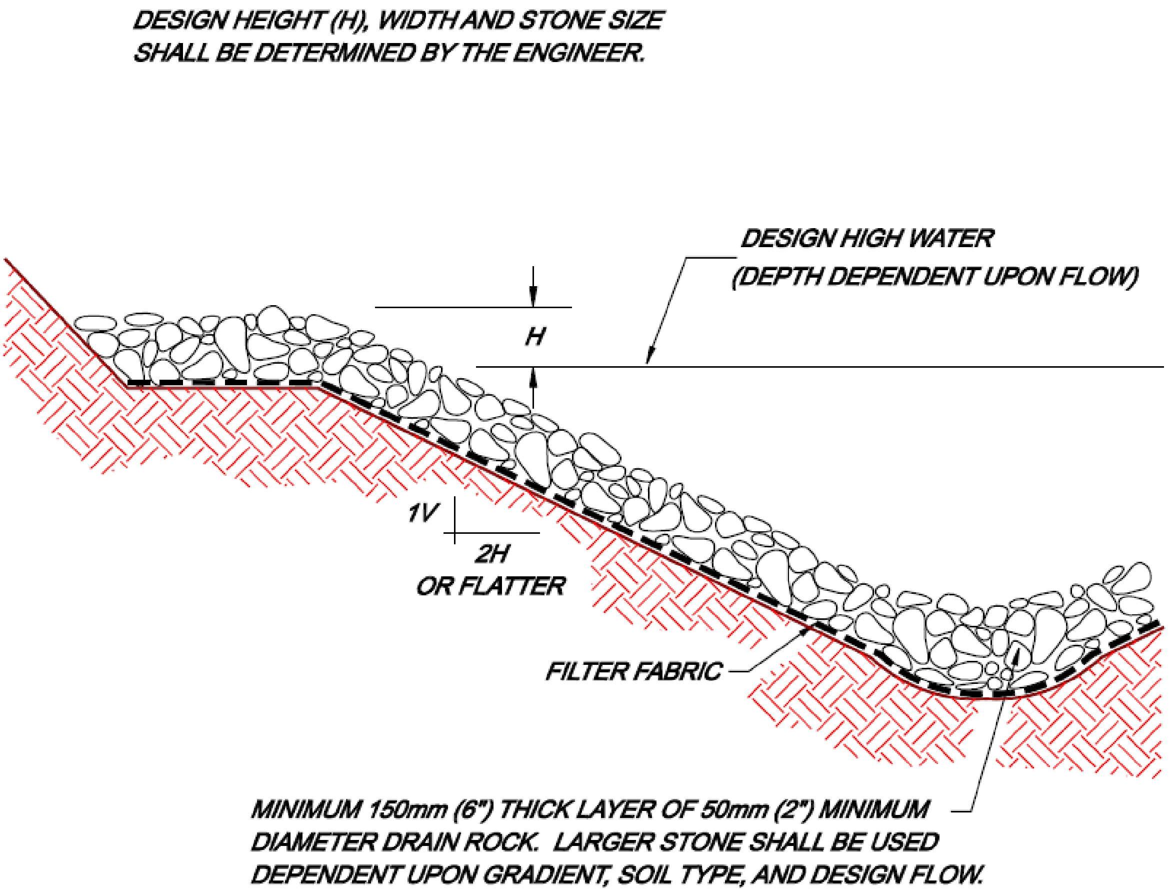
Inspection and Maintenance

Periodically inspect channels, especially after intense or sustained rainfall or snowmelt. Look for sediment accumulation, piping and scouring and bank instability. Be especially cognizant of damage at outlets and at points where concentrated flow enters the channel. Document channel condition, remove accumulated sediment and repair damaged areas immediately.

Construction Details

Refer to:

Figure 17: Typical Detail for Rock/Riprap Lined Channel



TYPICAL SECTION

Rock Lined Channel	THE CITY OF CALGARY WATER SERVICES
Erosion & Sediment Control Guidelines 2011	Source: Salix Applied Earthcare - Erosion Draw 5.0 © 1994 JOHN McCULLAH FILE: rckchnel.dgn

Figure 10-9: Typical Detail for Rock/Riprap-Lined Channel

BMP 9	TEMPORARY SLOPE DRAINS	Construction Site Stormwater Conveyance

Description and Purpose

Constructed slopes are often exposed to erosion between the time they are graded and permanently stabilized. It may be necessary to convey concentrated run-off down an un-stabilized cut or fill slope, while preventing erosion of the face of the slope. A temporary slope drain is a heavy duty flexible tubing, pipe, over-side drain, or other conduit extending from the top to the bottom of a cut or fill slope.

- **Stormwater Conveyance**
- **Stripping & grading to Final Stabilization**
- **Temporary Measure**
- **Used to Protect Exposed Slopes**

Applications and Advantages

- Temporary slope drains are generally used in conjunction with diversions to safely convey run-off down a slope until permanent water disposal measures can be installed.
- The practice is suitable where run-off that collects above a cut or fill slope, and cannot otherwise be conveyed around the slope, would cause severe erosion if it spilled over the slope.

Limitations

- Pipes, channels or other conduits must be correctly sized, installed and maintained to function at anticipated flow volumes until a permanent slope drain is installed, slopes are stabilized with vegetation and the upstream berm and ditch has been either removed or tied into the permanent drainage system.
- Severe erosion at the drain inlet structure, at the outlet can occur if the slope drain is not properly constructed to a stabilized outlet. Improper sizing or lack of maintenance can cause severe gully erosion.
- Slope drains must be securely anchored to the face of the slope.

Implementation

Materials

Temporary slope drains can be constructed from a variety of materials (i.e. flexible, heavy duty corrugated plastic pipe, corrugated metal culvert pipe or as open top over-side drains). The drainage area is used to determine slope drain sizing. The following information table is from the Alberta Infrastructure and Transportation ESC Design Guidelines for Highways (for information only; slope drain diameter must always be included in a design by a qualified professional):

Minimum Slope Drain Diameter Based on Contributing Area

Maximum Contributing Drainage Area (ha)	Minimum Pipe Diameter (mm, inside)
0.2	300
0.6	450
1.0	530
1.4	600
2.0	760

Construction

- Construct a temporary diversion ditch and berm along the top of the cut or fill slope to collect and direct run-off (see BMP 6). The top of the diversion berm must be a minimum of 0.3 m higher than the top of the slope drain inlet.
- Construct slope drains and place them on undisturbed soil or compacted fill at the slope locations indicated on the ESC drawing (more than one slope drain may be required if contributing upslope areas are too large for one drain).
- Always extend the drain beyond the toe of a slope and install a suitable energy dissipater (such as riprap, gravel or a concrete splash pad) at the downslope outlet end of all slope drains.
- Construct an interceptor channel, erosion resistant ditch block or other inflow apron structure (as clearly specified in the design) to the slope drain inlet. Slightly slope the inlet structure towards the slope drain. A T-pipe configuration at the inlet can help water to enter the drain and reduce potential scour or undermining. Seepage and scour at the intake structure is a major cause of slope drain failure.
- Install the slope drain and construct a compacted inlet berm (in 150 mm soil lifts) or barrier with a minimum of 0.45 m compacted soil cover above the top of the pipe to secure inlet.
- The side slopes of the cover fill must not exceed a 2H:1V gradient. Stabilize cover with vegetation or other temporary erosion control as soon as the slope drain is constructed.
- Install adequate scour protection (such as riprap at the inlet).
- Secure slope drains in place so as to prevent movement (i.e. steel anchor stakes, hold-down grommets or another approved method), spacing anchors on each side of the slope drain at maximum intervals of 3 m.

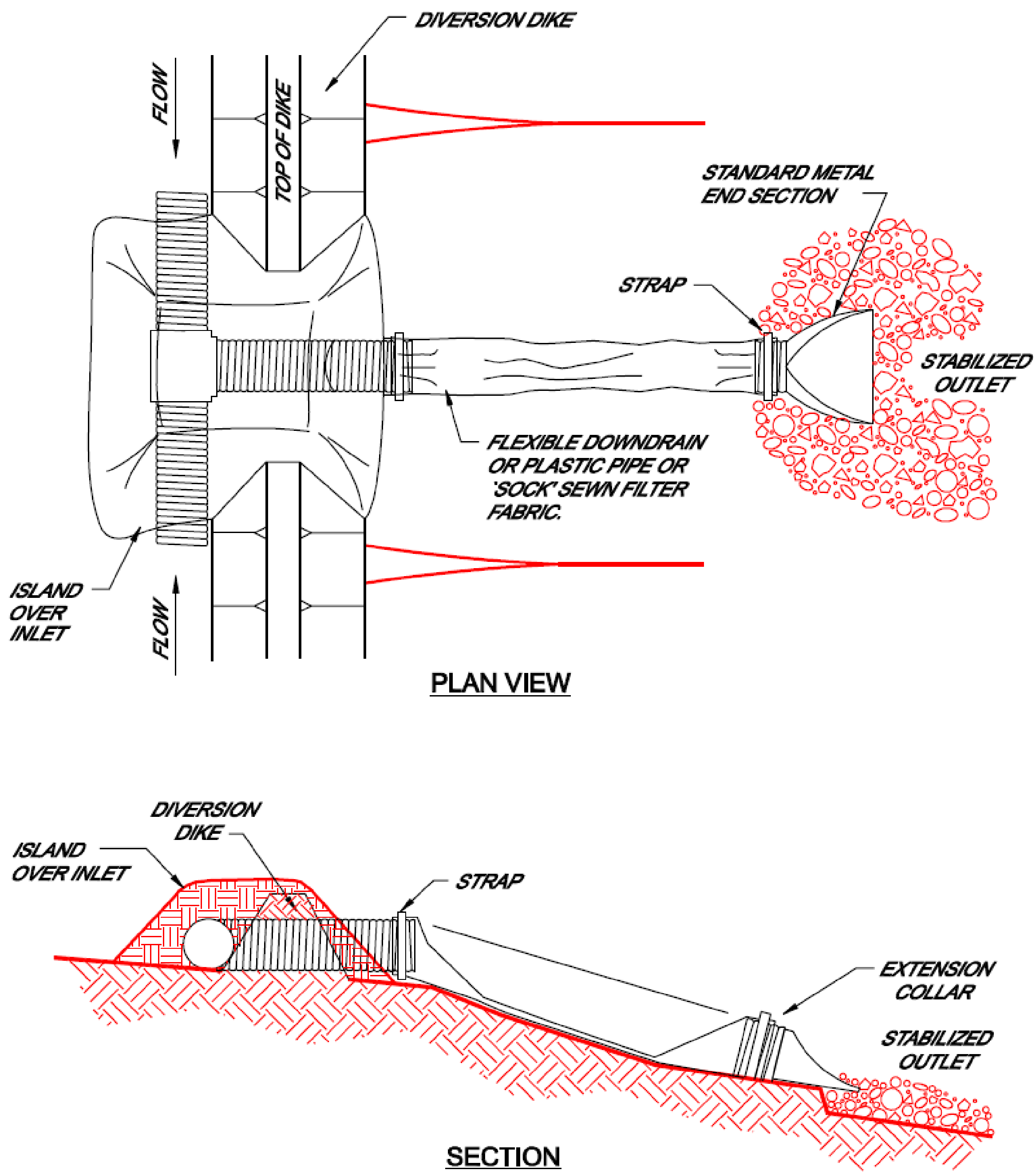
Inspection and Maintenance

- Inspect all slope drains and temporary berms, channels, inlet and outlets at least weekly and after all intense or sustained run-off or snowmelt likely to cause erosion.
- Promptly repair any damage to the slope drain, inlet and outlet and remove any accumulated sediment at the slope drain inlet.
- If there is evidence of slope drain movement, install additional anchors.
- Remove temporary slope drains and clean up and stabilize all residual disturbed areas (i.e. seed and mulch) once the permanent drainage system is constructed, temporary berms and channels have been removed and the slope has been stabilized with vigorous vegetation cover.

Construction Details

Refer to:

Figure 18: Typical Construction Detail for a Temporary Slope Drain



NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM A QUALIFIED PROFESSIONAL.

Temporary Slope Drain

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
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Figure 10-10: Typical Installation Detail for Temporary Slope Drain

BMP 10	ENERGY DISSIPATERS	Construction Site Stormwater Conveyance

Description and Purpose

Energy dissipaters are structures/hard armour placed at pipe outlets, in channels, and immediately downstream of check structures to reduce the velocity and dissipate the energy of concentrated water flow, thereby minimizing erosion and scour potential. Energy dissipaters can reduce flow energy in a relatively small area.

- **Stormwater Conveyance**
- **Temporary or Permanent Measure**

Applications and Advantages

- Ensure an appropriate energy dissipater is installed whenever the discharge velocity of a water conveyance exceeds the permissible velocity of the receiving channel or disposal area (i.e. where a lined conveyance channel discharges to an unlined area).
- Energy dissipaters known as splash pads should also be installed where storm drainage discharges from downspouts of new buildings (permanently or until permanent erosion control such as vegetation is developed).

Limitations

- Use adequately sized material (small rocks can be dislodged during high flows).
- Riprap aprons are relatively cheap and easy to install. Many dissipaters can be expensive and labour-intensive to construct
- Use of grouted riprap is not recommended in Calgary due to potential for freeze-thaw damage;
- May be labour-intensive to construct;
- In the case of extreme discharge velocities, riprap may be unsuitable and a special design by a qualified professional will be required.

Implementation

Design Considerations:

Note: Compliance with federal and provincial legislation is critical when working in, or adjacent to, watercourses. During the planning stage, provide any required notifications to regulatory agencies and obtain all required approvals before commencing work.

Design Storm: Design the dissipater to accommodate a ten-year peak run-off event or the design discharge of the channel, whichever is greater.

Riprap Material: Riprap should be comprised of a well-graded mixture of hard, angular, weather resistant stone (predominantly larger stone with sufficient smaller sizes to fill voids). The diameter of the largest stone size should be no greater than 1.5 times the d_{50} size.

Grade and Alignment: Ensure that the dissipater apron has zero grade and is installed so the surface is even with the surrounding ground (avoid any overfall). Ideally, the apron should be straight throughout its entire length: If a curve is necessary to align the apron with the receiving stream, locate the curve in the upstream section of riprap.

Dissipater Length must be sufficient to adequately dissipate energy. Length should be at least 4.5 times the diameter of the pipe or the channel at the outlet, but extend the dissipater downstream until stable conditions are reached. To prevent back scour, the dissipater apron should extend upstream at least 0.5 times the pipe/channel diameter.

Dissipater Thickness must be sufficient to control erosive energy (riprap dissipater thickness must be at least 1.5 times the thickness of the largest rock, with a minimum thickness of 0.3 m).

Dissipater Width must be at least 4.0 times the diameter of the pipe or channel at the outlet.

Underlay: To prevent erosion of fine material under a riprap dissipater, always install an underlay of heavy duty, non-woven geotextile or a layer of well-graded sand and gravel (at least 150 mm thick).

Construction

- Outlets of all water conveyances must be stabilized to prevent scour erosion.
- Grade the area to final design grades and elevations and excavate at the dissipater location to the required grade for dissipater placement. Compact the sub-grade to the density of the surrounding undisturbed material.
- Install a geotextile fabric or sand/gravel filter underlay.
- Install riprap in accordance with the specified grading limits shown on the construction drawings.
- To prevent damage to the geotextile fabric, a combination of machine and hand placement of riprap is required. Repair any damaged fabric by removing the riprap and placing another piece of fabric over the damaged area. Overlap all fabric joints a minimum of 0.3 m.

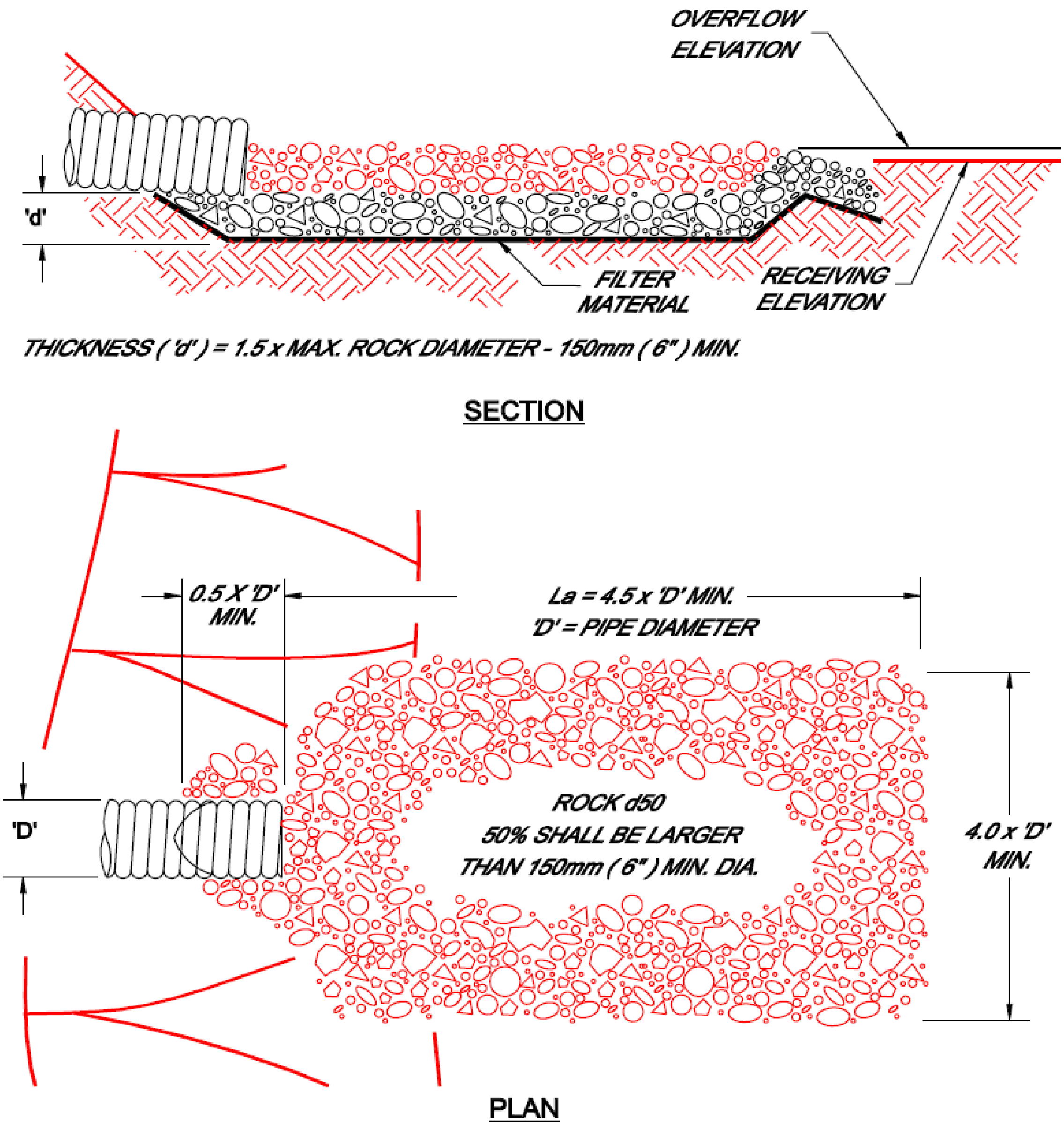
Inspection and Maintenance

- Periodically inspect riprap outlet structures for damage (at least monthly and following significant rainfall or snowmelt likely to cause erosion). Repair damage immediately.
- Energy dissipaters are generally permanent, so do not require removal unless specified.
- It may be necessary to periodically clean energy dissipation controls when voids become filled with sediment and debris.

Construction Details

Refer to:

Figure 19: Typical Installation Detail for Energy Dissipater



NOTES:

1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 150mm (6") THICK MINIMUM GRADED GRAVEL LAYER.

Energy Dissipator

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0

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Figure 10-11: Typical Installation Detail for Energy Dissipator

BMP 11	CHECK DAMS	Construction Site Stormwater Conveyance

Definition and Purpose

Note: Silt fence and straw bales must not be used in areas of concentrated run-off!

- **Stormwater Conveyance**
- **Stripping & grading to Final Stabilization**
- **Generally a Temporary Measure. Rock Checks can be Designed as Permanent**

The Primary purpose of check dams is to prevent erosion by decreasing velocity of run-off in a channel (sediment control is not the primary purpose of check dams). A secondary benefit of properly installed and maintained check dams is the temporary detention of run-off, allowing settling of coarse sediment (note that, if not frequently removed, settled sediment may subsequently be re-suspended).

Check dams can be constructed from a variety of materials (including suitable rock, sandbags, compost filter socks, straw wattles, triangular silt dike and synthetic permeable barriers). As there are a number of different products suited to different situations, the purpose of this information is to provide general guidance on the application, installation, inspection and maintenance of check dams.

Applications and Advantages

- Generally used as a temporary structure (rock checks may be permanent), where the length of service does not warrant the more expensive installation of channel linings.
- Intended to provide erosion control by decreasing run-off velocity in a defined channel.
- Check dams provide grade control by flattening the effective grade of the channel.
- Check dams can provide ponding in low-flow situations, providing relatively good settling of coarse sediment settling and promoting infiltration. Sediment may be re-suspended during higher flows.
- Best used in conjunction with rolled erosion control products.

Limitations

- For higher flows, water must be able to flow over (not around) check dams.
- Silt fence and straw bales are not suitable for use as check dams.
- Properly constructed and spaced check dams can reduce channel erosion, but provide minimal sediment control (sand and coarse silt may be retained, but run-off detention time is usually too short to allow fine sediment to settle).

- Note: Check dams are only suitable for limited drainage areas: Rock check dams are suitable for channels draining areas < 4 ha; other materials (sandbags, wattles, compost socks, synthetic check dams) are suitable for channels draining areas < 2 ha.

- Check dams must not be used in live streams/channels with extended base flows.
- Check dams may reduce the hydraulic capacity of the channel.

- Creation of turbulence downstream can cause erosion of the channel banks/base (incorporate a non-erosive lining such as a section of RECP immediately downstream of a check dam).
- Check dams should not be used in channels that are already grass-lined, unless erosion is expected. Ponded water may kill grass in grass-lined channels.
- Permanent check dams may obstruct construction and ditch maintenance (i.e. cleaning, mowing).
- Severe erosion can occur if dams are undermined or outflanked (water flows under or around the structure).
- Synthetic barriers can become brittle in winter and/or may be subject to traffic and snow damage when used in highway applications.
- Structures/material must be able to resist displacement by flowing water.
- Check dams may require extensive maintenance following large rainstorms or run-off events. Timely removal of accumulated sediment is necessary.

Implementation

Note: Due to the variety of materials used to construct check dams, guidance is only provided for rock check dams and synthetic permeable barriers. Always consult a qualified professional for a site-specific design.

Rock Check Dams

- Rock check dams should consist of clean, free-draining, well-graded aggregate, large enough to remain in place during high flow conditions. It is important that a mix of sufficient size rocks be used to ensure the stability of the structure. Where low flows are expected, mean rock diameter (D_{50}) should range from 75 – 150 mm. For higher flows, larger diameter rock should be used and the structures designed by a qualified professional.
- If constructing a series of check dams, the height and spacing between structures should be designed to reduce channel gradient to intervals of flatter gradient. Always ensure the bottom of the upstream check dam is the same elevation as the top centre of the downstream check dam.
- Excavate a trench perpendicular to the channel flow line (minimum 0.15 m depth), line the footprint with non-woven geotextile fabric and place rock (hand or machine-place; do not dump).
- Build up the structure by machine-placing and hand-placing rocks, ensuring that the structure extends a minimum of 450 mm beyond the tops of the channel banks. The flow-line (dam centre) should be least 300 mm below the elevation of the dam edges (this will allow water to flow over the structure rather than around it).
- The height of structures must be less than 0.8 m (to avoid impounding large volumes of run-off).
- The upstream slope of the check dam must be 2H:1V (minimum) and the downstream slope 3H:1V (minimum).
- Dams must be spaced so that the top elevation of each downstream dam is the same as the elevation of the toe of the adjacent upstream dam.
- The channel downstream of the lowest dam should be protected against erosion.
- Ensure that the upstream contributing area and channel reach is stabilized.

Synthetic Permeable Barriers

- Double panel or triangular panel low profile, porous synthetic barriers can also be used to dissipate run-off flow energy and velocity. Panels are patented designs, constructed with durable, lightweight synthetic materials, and designed to be reusable. Barriers manufactured from biodegradable material are also available.

- By reducing flow energy and velocity, these barriers can enable some settling of coarse sediment and provide temporary stabilization of lower gradient channels during vegetation establishment.
- Install synthetic barriers as per the manufacturer's recommended instructions.
- Synthetic barriers are generally used in conjunction with an appropriate RECP (to provide intimate ground contact between the soil and the base of the barrier, reduce potential undermining and to provide a splash pad immediately downstream of the barrier).
- Ensure the side panels of synthetic barriers are extended to a sufficient height on the outside of channels (to provide sufficient freeboard for channel flow).
- Maximum spacing of a series of synthetic barriers must ensure that the bottom elevation of the adjacent upstream barrier is the same as the top elevation of an adjacent downstream barrier.
- Barriers must be well anchored with pins (as recommended by the manufacturer).

Table 10-4: Maximum Spacing for Check Dams

Source: California Stormwater Quality Association

Ditch Grade	Minimum Weir Depth		
	150 mm	300 mm	450 mm
6 %	Not Recommended	4.5 m	7.5 m
5 %	Not Recommended	6.0 m	9.0 m
4 %	Not Recommended	7.5 m	12.0 m
3 %	4.5 m	10.5 m	15.0 m
2 % or less	7.5 m	15.0 m	24.0 m

Inspection and Maintenance

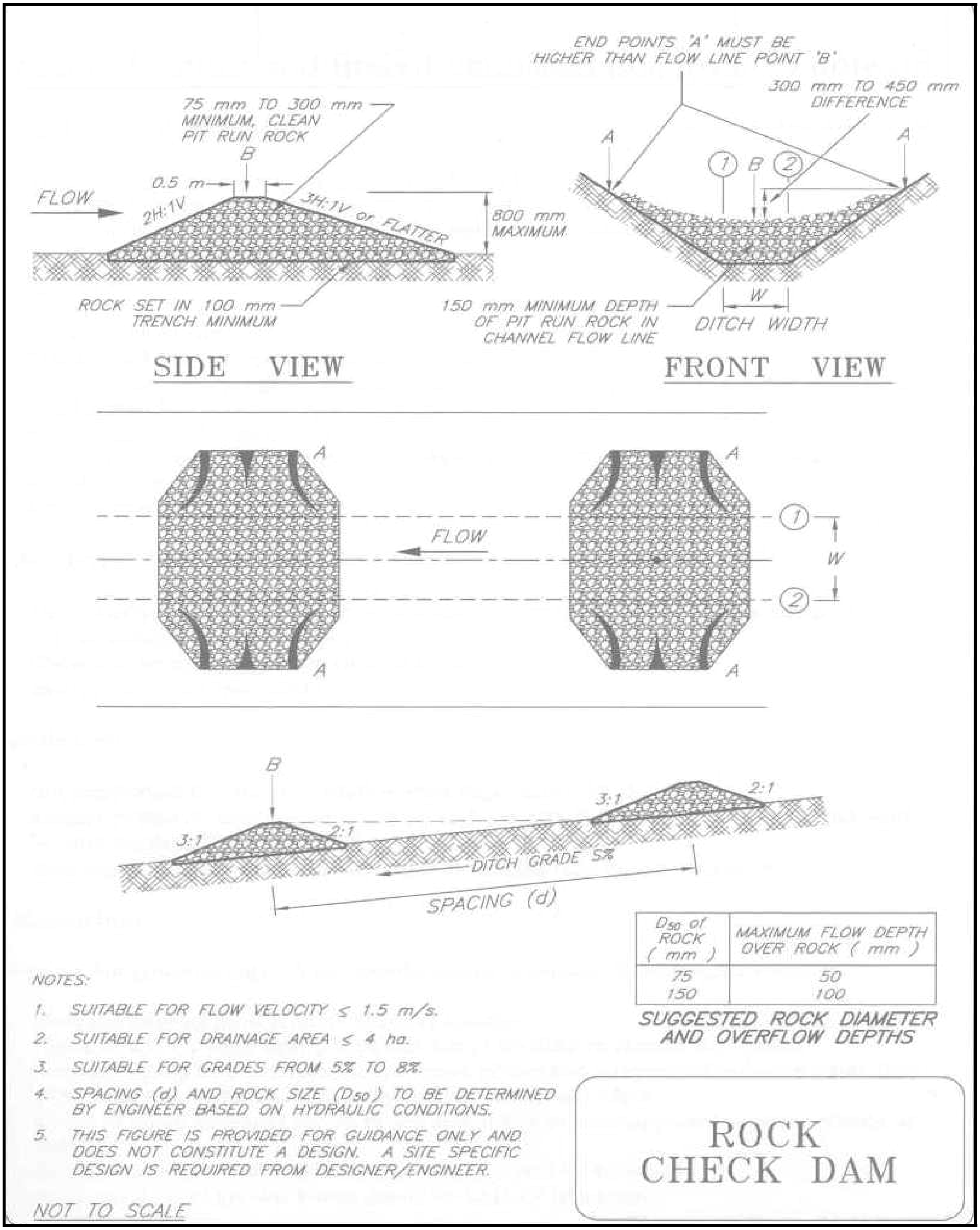
- Prior to permanent stabilization (and except during freeze-up), inspect all check dams and drainage channels at least weekly and after significant rainfall snowmelt likely to cause erosion.
- Repair all damage immediately. If significant erosion occurs between the dams, additional protection may be required (i.e. riprap lining, RECPs, additional check dams).
- Remove sediment behind the dams when it reaches 1/3rd the height of the centre elevation or as needed to prevent damage to channel vegetation and to maintain drainage through the structure.
- For rock check dams, add or remove rock to dams as needed to maintain design height, cross section and flow. Replace dislodged aggregate with heavier aggregate.
- Be careful not to damage check dam structures during sediment removal.

Construction Details

Refer to:

Figure 20: Rock Check Dam

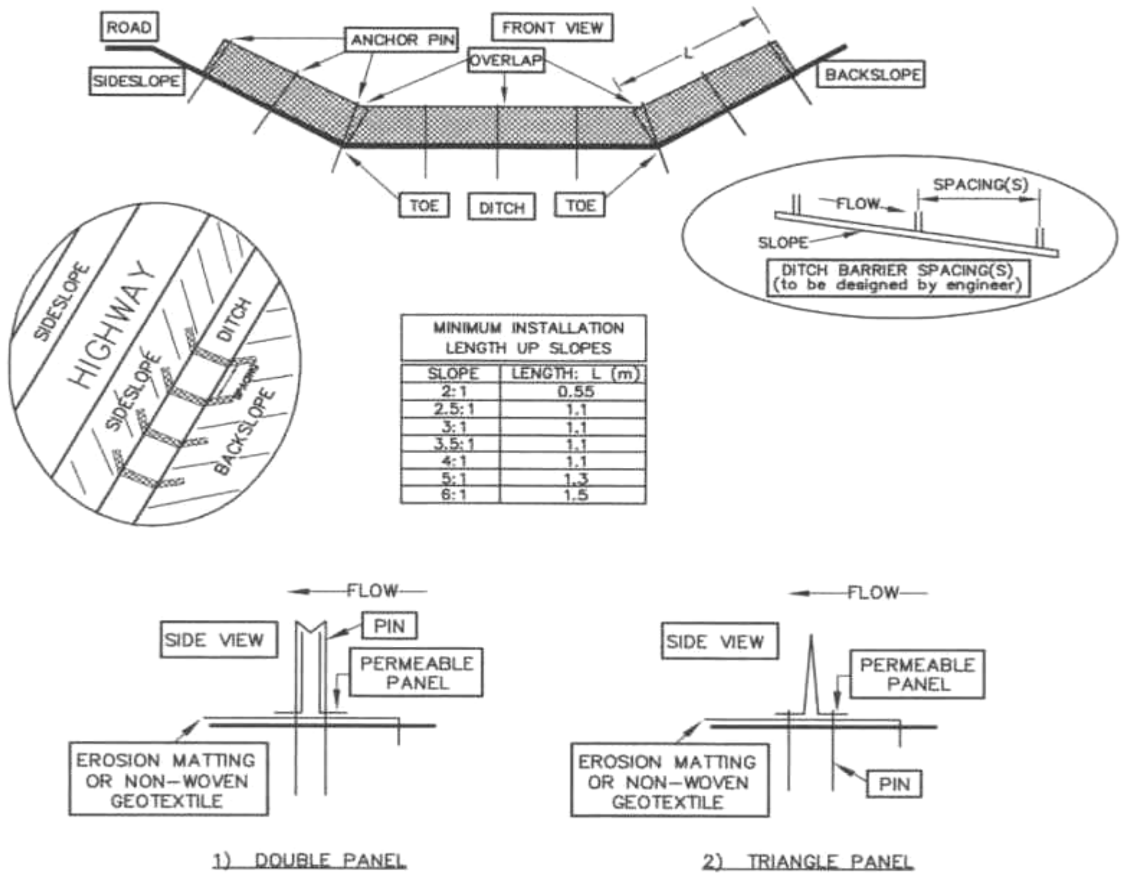
Figure 21: Synthetic Permeable Barrier



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

Figure 10-12: Rock Check Dam Detail

Source: Alberta Transportation; Design Guidelines for Erosion & sediment control for Highways. 2003



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

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

Figure 10-13: Synthetic Permeable Barriers Detail

Source: Alberta Transportation; Design Guidelines for Erosion & sediment control for Highways. 2003

Photo 11: A system of well-installed rock check dams (properly spaced and extended up the sides of the channel) on a road construction project.

Photo 12: Ditch checks can be subject to washout and undermining if not properly installed (spacing, anchoring, and configuration) or used as part of a system of erosion & sediment controls.

Table 10-5: Best Practices for Erosion Control

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	CHALLENGES/LIMITATIONS
BMP 12: Seeding (temporary and permanent) and Sod	• Important component of "phased" construction activities. • Temporary seeding is suitable for some interim areas requiring temporary erosion control (i.e. topsoil stockpiles, rough graded areas, berms). • Permanent seeding is suitable for areas which have been graded to final contour, prepared and topsoiled. • In combination with mulches, RECPs, compost or other erosion controls.	• Vegetation cover on exposed soils helps protect soil from erosion by raindrop impact, increases infiltration and reduces run-off. • Temporary seeding can reduce maintenance costs for other site controls (i.e. sediment traps). • Protects integrity of temporary earthen structures (i.e. diversion and containment berms, compost berms). • Complements other erosion control measures such as RECPs and roughening. • Relatively low cost compared to other ESC measures. • A variety of techniques are available for seed application, depending on-site conditions.	• Can be difficult in Calgary's climate (dry, cool, short growing season). Seasonal planting windows may not coincide with the construction schedule. • Not appropriate for areas subject to construction traffic. • May require additional erosion control measures and irrigation during seedling establishment. • Vegetation may require regular maintenance. • Reseeding and amendments may be required. • Requires the application of a suitable seed mix at optimum rates.
BMP 13: Mulching	• Generally used to provide temporary stabilization of soil, usually until permanent stabilizing vegetation is established.	• Mulch provides effective short term erosion control and can enhance soil temperature and moisture conditions for seedling establishment. • Mulching reduces soil particle detachment, run-off velocity, soil compaction and crusting, and can increase infiltration.	• Most mulches are limited to providing temporary erosion control. • Mulches need to be anchored on steep slopes or in windy conditions. • Best used in combination with vegetation for long-term erosion control. • Mulch type and availability will vary by location. • Some mulches prevent plant establishment.
BMP 14: Hydromulching and Hydroseeding	• Hydromulching: suitable for application of mulch (typically wood or paper fibre). • Hydroseeding: suitable for rapid application of mulch, tackifiers and other specialized soil amendments.	• A cost effective method of uniformly applying multiple materials (seed, fertilizer, mulch, tackifier) in one application to large areas (especially steep slopes and difficult terrain).	• Can be expensive, so is generally limited to large areas and steep slopes. • Requires the use of specialized equipment to mix and apply slurry. • Subsequent applications may be required to maintain mulch cover and/or where seed germination is poor. • On rough sites, seed can be caught up in mulch and desiccate (consider applying seed first).

<table>
<tr><th rowspan="2">BMP</th><th rowspan="2">APPLICATIONS</th><th colspan="2">COMMENTS</th></tr>
<tr><th>ADVANTAGES</th><th>CHALLENGES/LIMITATIONS</th></tr>
<tr><td>BMP 15: Rolled Erosion Control Products (Blankets and Mats)</td><td>• Suitable for application on steep slopes to complement vegetation establishment.
• Some heavier duty erosion control blankets and synthetic turf reinforcement mats are suitable for use in channels (subject to design velocities and shear resistance).</td><td>• Several categories and types of RECPs for a variety of site conditions/applications.
• Some software programs have been developed to assist with RECP selection.
• Can be a temporary or permanent measure (depending on the RECP selected).
• Provide immediate protection of erodible soils on cut/fill slopes at 3H:1V or steeper.
• Protection of exposed soils in ditches and channels (with water velocities of 1 - 2 m/sec) by providing additional shear resistance in conjunction with well-established vegetation cover (TRMs/C-TRMs).
• Useful for medium-term erosion protection on soils exposed outside of a vegetation establishment window.
• On disturbed slopes adjacent to water bodies or environmentally sensitive areas.</td><td>• Long-term erosion control still requires establishment of vegetation.
• Poor selection or installation is a common cause of failure.
• Some site preparation is required prior to installation.
• Product and installation costs can make RECPs expensive. Manufacturers are developing new equipment to speed installation time.
• Ensure only biodegradable or open weave netting is used for application in natural areas, wildlife corridors or adjacent to water bodies.</td></tr>
<tr><td>BMP 16: Compost Blankets</td><td>• Suitable for slopes 2H:1V or gentler, but can be combined with additional practices such as compost berms or compost socks to treat slopes as steep as 1H:1V.
• Must not be applied in areas subjected to concentrated run-off.
• A specified seed mix is usually incorporated with compost during application.</td><td>• Compost is organic, biodegradable and renewable.
• Compost retains a large volume of water and can promote infiltration and vegetation establishment (reduced run-off and erosion).
• Erosion control composts have a well-graded mixture of particle sizes: Compost blankets form a strong, three-dimensional protective soil cover and compost berms and socks are effective at filtering out suspended solids from sediment-laden run-off.
• Beneficial micro-organisms and organic matter promote the vigorous establishment of vegetation, as well as biodegradation of stormwater contaminants.
• When a pneumatic blower truck is utilized, a specified seed mix and rate can be incorporated with the application.</td><td>• In some areas, economical supply of suitable compost for erosion control may be limited. However, compost supply is rapidly growing in most urban areas.
• Compost quality and screen size is important. A well-graded mixture of coarse and fine particles is desirable for ESC applications.
• To prevent water from sheeting between the compost blanket material and soil surface on a slope, a minimum 1 m wide band of blanket material should be installed on the shoulder of the slope. Alternatively, a compost berm or filter sock may be placed at the top of the slope.</td></tr>
</table>

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	**CHALLENGES/LIMITATIONS**
BMP 17: Straw/Fibre Wattles (Rolls)	• As a temporary grade break on exposed slopes and grades.	• Wattles and fibre rolls provide grade breaks and reduce erosion by decreasing run-off velocity and rill formation on exposed slopes. • Can trap seed, organic matter and sediment washed down slope. • Wattles break down over time (no removal cost).	• Only suitable for temporary erosion control (vegetation provides long term erosion control). • Requires proper installation (entrench, stake and overlap ends) to prevent undermining. Installation can be expensive (hand labour). • Not suitable for concentrated run-off
BMP 18: Aggregate Cover	• For stabilizing large, flat, highly erodible areas (i.e. very silty or sandy soils) where vegetation or other cover is not feasible (i.e. temporary parking areas, seepage areas).	• Aggregate cover provides immediate erosion control.	• May be limited by high costs and/or lack of suitable aggregate availability. • Additional controls may be required in areas subject to groundwater seepage.
BMP 19: Riprap	• On cut/fill slopes subject to seepage, weathering and/or significant erosion, particularly where conditions prohibit establishment of vegetation. • On channel side slopes and bases. • As an inlet/outlet energy dissipater and on steep sections of bridge abutments. • For shorelines subject to wave action.	• Riprap is flexible (can adjust to changes resulting from settling or erosion beneath the stone. • The rough surface of riprap provides good energy dissipation in flowing water. • Durable, low maintenance and easy to install and repair.	• Requires a non-woven geotextile underlay or gravel blanket underlay to prevent erosion of underlying soil. • Requires design by a qualified professional. • Expensive, subject to availability and requires heavy equipment for transportation and placement. • For equivalent protection to a gabion mattress, open riprap typically needs to be placed at 2 – 3 times the thickness.
BMP 20: Cellular Confinement Systems	• As an alternative to traditional hard armouring steep slopes. • Flexible channel lining systems. • Porous pavement. • Temporary low-water stream crossings.	• Cells can be filled with soil and vegetated or filled with rock. • This practice is suitable for slopes as steep as 1:1. Application on steep slopes may require tendons for system stability.	• Availability can be limited; expensive; labour intensive. • Not suitable for slopes steeper than 1H:1V.

BMP 12	SEEDING AND SODDING	Erosion Control

Note: Before applying soil amendments, seed or sod to a site, always consult and adhere to local requirements and specifications for public lands. Always consult a local erosion control specialist or agronomist familiar with area soils, climate and local seeding requirements and mixes. Contractors must have experience at performing the type and scale of work required.

BMP 12a: Seeding

- **Temporary or Permanent Measure**
- **Use from Stripping and Grading to Final Site Stabilization**
- **Slopes, Stockpiles (Seeding), Borrow Areas, Landscaping**

Description and Purpose

The planting or placing of seed on disturbed soil after disturbed areas have been topsoiled or otherwise prepared for seeding. Seeding can provide both temporary and permanent cover and root structure to provide effective erosion control.

Important Definitions

Established Vegetation: The point at which individual plants and plant cover are self sustaining, providing dense vigorous cover.

Dormant Seeding: Refers to permanent seeding of final topsoiled grades in the fall/early winter (once temperatures are consistently low enough to prevent seed germination). The area is seeded with a permanent mix, fertilized and then protected with erosion control blanket or mulch. The seed remains dormant until soil temperature is warm enough in the spring to trigger germination and growth. This approach is used to eliminate seeding delays in the spring.

Surface Roughening: Harrowing or lightly tracking the soil surface up and down a grade can improve seed to soil contact and provide seedling safe sites (shade and moisture retention).

Pure Live Seed (PLS): PLS is an indicator of seed mix quality, based on seed purity and percent germination.

Temporary Seeding: Temporary seeding and mulching (or suitable temporary soil stabilization practices) are generally required for all exposed soils expected to be undisturbed for more than 30 days.

Permanent Seeding: Permanent seeding (along with temporary erosion control(s) to allow time to establish vegetation cover) is generally required for all exposed soils expected to be undisturbed for one year or more or for developing permanent vegetation cover compatible with the intended site use and adjacent areas.

Annual + Perennial Seed Mixes: In some cases, it is desirable to have both suitable annual and perennial species in a seed mix. The annual species are expected to provide temporary vegetation cover (erosion control) while the slower-developing perennial species develop.

Applications and Advantages

- Temporary seeding is used on suitable interim areas that are disturbed and require temporary protection. Temporary seeding is encouraged whenever possible to help reduce erosion on construction sites. Temporary seeding is an important component of "phased" construction activities.

Common areas for temporary seeding include topsoil stockpiles, rough graded areas, berms and other temporary earthen structures.

- Permanent seeding is applied to exposed areas which have been graded to final contour, prepared and topsoiled (i.e. prepared slopes and channels or exposed areas which are to be left dormant for a year or more).
- To provide temporary erosion control during vegetation establishment or to enhance the erosion control function provided by vegetation cover, it is often beneficial to employ suitable mulches or rolled erosion control products (RECPs) in combination with seeding.
- Perennial grasses, when used with turf reinforcement mats (TRMs), provide a fibrous root network (which helps anchor the TRM). These practices can greatly increase the maximum permissible velocities and are useful in stabilizing channels.
- Perennial grasses and legumes improve wildlife habitat and aesthetics.
- Establishing vegetation cover on exposed soils helps protect soil from erosion by raindrop impact, increases infiltration and reduces run-off. after establishment, temporary seeding can reduce sheet erosion by approximately 90% compared to exposed soil conditions (usda, scs, 1976).
- Temporary seeding can reduce maintenance costs for other site controls (i.e. sediment basin maintenance (clean-out) can be significantly reduced if temporary vegetative cover is established in the contributing drainage area). Temporary vegetation cover is also essential to protecting the integrity of other earthen structures used to control sediment (i.e. diversion and containment berms, compost berms).
- Seeding disturbed areas with a suitable mixture of grasses and forbs provides an inexpensive method of stabilizing soils.
- Established vegetation can act as a filter, trapping suspended sediment carried by run-off.

Limitations

- Establishing vegetation cover with temporary seeding can be difficult in Calgary's climate (dry, cool, short growing season). Seasonal planting windows may not coincide with the construction schedule.
- Establishing vegetation cover on steep slopes may require additional - and sometimes expensive - measures such as compost blankets, RECPs or hydromulching.
- Vegetation may require regular maintenance, especially adjacent to roadways.
- Reseeding and amendments may be required where there is poor vegetation establishment.
- Seeded areas may require temporary irrigation until self-sustaining vegetation cover is established.
- Seeding is not appropriate for areas impacted by construction activities/traffic.

Implementation

Timing

- Apply temporary seeding on suitable disturbed areas that will lie dormant for 30 days to one year. Apply permanent seeding on areas left dormant for 1 year or more or when no further disturbances are planned. In order to prevent costly maintenance operations on other erosion & sediment control practices, permanent vegetative cover should be established in phases; that is, as work is completed on upslope areas, permanent seeding practices are then applied to stabilize these areas.
- Permanent seeding is best done spring (prior to thunderstorm season) or in the fall.
- Seed blends for permanent seeding should typically include annuals, perennials and legumes.

- Seed rates for temporary and permanent seeding should be based on a PLS of 80%.
- 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.

Site Preparation

- For permanent seeding, confirm areas to be seeded will be dormant for one year or more or are at final contour and are ready for permanent seeding.
- Ensure concentrated run-off is being diverted away from all exposed slopes and areas to be seeded.
- Conduct soil tests to determine pH and nutrient content, then determine requirements for suitable soil amendments.
- For soil that is compacted, crusted or hardened, the soil should be loosened (with discing, raking or harrowing) and machine-tracked (refer to BMP…, Surface Roughening). Hydraulic planting generally requires less seedbed preparation (generally suited to slopes steeper than 2H:1V, where seedbed preparation is difficult).
- Seed to soil contact is the key to good germination. Prior to permanent seeding, prepare firm (but not compact) seedbed, 75 - 125 mm deep, with at least 75 - 100 mm topsoil depth (or as otherwise specified). The seedbed should be free of large clods and large stones. The prepared surface must be in reasonably close conformity to the lines, grades and cross sections shown on the grading drawings.

Seeding/Amendments

- Note: For seeding on City of Calgary Parks' lands, refer to as current edition of the Parks' Landscape Construction Specifications for more detailed requirements. Maintain all seeded areas as per Landscape Maintenance requirements from installation until the Final Acceptance Certificate is issued.

- All seed, fertilizer, mulch and other materials must be clearly marked and available for inspection (contents, weight, analysis, supplier, manufacturer) and tags should be kept by the project manager.
- To reduce requirements for pesticides and fertilizer/other amendments, choose adapted plant varieties based on environmental conditions, vegetation management needs and the intended site use. Legumes must be inoculated with plant-specific *Rhizobium sp.* bacteria before planting (either as pellet inoculated seed or inoculation in the field).
- Use certified Canada No. 1 seed, free of disease, weed seeds or other foreign materials, and meeting the requirements of the Seeds Act.
- Seed should have a minimum acceptable pure live seed (PLS) of 80%. This is calculated by multiplying the minimum seed purity (%) and the minimum germination (%) rates from the seed tag. Divide by 100 to get the % PLS.
- Seed to soil contact is the essential for good germination.
- Apply seed immediately after seedbed preparation while the soil is loose and moist. If the seedbed has been idle long enough for the soil to become compact, the topsoil should be harrowed/loosened.
- Always apply seed before applying mulch.
- Uniformly apply seed at the rates specified in the landscaping or erosion control plan.
- Apply fertilizer as specified. For broadcast seed applications, lightly rake seed and fertilizer into the soil by raking, chain dragging or other suitable means.

- Broadcast seed should be incorporated into the soil by raking or chain dragging, and then lightly compacted to provide good seed-soil contact.
- Apply mulch, tackifier, RECP or other specified material over the seeded areas.

Inspection and Maintenance

- Seeded areas must be inspected frequently, especially after significant run-off. If the seeded area is damaged due to run-off, immediate repairs must be made additional stormwater control measures may be required.
- Frequently evaluate germination and seedling density. Spot seeding can be done on small areas to fill in bare spots where grass did not grow properly.
- Temporary vegetated areas must be maintained until permanent vegetation or other erosion control practices can be established.
- Noxious weeds may need to be controlled by mowing or spraying. Mowing grass will encourage the establishment and spread of the grass.

BMP 12b: Sodding

Description and Purpose

Grass sod can be used to immediately cover and stabilize exposed soil, allowing rapid establishment of vegetation cover where seeding is not practical. The use of sod is generally much more expensive than seed; however, it has an immediate effect. In addition to providing rapid erosion control, sod can also be used to provide a protective vegetated buffer adjacent to sensitive areas (such as water bodies) or around storm drain inlets. Sod may be nursery or field sod composed of one or more species/cultivars of grasses and may contain associated plants such as legumes.

Applications and Advantages

- As a temporary or permanent measure.
- May be used to immediately protect soil surfaces from water and wind erosion where adequate topsoil, fertilizer and water for irrigation can be provided.
- Aesthetically pleasing erosion control and landscaping for single family lots.
- As a protective buffer around water bodies, other sensitive areas and around storm drain inlets.

Limitations

- Irrigation (watering) is required after placement and until rooting is established.
- Expensive and fairly labour intensive to install.
- Suitable sod may not be readily available.
- Field sod is not specifically produced for sale as turf and is generally not certified as to its composition or degree of weed infestation.
- Sod cannot be stored on-site for long periods of time

Implementation

- Sod must not be laid on frozen ground surfaces.
- During dry, hot weather, the ground surface must be cooled using irrigation before laying sod.
- Freshly installed sod must be irrigated to moisten the topsoil to minimum depth of 0.1 m. Irrigation aids in the development of roots within the topsoil.
- Successful installation requires the use of freshly cut, healthy sod. Minimize storage time.

Note: Refer to City of Calgary Parks' Landscape Specifications prior to sod application on City Parks' lands.

- Only apply sod during favourable weather conditions and in accordance with good horticultural practice.
- Prepare a smooth ground surface by removing large rocks, debris and other materials greater than 50 mm in diameter.
- Grade the surface to the final elevations, grades and cross-sections indicated on grading plans.
- Less than 48 hours prior to sod application, apply a slow release NPK 2-4-1 fertilizer (i.e. 12-25-10) at a rate of 175 kg/ha of phosphorous. Nitrogen make-up should be 50% water soluble and 50% slow release. Fertilizer application may be subject to adjustment based on the time of year, receipt of topsoil analysis and contractor recommendations.
- Lay sod strips on the prepared surface with long axis perpendicular to direction of slope (or in channels, perpendicular to anticipated direction of flow).
- Butt the joint ends of adjacent sod strips tightly together.
- Roll or tamp each sod strip firmly to ensure continuous contact between topsoil and underside of sod strip.
- On steep or unstable slopes, secure each strip of sod with an anchor embedded a minimum of 0.15 m into underlying soil. Anchors should be spaced a maximum distance of 0.6 m apart.
- Adjacent rows of sod strips must have staggered joints.

Inspection and Maintenance

- Inspect sodded areas at least weekly for the first two months after placement and after significant storm events or snowmelt likely to cause erosion.
- Areas damaged by washout or rilling must be re-graded and re-sodded immediately.
- Small bare spots may need to be re-sodded.
- Depending on the location and maintenance plan, sodded areas should be maintained by periodically fertilizing, irrigating, mowing and controlling weeds.
- Sod must not be mowed within one month of installation.

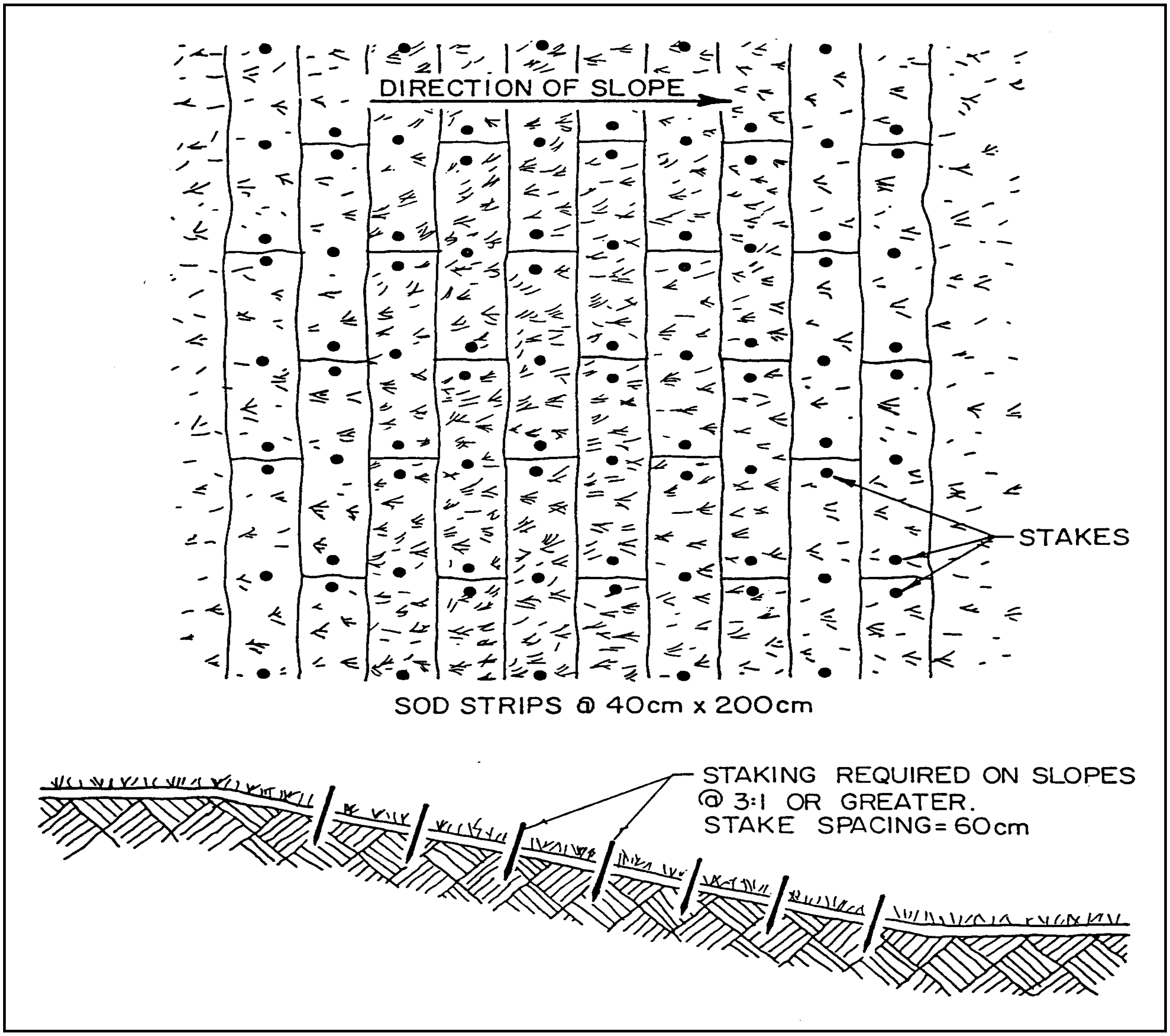


Figure 10-14: Typical Installation Detail for Grass Sod

BMP 13	MULCHING	Erosion Control

Note: Before applying mulch, seed or soil amendments to a site, always consult and adhere to local requirements and specifications for public lands. Always consult a local erosion control specialist or agronomist familiar with area soils, climate and local seeding requirements and mixes. Contractors must have experience at performing the type and scale of work required.

Description and Purpose

- **Erosion Control Mulches are a Temporary Measure**
- **Use on Slopes, Stockpiles and Other Exposed Soils from Clearing and Grubbing to Final Stabilization**

Mulching is the application of a protective layer of straw/other suitable material to exposed soil surfaces. Straw mulching and/or hydromulching is also used in conjunction with seeding and hydroseeding of critical areas to provide temporary erosion control and promote the establishment of vegetation. Mulching with straw or fiber mulches is also commonly used as a temporary measure to protect bare or disturbed soil areas that have not been seeded. In addition to absorbing raindrop impact and reducing soil erosion, suitable mulches can also help conserve soil moisture, moderate soil temperature, increase infiltration and protect seeds from predators, run-off and wind.

Mulches can be classified as “dry” (i.e. straw, compost, wood chips, RECPs, rock) and “wet” (i.e. wood fibre and paper slurry applied by hydraulic equipment). Straw mulching consists of placing a uniform layer of straw and binding it onto the soil with suitable devices. Hydraulic mulching typically consists of applying (using hydromulching equipment) a matrix of shredded wood fibre (or other suitable fibre), emulsifying agent and tackifier.

Applications and Advantages

- There are a large variety of mulches available for application on a range of slopes and soil types.
- Mulch application provides a relatively low-cost method of controlling erosion and/or promoting plant growth.
- Mulching is most commonly used to provide temporary stabilization of soil, usually until permanent stabilizing vegetation is established.
- On steep slopes, greater than 2.5H:1V, or where the mulch is susceptible to movement (by wind or water), consider hydraulic mulch application, application of a tackifier on the mulch or mechanical anchoring (i.e. straw crimping).
- To promote vegetation development and provide temporary erosion control, mulches can be applied after seeding (or, in the case of hydroseeding; during seeding). Where mulches are used to compliment vegetation establishment, they should be designed to last as long as it takes to establish effective vegetative cover for erosion control.
- Straw mulch is suitable for application to disturbed areas requiring temporary erosion control. Straw mulch is suitable on slopes where moderate rill erosion may occur. Straw mulch can be used in combination with temporary and/or permanent seeding strategies to enhance plant establishment.
- Hydraulic mulch is suitable for soil disturbed areas requiring temporary protection until permanent stabilization is established, and disturbed areas that will be re disturbed following an extended period of inactivity.

Limitations

- Mulches must be anchored on steep slopes (2.5H:1V or steeper) and/or where they are susceptible to movement by wind/water.
- Punching/crimping of straw may be difficult in sandy soils.
- Certain mulches may be unavailable or too expensive in some areas.
- Cost-effectiveness of mulching large areas can decrease if mulching by hand.
- Long-term erosion control may not occur if the mulch does not provide the required protection time for the establishment of long-term vegetation cover.
- Some mulches (i.e. wood chips, rock cover) may prevent (or slow) vegetation establishment.
- Organic mulches are not suitable for application if delivered in a wet or moldy state.
- Some organic mulches may contain weed seed (i.e. hay) and unwanted plant material.

Implementation

Where feasible/desirable, suitable vegetation should be shredded during clearing activities, providing a local supply of mulch (economical, plus it may provide a reservoir of local seeds).

Site Preparation

- Fine-grade the area of exposed soil.
- Remove large rocks, clods and debris that may prevent contact of the mulch with the soil surface.
- When seeding, follow the guidance in BMP 11 (Seeding).

Mulch Installation

Straw Mulching:

- The length and bulk of cereal straw makes it an excellent mulching product (reduces raindrop impact and moderates soil surface microclimate).
- Straw is weed free, light and readily available in small and large bales.
- Hay should not be used as mulch (contains weed seeds and may attract wildlife).
- For seeded sites, apply 3,500 – 4.500 kg/ha, aiming for 80 % cover.
- For unseeded sites, mulch at 4,500 – 6,500 kg/ha, aiming for 90 % cover.
- A standard square bale (about 35 kg) covers approx. 90m^2.
- For this practice to be effective, care should be taken to ensure that straw mulch is in close contact with the soil (rather than just providing cover).
- Straw mulch can be applied by hand or using a straw blower (can blow straw 50 – 80 feet).
- Straw placed on exposed areas and on slopes steeper than 2.5H:1V must be anchored.
- Anchor straw by machine tracking, crimping (weighted disks used to force/punch the fibres into the ground), applying a tackifier or netting (specify netting judiciously as birds, snakes and small mammals can get trapped in certain netting).

Compost (see Compost Blankets)

For *Hydraulically Applied Mulches*, see Hydromulching and Hydroseeding.

Inspection and Maintenance

- Except during freeze-up and until permanent vegetation cover is established, inspect a minimum of every seven days and after significant rainfall or snowmelt likely to cause erosion or damage to the mulch.
- Verify supplied materials and application meets site-specific specifications. Keep certification tags available for inspection.
- Areas where erosion is evident should be repaired as soon as possible. Care should be exercised to minimize the damage to protected areas while making repairs.
- Ensure that the integrity of the mulch is sufficient to provide the required period of temporary control.

BMP 14	HYDROMULCHING AND HYDROSEEDING	Erosion Control

Note: Retain the professional services of a consultant/designer specializing in erosion & sediment control, landscape design or agronomy and an experienced hydromulching/seeding contractor. For landscaping work on City of Calgary lands, contact Calgary Parks for further information (call 3-1-1).

Description and Purpose

- **Temporary or Permanent Measure**
- **Use for Areas that are Disturbed, but will Remain Inactive for a While (such as slopes, stockpiles)**

By using hydraulic equipment (hydroseeders and hydromulchers) seed, soil amendments, fibre mulch, and tackifiers can be uniformly broadcast, as a hydraulic slurry, onto the soil. Applying these materials as a water-based slurry (often in one application) can provide a cost-effective means of erosion control and/or revegetation.

Hydraulically applied mulches form a continuous blanket on the soil surface, protecting the soil from raindrop impact and wind erosion, conserving soil moisture, reducing soil crusting and increasing infiltration. This results in improved conditions for seed germination and plant growth.

Applications and Advantages

- Hydromulching: The slurry applied to the soil includes mulch (typically wood or paper fibre) and tackifier only (seed and soil amendments are not included).
- Hydroseeding: The slurry applied to the soil typically consists of seed, fertilizer, mulch, tackifiers and other specialized soil amendments.
- Hydromulching/hydroseeding is useful where it is desirable to apply a number of complementary erosion control materials and soil amendments in one (or more) applications.
- On steep slopes, other seeding methods may be unsafe or impractical. These methods are especially suitable for slopes steeper than 3H:1V where an adequate seedbed cannot be prepared and mulch is difficult to anchor.
- Useful for rocky soils, irregular soil surfaces or partially vegetated areas where installation of RECPs is precluded.
- Useful for critical sites that require multiple steps to maximize erosion control.

Limitations

- Requires specialized equipment to mix and apply the slurry.
- Not practical where hydromulching/seeding equipment cannot access the site (equipment is usually truck-mounted and hose range is limited to 150 m).
- Areas where seeding is not successful often require re-application or additional amendments.
- If applied in the same application, seed can be suspended in the mulch blanket and prone to desiccation during periods of drought (for rough/rocky sites, it is beneficial to hydroseed in a two or three-step application).

- Due to mechanical damage to seeds, higher seeding rates are typically required when compared to conventional cyclone or drill seeding (if seed mix includes native seed, this could add substantially to cost).
- Natural mulches will decompose faster than synthetic ones. Ensure the expected mulch life will exceed time required for vigorous vegetation establishment.
- Hydraulic matrices need at least 24 hours of curing/drying prior to precipitation.

Implementation

- In order to select appropriate hydroseeding/mulching materials, the designer must assess how the application will work with the construction schedule as well as water availability, soil conditions, topography and climate.
- Where possible, prepare a seedbed before hydroseed application.
- All legume seed must be inoculated. For pellet inoculated seed, hydroseed application must be done as quickly as possible after the seed is placed in the hydroseeder (otherwise inoculant could be washed off seed), or the seed dry-applied prior to hydromulching.
- For revegetation, each seed bag delivered to the site should be sealed and clearly marked as to species, purity, percent germination and expiry date. The container should be labelled to clearly reflect the % Pure Live Seed (PLS) and kept on-site for inspection purposes.

Hydraulically applied mulches include mulches made from wood fibres, paper fibres, combination recycled wood and paper fibres and polyester and/or polypropylene fibres. Hydraulic mulches must be mixed with seed, fertilizer and additives as specified and applied at the manufacturer recommended rate.

- Avoid over-spray of slurry to roads, sidewalks, watercourses, existing vegetation, etc.
- For revegetation, adequate mulch application is required to keep seeds in place and moderate soil moisture and temperature until the seeds germinate and grow (this is especially necessary in Calgary where the short growing season may limit germination of seeds until the following spring).
- Desirable ground coverage for hydraulic mulch is 80 –100 %.

Cellulose Fibre Mulches

- Paper fibre mulch is produced from recycled newsprint, magazine, or other waste paper sources.
- Mulch is mixed in a hydroseeder and applied as a liquid slurry (either alone, or in combination with seed, fertilizer and tackifier). Hydraulic application of paper fibre is easier than for wood fibre.
- Typical application rates are 60 kg mulch/1,000 litres water, applied at 1700-2200 kg/ha in order to achieve uniform, effective coverage.
- Paper mulch can also be used to tack and bind straw mulch (at a lower rate, typically 850 kg/ha).
- Short fibre lengths and rapid decomposition (versus straw and wood fibre) can limit the longevity of erosion control effectiveness.

Hydraulically Applied Wood Fibre

- Wood fibre mulches are manufactured to provide fibres that are typically 4 – 8 mm long.
- Wood fibre products have longer fibre lengths and provide improved durability versus paper fibre.
- Although more effective than cellulose mulches, wood fibre products are more expensive;

- Hydraulic applications of wood fibre are typically done with 20 kg of mulch in 500 L of water applied at 1,500 to 2,500 kg/ha (application at rates lower than 1,500 kg/ha provides little erosion control or mulching benefit).
- Wood fibre is susceptible to wind and water movement unless tacked to the ground.
- Wood fibre may not supply sufficient bulk to adequately control erosion on steep slopes.

Hydraulically Applied Bonded Fibre Matrix (BFM)

- Bonded fibre matrix (BFM) is a thick, three-dimensional, permeable blanket-like covering that holds soil and seed in place.
- BFM typically consists of longer fibres, combined with tackifiers and binding agents. BFM is chemically-bonded, mechanically-bonded or (more typically) a combination of the two.
- Chemically-bonded BFMs require a curing or drying period following application (at least 24 hours), so ensure there is no risk of precipitation during this period.
- BFM is typically applied at rates from 3,500 to 5,000 kg/ha, or at the manufacturer's recommended rate.
- A biodegradable BFM is composed of materials that are 100% biodegradable. The binder in the BFM should also be biodegradable and should not dissolve or disperse upon re-wetting.

Tackifiers/Binders

- Tackifiers are organic or polymer agents that bond mulch fibres and soil together, increasing the erosion control effectiveness of mulching.
- Additionally, some polymers, plant mucilage and guar increase hydraulic application performance by providing lubrication.
- Typical application rates are 45 – 70 kg/ha for polymers and 90 – 140 kg/ha for guar and plant mucilage (follow manufacturer specifications).
- Cementitious binders (formulated from hydrated lime or gypsum) can be mixed with water and applied to temporary roads for dust control or with fibre mulch, seed and fertilizer for erosion control (form a permeable crust on the soil surface).
- Acrylic co-polymers mixed with water are also used for dust control.

> Hydroseeding Note: Applying all the mulch with seed, fertilizer and tackifier in one hydroseeding pass can result in suspension of seed in the matrix (i.e. poor seed to soil contact). It may be desirable to follow a two or three-step method, especially on rocky sites where seeds could become suspended and desiccated.

Two Step Seeding Method (with hydraulic mulch)

- Apply seed, at the recommended rate, and half the recommended mulch (850 - 1,100 kg/ha), as a slurry. This helps assure maximum seed to soil contact.
- Apply the remaining mulch with the tackifier and fertilizer. Polymer tackifiers are applied at rates of 45 - 70 kg/ha and organic tackifiers at a rate of 90 - 135 kg/ha.

Three-Step Straw Mulch Method (for steep and critical erosion-sites)

- Apply seed hydraulically in a slurry with 600 kg/ha hydraulic mulch.
- Secondly, apply straw mulch at a rate of 2,250 kg/ha.
- Finally, apply fertilizer, tackifier and the remaining hydraulic mulch at 600 - 850 kg/ha, or as specified.

Inspection and Maintenance

- Except during freeze-up, inspect a minimum of every seven (7) days after initial application and after intense or sustained rainfall or snowmelt likely to cause erosion.
- Verify hydromulch and hydroseed applications meet specifications. Record materials used and keep all certification tags for inspection and records.
- Areas where erosion is evident must be repaired as soon as possible;
- Care should be exercised to minimize the damage to protected areas while making repairs.
- Where seeds fail to germinate, or they germinate and die, the area must be reseeded, fertilized and mulched within the planting season, using not less than half the original application rates;
- For temporary applications, maintain an unbroken ground cover throughout the period of construction that the soils are not being reworked.
- For erosion control (with the exception of rock, wood and bark mulches), the effectiveness of the mulch cover must last until vegetation is established. Inspection should assess the integrity of the mulch based on the quality and diversity of vegetation being established.

BMP 15	ROLLED EROSION CONTROL PRODUCTS	Erosion Control

Note: More detailed information on rolled erosion control product development, testing, selection and installation is provided by the Erosion Control Technology Council (ECTC, www.ectc.org) and in manufacturer specifications and design software.

- **Due to Relatively High Cost; Typically Used During Permanent Stabilization**
- **Also Effective for Temporary Erosion Control on Steep Slopes**

Description and Purpose

Erosion control blankets are machine-produced mats of organic, biodegradable mulch such as straw, curled wood fibre (excelsior), coconut fibre or a combination thereof, evenly distributed on or between photodegradable polypropylene or biodegradable fibre netting. Synthetic erosion control blankets are composed of ultraviolet stabilized synthetic fibres. Nettings and mulch material are stitched to ensure integrity and blankets are supplied in rolls for ease of handling and installation.

The longevity and strength of RECPs is determined by their structure and the susceptibility of the materials to biological and photo-degradation. RECPs can be grouped into three categories:

Erosion control blankets (ECBs): Temporary, degradable RECPs composed of processed natural or polymer fibres mechanically, structurally or chemically bound together to form a continuous matrix.

Turf reinforcement mats (TRMs) and composite turf reinforcement mats (C-TRMs): Long-term non-degradable RECPs composed of UV-stabilized, non-degradable synthetic fibres, nettings and/or filaments processed into three dimensional reinforcement matrices designed for permanent and critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. TRMs provide sufficient thickness, strength and void space to permit soil filing and/or retention and development of vegetation within the matrix.

Applications and Advantages

- Several categories and types of RECPs have been developed for a variety of applications. Many RECPs have undergone rigorous product testing and manufacturers/suppliers can provide good product and application information (and, in some cases; selection software). Visit www.ectc.org and consult with your RECP supplier.
- Can be a temporary or permanent measure (depending on the RECP selected).
- Provide immediate protection of erodible soils on cut/fill slopes at 3H:1V or steeper.
- Protection of exposed soils in ditches and channels (with water velocities of 1 - 2 m/sec) by providing additional shear resistance in conjunction with well-established vegetation cover (TRMs/C-TRMs).
- Useful for providing medium-term erosion protection when soils are exposed outside of a suitable growth window for vegetation establishment.
- Suitable for disturbed slopes adjacent to water bodies or environmentally sensitive areas Note: for these areas, selection of wildlife friendly products with open, biodegradable netting is important.

Limitations

- RECPs are expensive to purchase and install. High cost typically limits the use of RECPs to areas of concentrated channel flow and steep slopes. Proper RECP selection and installation is critical and requires experienced designers and contractors.
- Vegetation provides ultimate erosion control. To avoid creating unfavourable conditions for seed germination and plant growth, the designer must always assess the effectiveness of the RECP based on installation timing, site soils, aspect and slope.
- Commonly, failure to properly install the RECP (entrenchment, stapling) or provide consistent RECP:soil contact (requires proper site preparation) can result in erosion under the product.
- Temporary blankets may require removal before implementation of permanent measures.
- Not generally suitable for excessively rocky sites or in areas where final vegetation will be mowed (use of biodegradable netting helps address the mowing issue).

Installation

Note: For general guidance only. Always consult RECP manufacturers and a professional specializing in erosion & sediment control to ensure appropriate RECP selection, installation, inspection and maintenance.

Follow the manufacturer's installation specifications. If not available, the following general installation methods may be used.

RECP (Erosion Control Blanket) Installation on Hill Slopes

1) Ensure the slope is properly prepared before installing the blanket. The slope should be fine-graded to a smooth profile and relatively free of weeds, clods, stones, debris, rills and crusting. Fill any voids and make sure that the slope is lightly compacted.
2) Seed the area with a seed rate and mix suitable for the area and site-specific soil conditions.
3) At the top of the slope, dig an anchor trench 150 mm deep by 150 mm wide. Ideally, set the anchor trench at least 1 m back from the crest of the slope (this will help prevent water from flowing under the blanket and causing erosion). Install the end of the blanket in the trench, providing 750 mm of excess blanket extended upslope of the trench. Staple at 300 mm centres along the width of the trench.
4) Backfill the anchor trench and compact the soil. Place seed over the compacted soil. Cover the compacted soil with the remaining 300 mm of the terminal end of the blanket. Staple or stake the terminal end down slope of the anchor trench on 300 mm centres.

RECP Anchoring: U-shaped wire staples, metal geotextile stake pins, or triangular wooden stakes can be used to anchor mats and blankets to the ground surface. Wire staples should be made of minimum 11 gauge steel wire and should be U shaped with 200 mm legs and a 25 mm crown. Wire staples and metal stakes should be driven flush to the soil surface.

5) Starting at the crest of the slope, "walk" the blanket down the slope (unrolling of heavy rolls can be controlled using temporary stakes). Excess slack should be pulled out of the blanket every 6 – 7 m, taking care not to overstretch the blanket. Secure the blanket using staple patterns and staple types/sizes as recommended by the manufacturer. Follow the manufacturer's recommended

overlap when rolling out adjacent sections of blanket. Secure the overlaps with staples at recommended intervals.

6) If the blanket needs to be spliced in the middle of a slope, ensure the blanket is "shingled" with the up-slope blanket overlapping the down-slope blanket. There should be 100 mm of overlap in a splice. Use a staple check slot to secure the overlap: Place a row of staples 100 mm on center and then placing a second, staggered row of staples 100 mm on center.

7) The blanket must extend at least 0.6 m beyond the toe of the slope. Secure the blanket with staples or stakes 300 mm on centre.

Installation of Turf Reinforcement Mats (TRMs/C-TRMs) in Channels

1) Ensure the channel is properly prepared before installing the TRM. The channel should be fine-graded to a smooth profile and relatively free from all weeds, clods, stones, debris, rills and crusting. Fill any voids and make sure that the channel is lightly compacted.

2) Seed the area with a seed mix and rate suitable for the area and site-specific soil conditions. If mat installation is delayed, the contractor must rework and reseed any rutted, eroded or crusted sections of the channel prior installation.

3) At the top of the channel, dig an anchor trench, 150 mm deep by 150 mm wide, perpendicular to the flow line. Install the end of the mat in the trench, providing 300 mm of excess mat extending upstream of the trench. Staple the mat at 300 mm centres along the width of the trench.

4) Backfill the anchor trench and compact the soil. Place seed over the compacted soil. Cover the compacted soil with the remaining 300 mm of the terminal end of the blanket. Staple or stake the terminal end down slope of the anchor trench on 300 mm centres.

5) Unroll the mat *in the direction of water flow*, starting with the mat in the channel bottom. Minimize the number of seams in the channel bottom and avoid seams in the channel centre or areas that may receive concentrated run-off. Install adjoining mats away from the centre of the channel bottom using overlaps as recommended by the manufacturer. Staple the overlap seams as specified for the product.

6) Staple or trench check slots should be installed perpendicular to the flow direction every 7.5 m of channel. Check slots force water that is flowing under the mat back to the surface. A staple check slot consists of a double row of staples or stakes on 100 mm centres. The rows should be staggered and placed 100 mm apart. An alternative is to excavate a check slot the same dimensions as the end trench. Secure the mat in the upstream side of the check slot with staples or stakes on 300 mm centres. Flip the mat on the upstream edge. Back fill the check slot as shown and compact the soil.

7) Continue to roll the mat along the channel bottom and side slopes in the direction of the water flow. As the mat is installed from the channel bottom up the channel sides, use a shingle type installation (with the up-slope mat overlapping the lower mat 100 mm, or as specified by the manufacturer. Mats should be spliced using a check slot, with the upstream mat overlapping the downstream at least 100 mm.

8) At the terminal end of the channel, secure the mat in a with a 300 mm deep by 150 mm compacted anchor trench.

9) Bury the edges of the matting in 100 mm deep by 100 mm wide longitudinal anchor trenches, extending the mat at least 75 mm above the crest of the channel side slopes;

10) Some TRMs require filling with soil: In these cases, seed the matting and the entire disturbed area after mat installation, but prior to filling the mat with soil.

Inspection and Maintenance

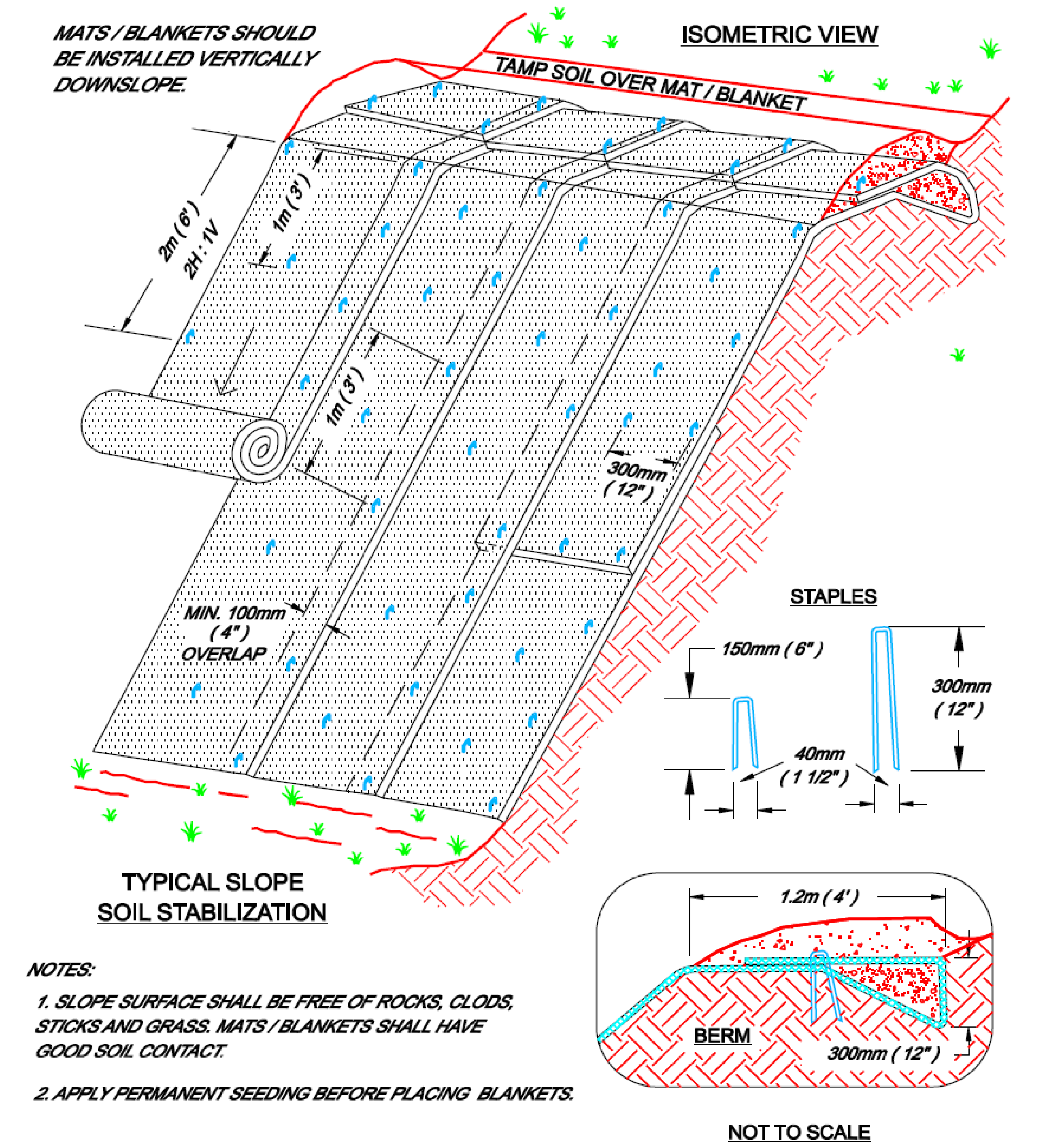
- Prior to establishment of vigorous vegetation cover, inspect RECP installations a minimum of every seven days and following intense or prolonged rainfall or snowmelt likely to cause erosion.
- Ensure RECPs have good contact with the soil and look for any erosion, undermining or blanket separation. Ensure that check slots and joints are secure and that staples are flush with the ground. Repair any damage immediately and reseed as necessary.
- A dressing of fertilizer may be required to improve vegetation establishment a year after RECP installation.

Construction Details

Refer to:

Figure 23: Typical Installation Detail for RECPs on Slopes

Figure 24: Typical Installation Detail for RECPs in Channels



NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS / BLANKETS SHALL HAVE GOOD SOIL CONTACT.

2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.

3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

THE CITY OF CALGARY WATER SERVICES

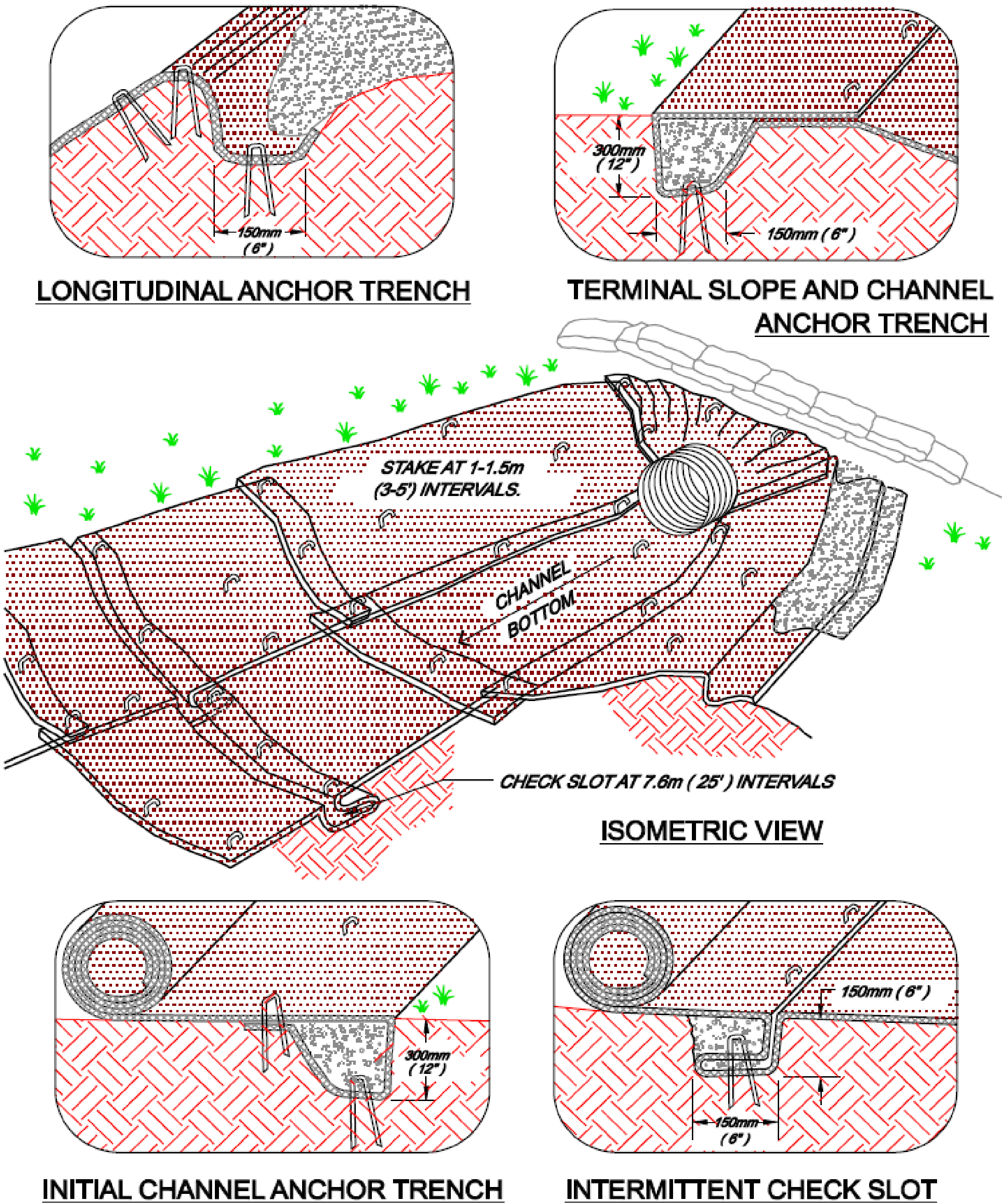
Erosion Blankets & Turf Reinforcement Mats: Slope Installation

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0

 FILE: blnktslp.dgn

Figure 10-15: Typical Installation Detail for RECPs on Slopes



NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURER'S SPECIFICATIONS.

Erosion Blankets & Turf Reinforcement Mats: Channel Installation	THE CITY OF CALGARY WATER SERVICES
Erosion & Sediment Control Guidelines 2011	Source: Salix Applied Earthcare - Erosion Draw 5.0 © 1994 JOHN McCULLAH FILE: blnktcha.dgn

Figure 10-16: Typical Installation Detail for RECPs in Channels

BMP 16	COMPOST BLANKETS	Erosion Control

Description and Purpose

- **Typically used for Permanent Erosion Control Systems**
- **Can be an Effective Temporary Erosion Control Practice for Steep Slopes**

Compost is produced by the controlled biological decomposition of organic materials such as agricultural, forestry, food, industrial and garden and leaf residuals. Effective composting requires a high-temperature, rapid decomposition (thermophilic) phase (which sanitizes the product) and a lower-temperature stabilization phase. The thermophilic phase must be able to reduce pathogens to acceptable levels, as well as destroy noxious weed seeds/propagules. Compost provides a good source of slow-release nutrients and enhances soil biological activity (improves plant growth and vigour).

Compost, applied as a blanket to an exposed slope, can significantly reduce raindrop erosion, as well as sheet, rill and gully erosion. Compost can also remove contaminants such as TSS, nutrients and metals from stormwater run-off. In many cases, compost blankets are more effective at promoting vegetation establishment, controlling erosion and suppressing weeds than RECPs or Hydroseeding. Compost blankets can be applied by hand on small areas, but are generally applied using a pneumatic blower truck.

Note: Compost has traditionally been used as a soil amendment, applied as a finely screened, stabilized product. Application for erosion & sediment control, however, typically requires compost with a coarse, woody fraction (improves filtration rate and structural integrity).

A Compost blanket has good compost:soil contact, reducing the potential for water erosion under the blanket. This problem can further be reduced by keying the compost blanket into the crest of the slope and installing a compost berm or sock (see BMP…, Compost Berms and Filter Socks) along the slope crest.

Note: Compost Quality: All compost **sold** in Canada must comply with the requirements of the Federal *Fertilizers Act and Regulations*. The City of Calgary requires that compost **applied** in compost blankets, compost berms and compost filter socks meets *Category A* quality in accordance with all criteria identified in the Canadian Council of Ministers of the Environment (CCME) document *Guidelines for Compost Quality* (October 2005, and as amended from time to time). The CCME document can be purchased online at www.ccme.ca/publications.

Applications and Advantages

- Compost blankets can be installed on any soil surface: rocky, frozen, flat, or steep. A specified seed mix is usually incorporated with compost during application.
- Compost blankets can be applied to slopes 2H:1V or gentler, but can be combined with additional practices such as compost berms or compost socks to treat slopes as steep as 1H:1V (stream banks, road embankments, exposed construction site slopes). Compost blankets must be extended 1 – 1.5 m over the crest of the treated slope.
- Compost blankets must not be applied in areas subjected to concentrated run-off.

- Compost is organic, biodegradable and renewable.
- Compost retains a large volume of water and can promote infiltration and vegetation establishment (reduced run-off and erosion).
- Erosion control composts have a well-graded mixture of particle sizes: Compost blankets form a strong, three-dimensional protective soil cover and compost berms and socks are effective at filtering out suspended solids from sediment-laden run-off, allowing clean water to pass (unlike other practices such as silt fence which can quickly become plugged with sediment and act as water dams).
- Compost provides a matrix rich in beneficial micro-organisms and organic matter, promoting the vigorous establishment of vegetation, as well as biodegradation of stormwater contaminants.
- Numerous studies have shown the low or zero leaching of nutrients, metals and salts from compost.
- Compost can suppress noxious weeds, allowing desirable vegetation to better compete for nutrients and moisture.

Limitations

- In some areas, economical supply of suitable compost for erosion control may be limited.
- In Calgary, the supply of compost from municipal garden waste and leaf waste composting is limited, but continuing to grow. Compost supply from the forestry sector is reasonable.

Implementation

- Specified compost depth is dependant on slope steepness and annual precipitation, but is typically 50 – 100 mm (50 mm for 4H:1V slopes to 100 mm for 2H:1V slopes, with additional control measures required for slopes steeper than 2H:1V).
- When a pneumatic blower truck is utilized, a specified seed mix and rate can be incorporated with the application.
- Compost quality and screen size is important. A well-graded mixture of coarse and fine particles is desirable for ESC applications.
- In order to prevent water from sheeting between the compost blanket material and soil surface on a slope, a minimum 1 m wide band of blanket material should be installed on the shoulder of the slope. Alternatively, a compost berm or filter sock may be placed at the top of the slope.
- Compost blankets generally need to be installed by a specialized, certified supplier using a pneumatic blower truck and compost meeting CCME Category A requirements.
- Always ensure upstream run-off is diverted away from exposed slopes.
- Prepare the slopes by removing loose rocks, roots, clods, stumps and debris over 50 mm in diameter.
- Machine track-walk up and down slopes (if feasible) before application.
- For very steep slopes, compost berms, straw wattles or compost socks should be installed at intervals (install on contour), so as to reduce effective slope length.
- To provide a stable, three-dimensional blanket, compost should consist of both large and small fragments. Finer grades (screened through 10 - 15 mm) have increased nutrient availability, promoting vegetative cover. Inclusion of coarser grades promotes infiltration and improves the structural integrity and resistance of blankets exposed to wind, rainfall and run-off. Optimal moisture

content at application is 25 – 40%. Compost outside this range can be difficult to apply and wet compost is expensive to transport.

- Compost must be free of weeds, weed seeds, pesticide residues and garbage.

Inspection and Maintenance

- Inspect compost blanket installations at least monthly and following significant rainfall or snowmelt.
- Re-apply compost to bare or eroded areas.
- Reseed areas with poor germination or vegetation establishment.

Photo 13: Protection of water body adjacent to a stripped area of land is enhanced with a seeded compost berm and compost blanket (promotes filtering of sediment-laden run-off and provides an erosion-resistant buffer.

Photo 14: Installation of a compost berm

BMP 17	STRAW/FIBRE WATTLES	Erosion Control

Description and Purpose

Straw/Fibre wattles (commonly called rolls) consist of bundled straw (or other natural fibre) wrapped in photo-degradable open-weave plastic netting and staked (using wood stakes or live willow stakes) into the soil along slope contours as a grade break. Wattles can also retain sediment and seed washed downslope and retain moisture, promoting the growth of vegetation. Wattles are typically 200 mm diameter and 8-9 m long. Mobile units that can produce continuous lengths of fibre wattle have recently been developed.

- **Temporary or Permanent Measure**
- **Use from Stripping and Grading to Final Site Stabilization**
- **Slopes, Stockpiles (Seeding), Borrow Areas, Landscaping**

Applications and Advantages

- Useful for long, exposed slopes (reduce slope length, reduce rilling and decrease run-off velocity).
- Relatively low-cost option for controlling sheet and rill erosion on slopes.
- Used as a grade break, where a gentle slope changes to a steeper slope.
- Can be used in combination with live-staking (bioengineering application).
- Plastic netting will eventually photo-degrade, eliminating the need for retrieval and disposal of materials after the straw has broken down.
- Straw becomes incorporated into the soil with time, adding organic material to the soil and retaining moisture for vegetation.

Limitations

- Only suitable as a temporary (one to two year life) erosion control practice (long term erosion control requires establishment of sustainable vegetation cover).
- Limited to sheet-flow conditions. Not suitable in areas subjected to concentrated run-off.
- May be labour intensive to install and maintain.
- Undermining and failure can result from poor installation and maintenance (failure to properly trench, stake and overlap joints).

Implementation

- Prepare the slope by removing large rocks and debris.
- Repair any rills and gullies on the slope and ensure upstream run-off is diverted away from exposed slopes.
- Starting at the toe of the slope, excavate small trenches across the slope. Trenches must be deep and wide enough to accommodate half the thickness of the roll (typically 0.15 m x 0.15 m). It is critical that rolls are installed perpendicular to water movement, parallel to the slope contour.
- Space trenches at contour intervals of 1 - 8 m, depending on steepness of slope. The steeper the slope, the closer the trench spacing.
- Place fibre rolls into the trench, ensuring continuous contact between the roll and soil.

- Overlap the ends of rolls at least 0.15 m by excavating some additional trench at overlaps.
- Prior to placing wood stakes or live willow stakes, use a metal bar to drive pilot holes through the roll and into the soil. Stake spacing must not exceed 1.2 m. Ensure overlaps are well staked. Drive stakes through prepared holes into the soil. Leave only 25 - 50 mm of stake exposed above the roll.
- Place and compact excavated soil on the upslope side of the roll and seed with a specified seed mix.

Inspection and Maintenance

- Except during freeze-up, inspect straw rolls and slopes at least weekly and promptly after significant rainfall or snowmelt.
- Ensure all sections of rolls are in good contact with the soil.
- Repair any rills or undermining promptly. Additional run-off or erosion control is required for areas subject to rilling.
- The straw or organic fibre in the rolls will decompose and netting will photo-degrade.

Construction Details

Refer to:

Figure 25: Installation Detail for Straw/Fibre Rolls or Compost Socks

Photo 15: Straw wattles provide an excellent type of ditch check in small ditches conveying small volumes of run-off.

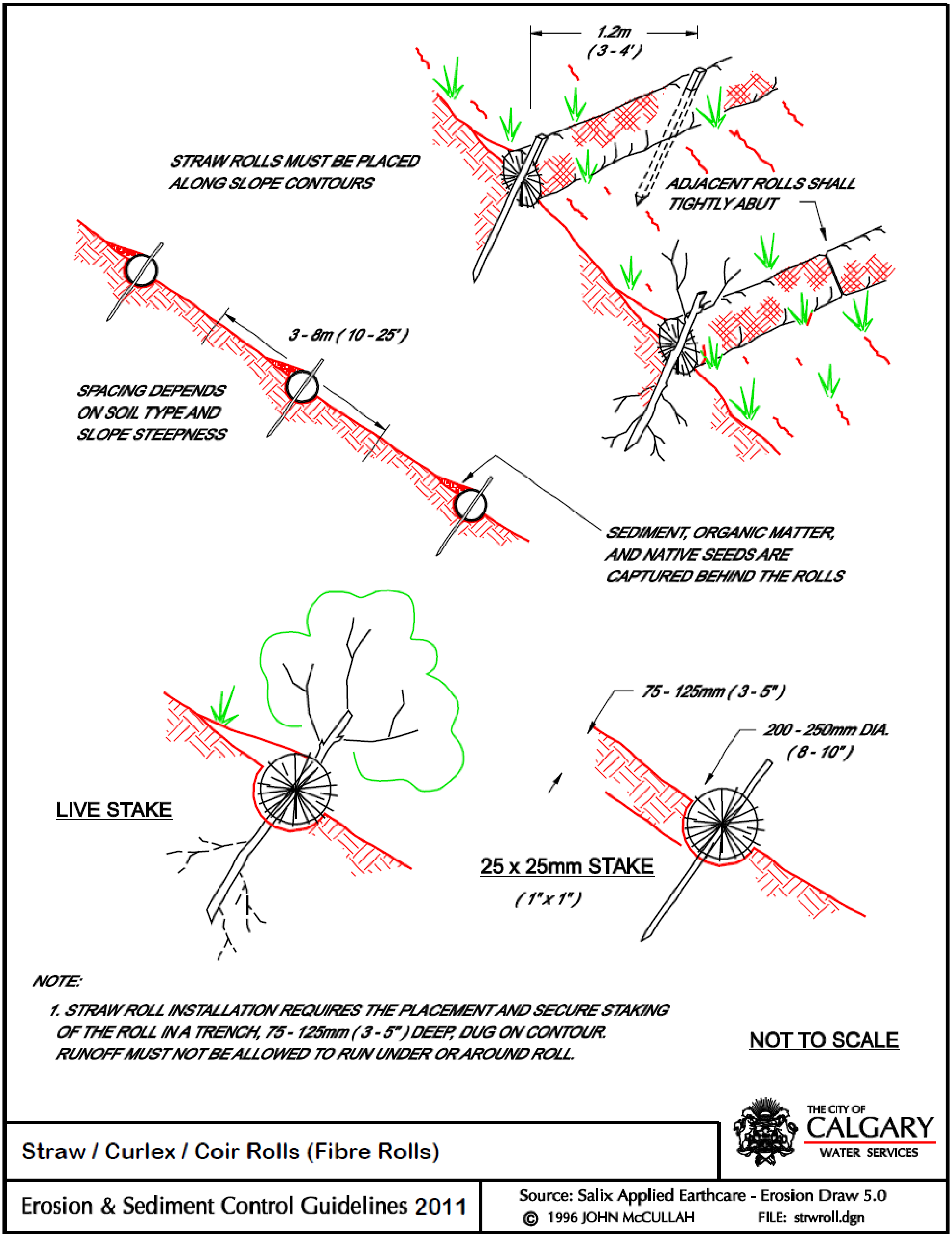


Figure 10-17: Installation Detail for Straw/Fibre Rolls or Compost Socks

BMP 18	AGGREGATE COVER	Erosion Control

Description and Purpose

- **Temporary or Permanent Measure**
- **Parking lots, haul roads, and staging areas**

A blanket of crushed stone or gravel applied directly to erodible soil surface. Aggregate cover is a blanket of crushed stone/gravel applied to erodible soil surfaces to reduce erosion or to remediate soil loss caused by piping on exposed slopes subject to groundwater seepage.

Applications and Advantages

- Useful for stabilizing large, flat, highly erodible areas (i.e. very silty or sandy soils) or where vegetation or other cover is not feasible (i.e. temporary parking areas).
- For areas of high groundwater seepage (must be used in conjunction with a non-woven geotextile fabric underlay).

Limitations

- May be limited by high costs and/or lack of suitable aggregate availability.
- Additional controls may be required in areas subject to groundwater seepage.

Implementation

- For quick stabilization, aggregate should be applied immediately after the sites have received their initial grading.
- Place non-woven geotextile to protect sub-grade soils.
- Place aggregate blanket
- Grade aggregate to design thickness. Ensure grades are sufficient to provide adequate drainage.
- On temporary roadways and parking areas, a 150 - 200 mm blanket of crushed granular aggregate should be applied to the site immediately after grading.
- On slopes with highly erosive soils (silt and sand), the granular blanket must be 30 – 50 mm thick.
- Aggregates must **not** contain mine waste, iron blast furnace slag or blended nickel slag or clinkers due to the potential of ground water contamination from materials contained in the aggregate.

Inspection and Maintenance

- Roadways and parking areas may require periodic top-dressing.
- Slopes should be checked for washouts after storms. Any damage must be quickly repaired.

BMP 19	RIPRAP	Erosion Control

Description and Purpose

Riprap (large, loosely placed cobbles/boulders) is a versatile, highly erosion-resistant material. Riprap armouring involves placing a layer of suitable rock to protect the soil surface from erosive forces and/or improve stability of soil slopes that are subject to seepage or have poor soil structure.

- **Temporary or Permanent Measure**
- **Channels and steep slopes**

Note: "Pre-cast riprap" is a term commonly applied to grid pavers, articulated concrete mats, concrete armour units, and interlocking concrete blocks. These modular concrete units are used to armour slopes and stream banks, while providing pockets for the establishment of vegetation. The specific design and installation should follow manufacturer's instructions.

Applications and Advantages

- For cut and fill slopes subject to seepage, weathering and/or significant erosion, particularly where conditions prohibit establishment of vegetation.
- On channel side slopes and bottoms (flow velocities of 2 – 5 m/sec: See BMP….Riprap-Lined Channels).
- As an energy dissipater (see BMP…,Energy Dissipaters) and on steep sections of bridge abutments.
- For shorelines subject to wave action.

Note: Must be used in conjunction with a non-woven geotextile or gravel filter underlay.

- Riprap is flexible (can adjust to changes resulting from settling or erosion beneath the stone.
- The rough surface of riprap provides good energy dissipation in flowing water.
- Durable, low maintenance and easy to install and repair.

Limitations

- Expensive, subject to availability and requires heavy equipment for transportation and placement.
- For equivalent protection to a gabion mattress, open riprap typically needs to be placed at 2 – 3 times the thickness.

Implementation

- For areas that will require riprap, try to schedule riprap placement to immediately follow disturbance and grading (i.e. for inlet or outlet protection, riprap should ideally be placed before run-off causes erosion).
- Riprap is classed as either graded or uniform: Graded riprap includes a wide mixture of stone sizes, whereas uniform riprap consists of stones nearly all the same size. Graded riprap is generally preferable because it is cheaper, easier to install and forms a dense, flexible cover.

- Stone used for riprap should be hard, durable, erosion resistant field or quarry materials (avoid sedimentary rock). The material should be angular and not subject to breaking down when exposed to water or weathering. Specific gravity should be at least 2.5.

Filter Blankets

A filter blanket is a layer of material placed between the riprap and the underlying soil to prevent soil movement into or through the riprap. A suitable filter may consist of well-graded gravel or gravel-sand layer or a suitable non-woven geotextile filter fabric. The design of gravel filter blankets is based on the ratio of particle size in the overlying filter material to that of the base material in accordance with the following design relationship:

$$\frac{D_{15}\text{ Filter}}{D_{85}\text{ Base}} \leq 5 \quad \text{and} \quad 5 < \frac{D_{15}\text{ Filter}}{D_{50}\text{ Base}} \leq 40 \quad \text{and} \quad \frac{D_{50}\text{ Filter}}{D_{50}\text{ Base}} \leq 40$$

Subgrade Preparation

- Prepare the subgrade for the riprap and filter (underlay) to the required elevations and grades shown on the drawings.
- Compact any fill required in the subgrade to a density approximating that of the undisturbed material.
- Excavate the subgrade sufficiently deep so the finished grade of the riprap will be at the elevation of the surrounding area.
- Channels should be excavated sufficiently to allow placement of the riprap in a manner such that the finished inside dimensions and grade of the riprap meet design specifications.

Sand And Gravel Filter Blankets

- Install the filter blanket immediately following subgrade preparation.
- For a gravel filter layer, spread the gravel in a uniform layer to the specified depth.
- Where more than one layer of filter material is used, spread the layers with minimal mixing.

Non-Woven Geotextile Filter

- Place the geotextile on the prepared subgrade.
- Overlap the edges of the fabric by at least 600 mm and space anchor pins every 1 m along the overlap.
- Bury the upper and lower ends of the cloth a minimum of 300 mm.
- Carefully place riprap (by machine and hand) in order to avoid damaging the cloth. If damage occurs, remove the riprap and repair by placing another piece of filter fabric over the damaged area, with an overlap of at least 300 mm.
- For placement of large riprap, a 100 mm thick layer of sand or gravel is recommended to protect the cloth.

Stone Placement

- Riprap must consist of a graded mixture such that 50 % of the mixture by weight must be larger than the D_{50} size selected by the designer. The largest rock size must be no more than 1-1/2 times the D_{50} size while the smallest size must be approximately 25 mm.

- The minimum thickness of the rip-rap layer must be 1-1/2 times the maximum stone diameter, but not less than 300 mm.
- Riprap must be installed in one operation, immediately after the filter placement.
- Install riprap so that it forms a dense mass of well-graded stone with a minimum of voids.
- The desired distribution of stones throughout the placement may be obtained by selective loading at the quarry and controlled dumping during final placement.
- Be careful not to damage or dislodge the underlying base or filter when placing riprap.
- The toe of the riprap must be keyed into a stable foundation.
- Hand placement may be necessary to help achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface.
- The finished grade of the riprap must blend with the surrounding area.

Inspection and Maintenance

Riprap should be inspected periodically for scour or dislodged stones.

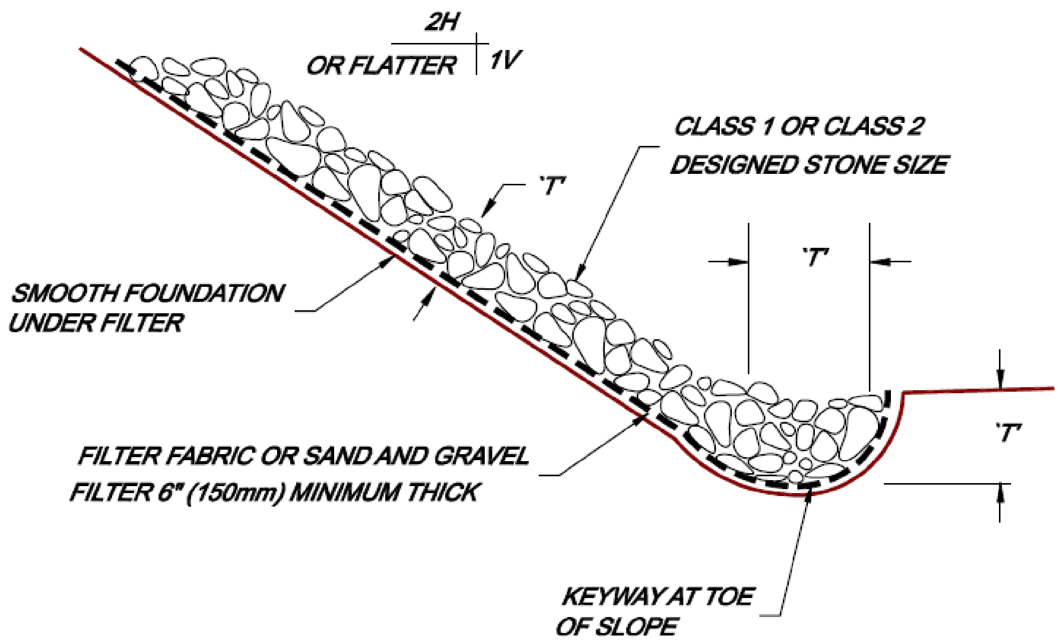
Control weed and brush growth as required.

Little maintenance is generally required.

Construction Details

Refer to:

Figure 26: Riprap Slope Protection



TYPICAL SECTION

NOTE:
'T' = THICKNESS: Thickness shall be determined by the Engineer.
Minimum thickness shall be 1.5x the maximum diameter, never less than 150mm (6").

The toe of the riprap must be keyed into a stable foundation.
Hand placement may be necessary to help achieve proper
distribution of stone sizes to produce a relatively smooth, uniform surface.
The finished grade of the riprap must blend with the surrounding area.

INSPECTION & MAINTENANCE:
Riprap should be inspected periodically for scour or dislodged stones.
Control weed and brush growth as required.
Little maintenance is generally required.

Riprap Protection

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Source: Salix Applied Earthcare - Erosion Draw 5.0
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Figure 10-18: Riprap Slope Protection

BMP 20	CELLULAR CONFINEMENT SYSTEMS	Erosion Control

Description and Purpose

- **Permanent Measure**
- **Steep Slopes**

Cellular Confinement Systems (CCS) are three-dimensional, honeycomb soil-retaining structures used to mechanically stabilize fill soils, allowing slope and channel protection, load support and earth retention applications. Expandable panels create a cellular system that confines topsoil, protects and reinforces the root zone and permits infiltration.

Applications and Advantages

- Erosion control on steep slopes: As an alternative to traditional hard armouring, cells can be filled with soil and vegetated. This practice is suitable for slopes as steep as 1:1. Application on steep slopes may require tendons for system stability.
- Flexible channel lining systems (either vegetated or rock filled).
- As a porous pavement system with aggregate or topsoil/vegetation fill.
- Temporary low-water stream crossings (rock filled).

Limitations

- Availability can be limited; expensive; labour intensive.
- Not suitable for slopes steeper than 1H:1V.

Implementation

- Grade the slope to design elevations and grades.
- Remove rocks and debris from the matting location.
- Excavate the area so that the top of the CCS is flush with or slightly lower than the adjacent terrain or final grade.
- Install the CCS in accordance with manufacturer directions.
- Matting must be placed longitudinal to the direction of flow/down-slope.
- Place the fill material in the expanded cells with suitable equipment such as a back-hoe, front-end loader or conveyer. To avoid CCS deformation, start infilling at the top of the slope.

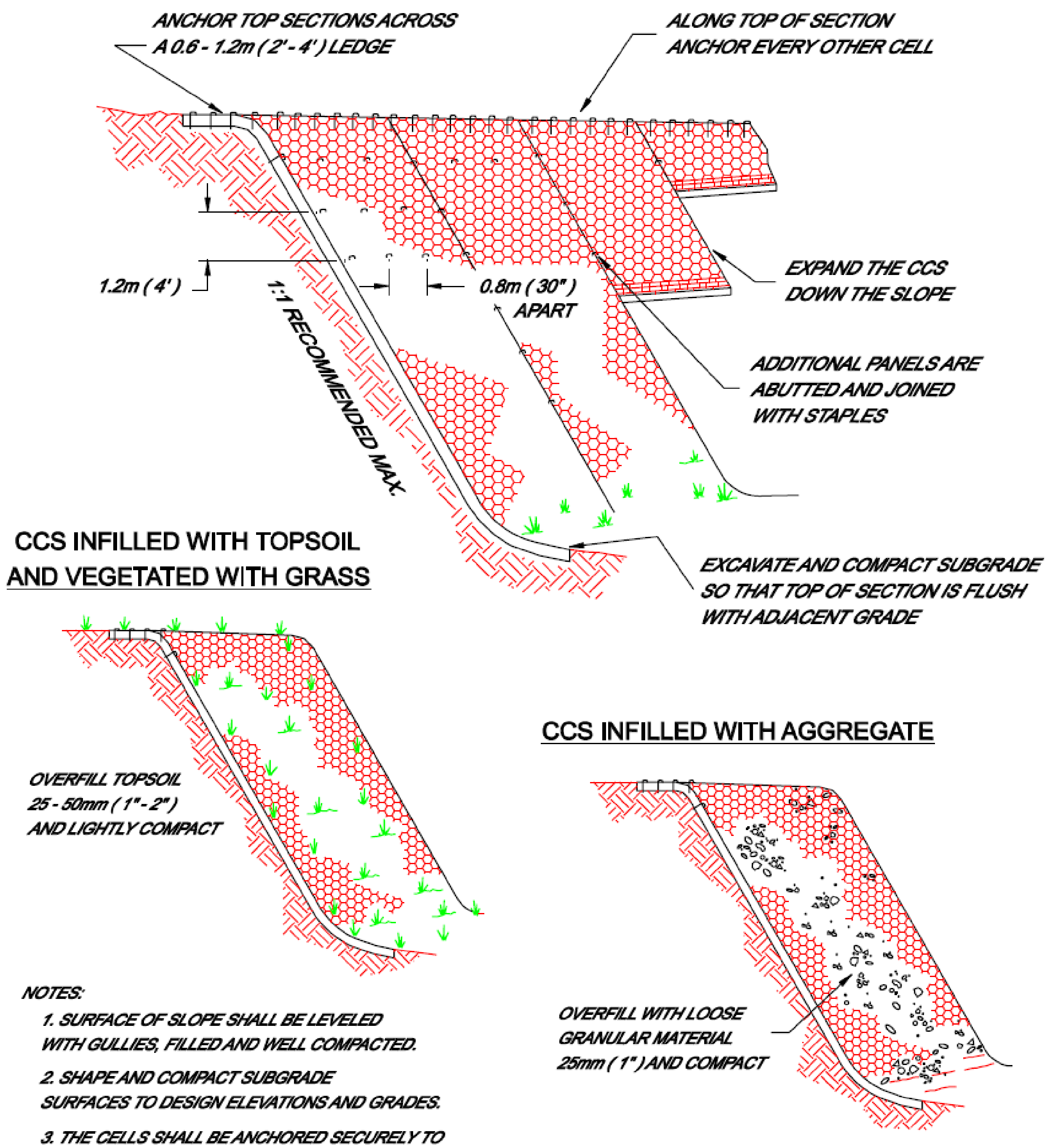
Inspection and Maintenance

- Prior to establishment of a vigorous vegetation cover, areas treated with a CCS should be regularly inspected, especially after heavy, prolonged rain. Check for damage or loss of material and undertake any necessary repairs immediately.

Construction Details

Refer to:

Figure 27: Cellular Confinement System Material/Installation



NOTES:

1. SURFACE OF SLOPE SHALL BE LEVELED WITH GULLIES, FILLED AND WELL COMPACTED.
2. SHAPE AND COMPACT SUBGRADE SURFACES TO DESIGN ELEVATIONS AND GRADES.
3. THE CELLS SHALL BE ANCHORED SECURELY TO PREVENT DISPLACE-MENT AND DEFORMATION OF PANELS WHEN BACKFILLING.
4. INFILL FROM CREST OF THE SLOPE TO TOE TO PREVENT DISPLACEMENT. LIMIT DROP HEIGHT TO 31m (3').

NOT TO SCALE

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Cellular Confinement System for Slope Stabilization

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Source: Salix Applied Earthcare - Erosion Draw 5.0
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Figure 10-19: Cellular Confinement System Material/Installation

BMP 21	LIVE STAKING, BRUSH LAYERING AND FASCINES	Erosion Control

Description and Purpose

- **Permanent Measure**
- **Steep Slopes, Channels and Banks with Adequate Moisture Regime**

Biotechnical soil stabilization consists of installing woody plantings and live woody material to develop a deep, heavy root matrix in the soil, increasing subsurface soil strength and stabilizing soils with deeper root systems than grasses and forbs can provide.

Live Staking: Insertion and tamping of live, vegetative cuttings into the ground in a manner that allows the stake to take root and grow.

Brush Layering: Cuttings or branches of easily rooted tree species are layered between successive lifts of soil fill to construct a reinforced slope or embankment.

Wattles or Live Fascines: Live branch cuttings, usually willow species, bound together into long, cigar-shaped bundles used to stabilize slopes and stream banks.

Applications and Advantages

- Repair of small earth slips and slumps or to protect slopes from shallow slides 1-2 feet (0.3-0.6 m) deep.
- Wattling may be used to stabilize entire cut or fill slopes or localized gully areas of slopes.
- Wattling may be installed during construction (dormant season) or as a remedial action on existing slopes.
- The wattle bundles, binding rope and stakes are all structural components which combine to stabilize the surface layers of the slopes by resisting hydraulic and gravitational forces.
- Wattling prevents rills and gullies by reducing the effective slope length and thereby dissipating the energy of water moving downslope. Wattles immediately reduce surface erosion.
- The terraces formed by a series of wattles trap sediment and detritus. Infiltration is increased as run-off is slowed and on dry sites this increases the available water for plant establishment.
- Vegetation establishment is enhanced because wattling provides suitable micro-sites for plants by reducing surface erosion, increasing infiltration rates and by forming a series of terraces with shallower slope angles.

Limitations

- May be limited by material and labour availability and time of year.
- Can be very labour-intensive.

Implementation

- Plant material harvest and installation should be performed during its dormant season (late fall to early spring).

- Survey the identify willow species, growth form, soil and site conditions on adjacent sites and compare their conditions to the construction site. Planting will be more successful if the soil, site conditions, and species selected match stable and vegetated nearby sites.

Wattles:

- The ideal plant materials for wattling are those that: 1) root easily; 2) are long, straight and flexible; and 3) are in plentiful supply near the job site. Willow (*Salix* sp.) makes ideal wattling material. Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on-site before construction begins.
- Young (less than 1 year old) wood or suckers will often sprout easier under optimum conditions but healthy, older wood (1 to 4 years old) has greater energy reserves necessary to consistently sprout and the older wood is much stronger. If possible, mix younger wood with older wood for the bioengineering application such that a majority of the material is 1 to 4 years old.
- All cuttings should be soaked for a minimum of 24 hours.
- Cuttings should be long (1 m minimum), straight branches up to 40 mm in diameter.
- Cuttings shall be tied together to form bundles, tapered at each end, 2-10 m in length, depending on-site conditions or limitations in handling.
- The completed bundles should be 15-30 cm in diameter, with the growing tips and butt ends oriented in alternating directions.
- Stagger the cuttings in the bundles so that the tips are evenly distributed throughout the length of the wattle bundle.
- Wattle bundles should be compressed and tightly tied with rope or twine of sufficient strength and durability.
- Install wattles into trenches dug into the slope on contour.
- Spacing of contour trenches (wattles) is determined by soil type, potential for erosion and slope steepness.
- Place the wattles immediately after trenching to reduce desiccation of the soil.
- Wattles should be staked firmly in place with construction stakes.
- Proper backfilling is essential to the successful rooting of the wattles. Backfill wattles with soil from the slope or trench above.
- Seed and mulch the slope.

Live Stake Harvesting:

- Stakes shall be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring, or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight.
- Use live wood at least 1 year old or older. The best wood is 2-5 years old with smooth bark that is not deeply furrowed.
- Make clean cuts with un-split ends. Trim branches from cutting as close as possible. The butt end of the cutting shall be pointed or angled and the top end shall be cut square.
- Cuttings should be at least 20 mm diameter or larger depending on the species. Highest survival rates are obtained from using cuttings 50 to 75 mm in diameter. Larger diameter cuttings are needed for planting into rock riprap.
- Cuttings should be long enough to reach into the mid-summer water table, if possible.

- No less than 1/2 the total length of cutting must be buried into the ground.
- Stakes must not be allowed to dry out. All cuttings should be soaked in water for a minimum of 24 hours. Soaking significantly increases the survival rate of the cuttings.
- Plant stakes 0.3-1 m apart.
- It is essential to have good contact between the stake and soil for roots to sprout. Tamp the soil around the cutting.
- Do not damage the buds, strip the bark or split the stake during installation.
- Stakes must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.

Inspection and Maintenance

Regular inspection and maintenance of wattle installations should be conducted, particularly during the first year.

Repairs should be made promptly. Stakes that loosen because of saturation of the slope or frost action should be re-installed.

Rills and gullies around or under wattles should be repaired.

Construction Details

Refer to:

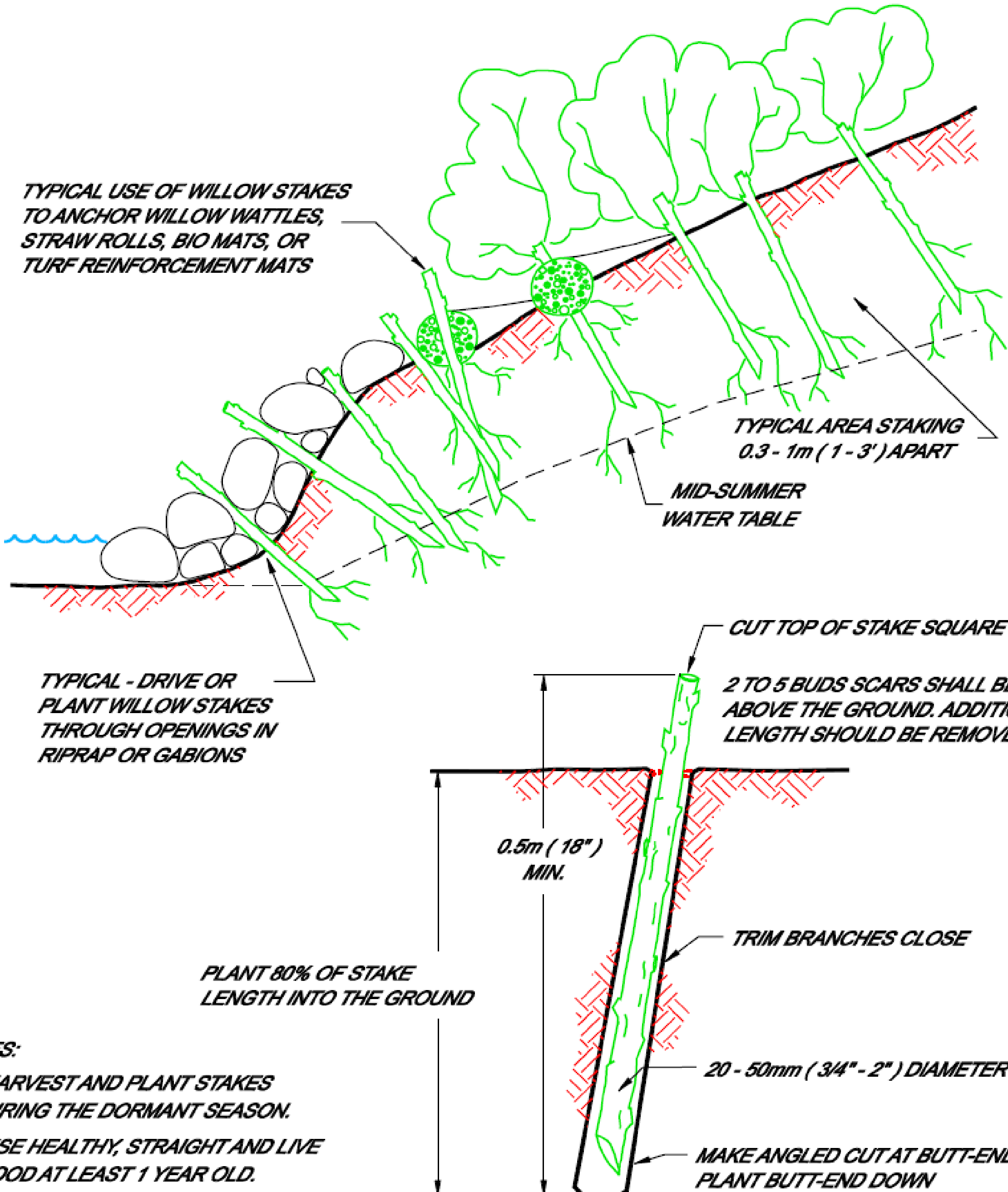
Figure 28: Live Staking Material/Installation

Figure 29: Installation Detail for Wattles/Live Fascines

Figure 30: Installation Detail for Brush Layering

Figure 31: Slope Stabilization Using Bioengineering Techniques

Photo 16: Streambank Biotechnical/Bioengineering Project on the Pembina River, west central Alberta (note the use of brush layering, riprap toe protection and rock vanes).



NOTES:

1. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON.
2. USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD.
3. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION. USE A PILOT BAR IN FIRM SOILS.
4. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
5. TAMP THE SOIL AROUND THE STAKE.

NOT TO SCALE

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Live Staking

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Source: Salix Applied Earthcare - Erosion Draw 5.0
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Figure 10-20: Live Staking Material/Installation

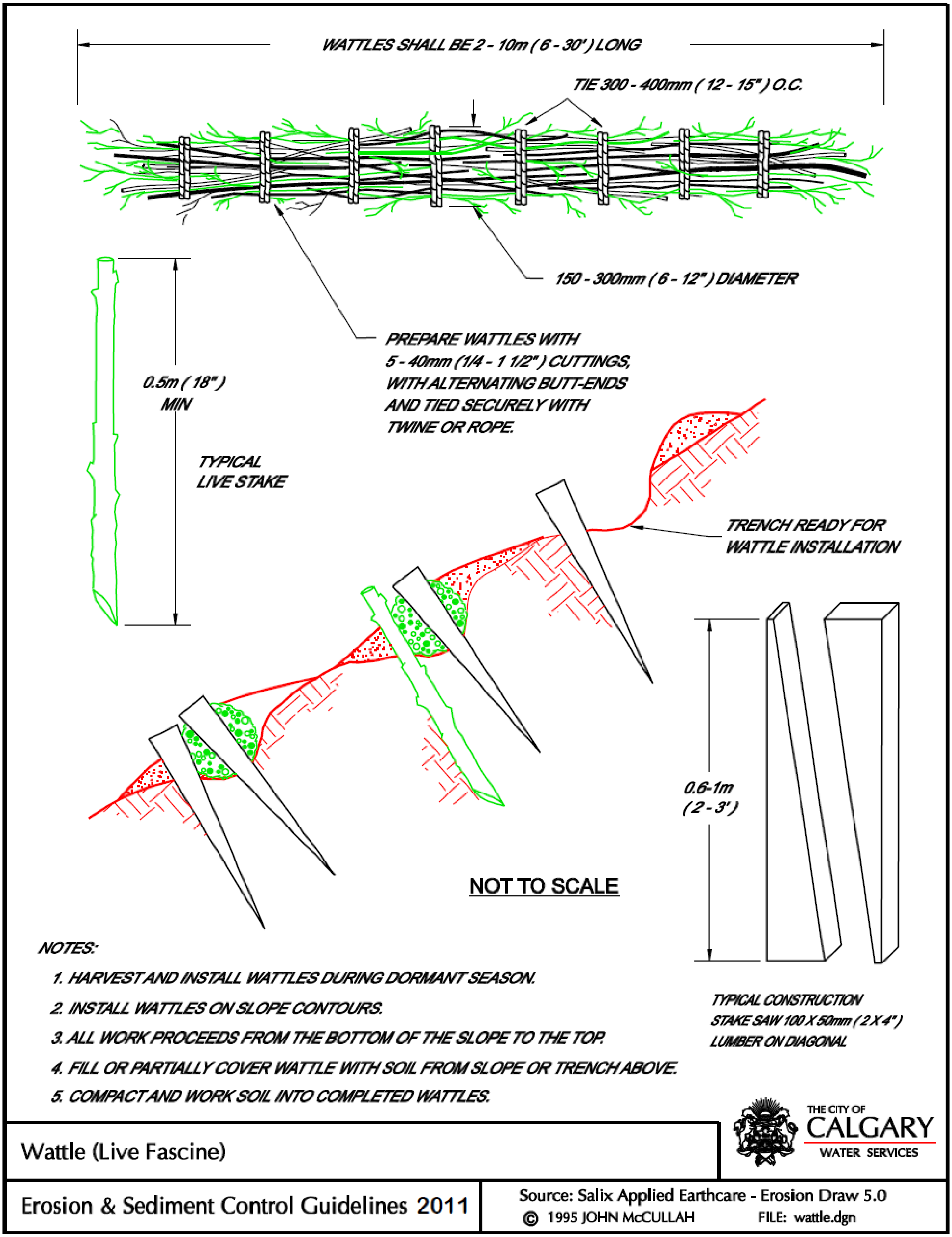


Figure 10-21: Installation Detail for Wattles/Live Fascines

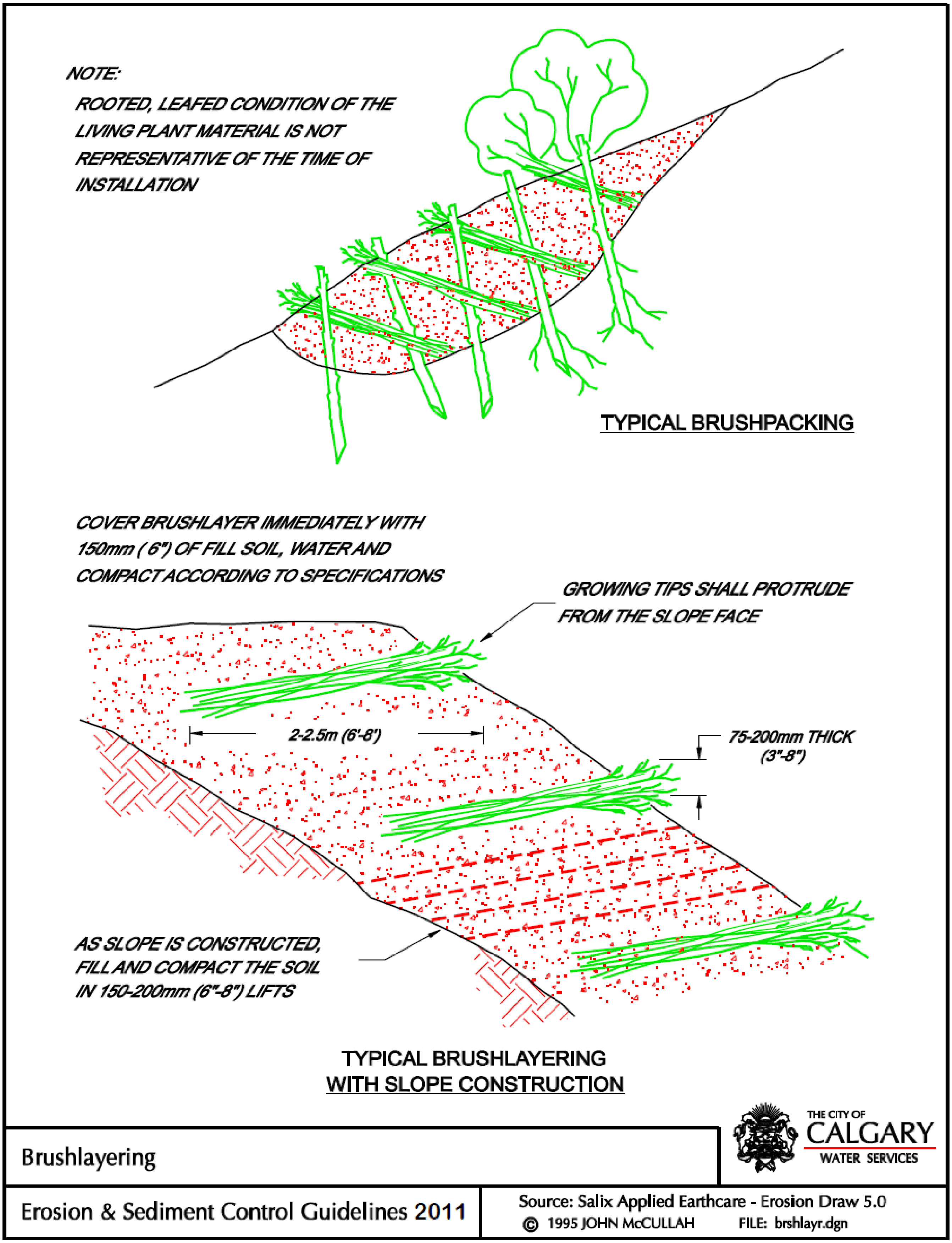


Figure 10-22: Installation Detail for Brush Layering

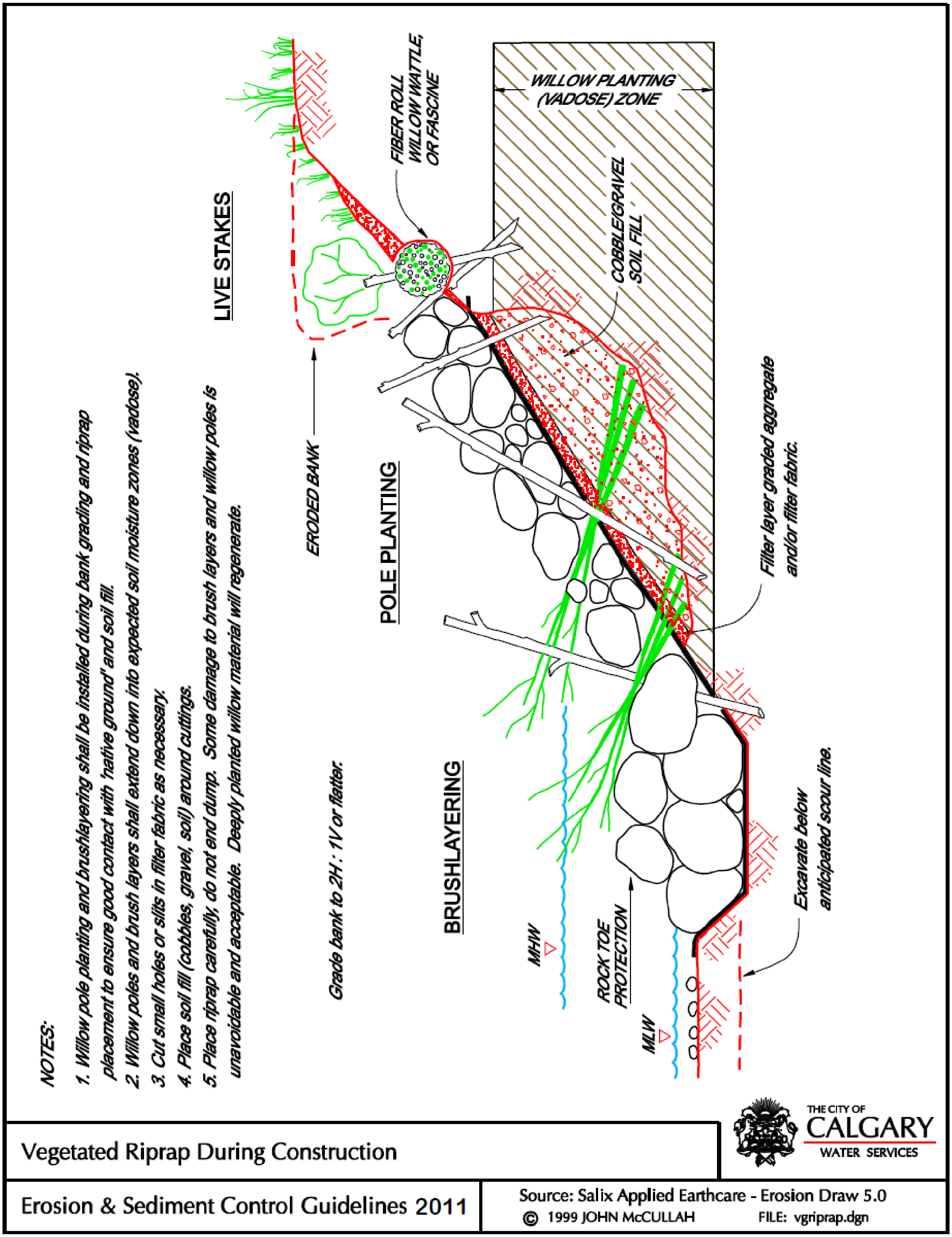


Figure 10-23: Slope Stabilization Using Bioengineering Techniques

Table 10-6: Best Practices for Sediment Control

<table>
<tr><th rowspan="2">BMP</th><th rowspan="2">APPLICATIONS</th><th colspan="2">COMMENTS</th></tr>
<tr><th>ADVANTAGES</th><th>CHALLENGES/LIMITATIONS</th></tr>
<tr><td>BMP 22: Dust Control</td><td>• Dust control measures should be applied to large areas of exposed soil, especially sub soils that are disturbed and prone to drying out.
• Dust control measures should also be applied to stockpiles, haul roads and other disturbed areas exposed to wind.</td><td>• The timely implementation and frequent inspection and maintenance of practices used to control dust can significantly improve the health and safety of construction workers and the general public.</td><td>• Water or chemical dust suppressants may need frequent re-application, especially in dry, windy conditions or in areas under heavy disturbance.
• Ensure chemical dust suppressants are appropriate for use and environmentally benign. Always obtain and adhere to product Material Safety Data Sheets.</td></tr>
<tr><td>BMP 23: Best Practices for Construction Dewatering</td><td>• Construction dewatering refers to the removal of impounded storm run-off or groundwater from a construction site (i.e. excavations, coffer dams, sediment traps and basins). Water is commonly discharged to a storm sewer or, occasionally, a sanitary sewer.
• The City of Calgary sets strict conditions on the quality, rate and volume of the discharge: This generally requires that best practices are implemented to control sediment and other contaminants.</td><td>• Construction dewatering is generally intended to regain access to excavations impacted by storm run-off or groundwater seepage. Forecasting and planning for dewatering can reduce project delays and ensure compliance with regulations.
• Dewatering of sediment traps and basins (via a suitable outlet structure or by pumping) is sometimes required to provide access for sediment removal and to maintain required storage volume.
• Dewatering of excavations and areas with ponded water can improve site safety and reduce mosquito breeding.</td><td>• Dewatering to a City storm or sanitary sewer requires prior written permission (permit).
• Consultants and contractors must be familiar with dewatering best practices and may often need to apply a combination of source controls and sediment controls (treatment train) to be effective.
• Many dewatering controls only address sediment and not other contaminants such as metals and hydrocarbons. In many cases, detailed information on-site history and baseline water quality is essential.
• Fine sediment is very difficult to filter or settle using conventional means and is best controlled at the source.
• It may be necessary to use suitable flocculants or coagulants to promote settling of fine silt and clay-size material.</td></tr>
<tr><td>BMP 24: Sediment traps and basins</td><td>• Installed at the site perimeter, as well as intermediate points, to retain concentrated, sediment-laden run-off.
• Sediment basins are suitable for disturbed drainage areas greater than 2.0 ha. Sediment traps are</td><td>• Depending on upstream soil texture, and if properly designed, installed and maintained, traps and basins can remove 70 – 80 % of the sediment from detained run-off.
• The use of a skimmer device connected to an outlet improves sediment-trapping efficiency by better regulating the filling and draining of a basin.</td><td>• Basins must be designed by a qualified professional.
• 100% sediment removal effectiveness is not possible, especially for silt and clay-sized material: Must be used as a complement to run-off and erosion control.
• Must be frequently inspected and maintained to ensure effectiveness.
• Keep children away from traps/basins.</td></tr>
</table>

<table>
<tr><th rowspan="2">BMP</th><th rowspan="2">APPLICATIONS</th><th colspan="2">COMMENTS</th></tr>
<tr><th>ADVANTAGES</th><th>CHALLENGES/LIMITATIONS</th></tr>
<tr><td></td><td>suitable for disturbed drainage areas of ≤ 2.0 ha</td><td></td><td>It may be necessary to conduct approved dewatering of the structure or to design more detention than retention (i.e. device or outlet for slowly draining the structure).
Traps must <u>not</u> be located in live streams.
Periodic removal of accumulated sediment is required.</td></tr>
<tr><td>BMP 25: Compost Berms and Compost Filter Socks</td><td>Berms/socks can be installed at the base of slopes with gradients of 2H:1V or less (for steep slopes, berms/socks can also be installed, on contour, to reduce slope length).
Berms/socks must be installed perpendicular to sheet flow, allowing run-off to be intercepted, detained and filtered. Filter socks can be staked in channels (as temporary check dams) to reduce the velocity of low to moderate flows (control channel erosion).</td><td>A suitable seed mix can be incorporated into berms and socks during construction.
Filter socks are flexible and can be filled in place or filled and moved into position.
A range of biodegradable and synthetic mesh casing is available for compost socks. Casing provides added structural stability and integrity to the compost, allowing application for areas such as steeper slopes, low flow channels and for stream bank/shoreline bioengineering projects.
Compost is organic, biodegradable, renewable, and can be left onsite.
The flexibility, continuity and weight of berms and filter socks allows for good conformity and surface contact with site soils, reducing potential for undermining.
Installation does not require disturbing the soil surface.
Compost retains a large volume of water (reduced erosion potential, enhanced seedling establishment).
Compost berms and socks are more effective at providing filtration of sediment-laden run-off than traditional controls such as silt.
Compost can adsorb stormwater contaminants such as heavy metals, nutrients, pesticides and hydrocarbons.</td><td>Only suitable for detention and filtration of sheet run-off or (for socks) low to moderate channel flow.
Use only sanitized, mature compost that meets all local, provincial and federal (CCME Category A) requirements.
To maximize effective filtration, compost should consist of both large and small fragments.
Compost must be free of weeds, weed seeds, pesticide residues and garbage.</td></tr>
<tr><td>BMP 26: Silt Fence</td><td>Silt fence is installed along contours and in “smile” and “J-hook” patterns designed to detain sediment-laden <u>sheet flow</u> from small, disturbed areas.
Silt fence is most effective</td><td>In combination with upstream erosion and run-off controls, silt fence can be an effective way to capture and settle coarse sediment from <u>small areas subject to sheet flow</u>.
Silt fences generally have a useful life of one up to season (dependant on the amount of maintenance required).</td><td>Improperly silt fence installation, inspection and maintenance can increase erosion.
As a temporary practice, silt fence must be removed when the contributing area is stabilized.
Silt fence should be considered, wherever possible, as a “last line of defence”. There is no substitute for controlling upstream run-off and</td></tr>
</table>

<table>
<tr><th rowspan="2">BMP</th><th rowspan="2">APPLICATIONS</th><th colspan="2">COMMENTS</th></tr>
<tr><th>ADVANTAGES</th><th>CHALLENGES/LIMITATIONS</th></tr>
<tr><td></td><td>for trapping larger particle sizes (coarse silt to sand): Finer-size material (fine silt and clay-size) is <u>not</u> detained.
• Silt fence is a suitable practice for the toe of short, exposed cut and fill slopes, as a <u>contour</u> boundary between a construction site and off-site critical areas such as streets, storm sewer inlets and environmentally sensitive areas and as a stockpile perimeter control.
• Clean run-off must be diverted away from sediment containment controls such as silt fence.</td><td></td><td>erosion.
• Long, continuous runs of fence concentrate run-off and commonly lead to failures.
• Do not install silt fence at locations where concentrated run-off occurs or may occur.
• Silt fence is not effective unless properly sliced or entrenched and compacted into the ground.
• Silt fence must not be designed to impound sediment or water more than 0.5 m high.
• Silt fence does a poor job of controlling clay and fine silt in sediment-laden run-off: Run-off is usually not detained long enough to allow settling of fine soil particles.
• Do not place silt fence on a slope. Unless intended as a diversion.
• Ensure the maximum area draining to silt fence is 0.1 ha (1/4 acre) per 30 m of fence (or less for fence at the toe of steep slopes).</td></tr>
<tr><td>BMP 27: Storm Inlet Sediment Control</td><td>• Temporary sediment control devices on active storm inlets draining small, disturbed areas can provide some removal of coarse sediment.
• Inlet sediment controls are not a substitute for run-off, erosion control and on-site sediment control. They require very frequent inspection and maintenance.</td><td>• Can provide some limited temporary ponding and filtering of run-off during minor rainfall or snowmelt events.
• Relatively easy to install, inspect and maintain.</td><td>• Inlet sediment control is a temporary practice. It is <u>not</u> a substitute for proper design and implementation of upstream run-off, erosion & sediment control.
• Controls are generally only effective at providing temporary detention and filtering of run-off resulting from minor rainfall or snowmelt. Controls will be overwhelmed, ineffective and may cause excess back-up or diversion of run-off during moderate to large rainfall or snowmelt events.
• Very frequent inspection and maintenance is required.
• Silt fence and straw bales are generally not effective materials for storm inlet sediment control.</td></tr>
</table>

BMP	APPLICATIONS	COMMENTS	
		ADVANTAGES	CHALLENGES/LIMITATIONS
BMP 28: Flocculants and Coagulants Note: This BMP discusses two categories of chemicals that are locally available: Chitosan and anionic polyacrylamide (PAM). The advice of manufacturers, suppliers, sediment control specialists and regulators must be sought prior to using chemicals for sediment control.	• Chitosan is commonly used as a coagulant in long-term construction dewatering activities in Calgary (to complement other dewatering practices when fine silt and clay-size material is unavoidably suspended in water). • Anionic PAMs are intended for use on soils that contain high amounts of fine silt and clay-size material. PAMs can be soil applied (to improve soil structure and reduce erosion by wind or water) or to treat sediment-laden water upstream of retention or detention controls. Anionic PAMs complement the use of other ESC practices when the timely establishment of vegetation may not be feasible or adequate, or where conventional temporary ESC is limited.	• Chitosan and Anionic PAMs – selected on the basis of site-specific soil and water quality information and applied at low dosages - are non-toxic to aquatic life. • Aggregation improves the resistance of fine-grained soils to particle detachment and entrainment by wind (dust control) and water, providing temporary protection for exposed soils prior to final stabilization. • Aggregation of fine particles in fine grained size can increase soil pore volume and permeability. • *In situ* flocculation or coagulation of fine silt and clay-size particles enhances particle settling and complements other sediment control practices.	• Note: Cationic PAM products must never be used as they are toxic to fish at extremely low levels (bind to fish gills and cause suffocation). • Product effectiveness is affected by soil texture and – to a degree – soil chemistry: This requires site-specific soil information. This may limit product bulk ordering or reuse on multiple sites. Soil sampling and analysis may take several days to complete. • Mechanical mixing or agitation is generally required after introduction of the product to water. • May enhance precipitation of fine sediments in downstream sediment control structures, increasing maintenance requirements (removal of sediment). • Over-dosage of product can cause dispersion of fine particles, negatively impacting soil structure and particle settling in water. • Intended to complement conventional ESC practices: Not a substitute for timely planning and implementation of suitable ESC practices. • Effectiveness of some products can be affected by temperature. The manufacturer must account for this when providing specific product and dosing rate recommendations.

BMP 22	DUST CONTROL	Sediment Control

Description and Purpose

Soil erosion by wind can be a significant problem. Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways and into watercourses.

- **All Stages of Construction Where There is Exposed Soil**
- **Especially Haul Roads, Stripped Areas, and Stockpiles**

Applications and Advantages

- Dust control measures should be applied to large areas of exposed soil, especially sub soils that are disturbed and prone to drying out.
- Dust control measures should also be applied to stockpiles, haul roads and other disturbed areas exposed to wind.
- The timely implementation and frequent inspection and maintenance of practices used to control dust can significantly improve the health and safety of construction workers and the general public.

Limitations

- Dust control measures such as water application and chemical dust suppressants will need to be frequently inspected and the measures reapplied.

Implementation

Dust can be controlled by:

- Clearing vegetation only from areas that will be worked right away.
- Vegetating or applying mulch to areas that won't receive vehicle traffic.
- Constructing wind breaks or wind screens.
- Spraying the site with water until the surface is wet. Care should be taken that this does not lead to tracking of mud onto nearby streets.
- Spraying exposed soil areas with a dust palliative. Used oil is prohibited as a dust suppressant.
- Stopping work in serious adverse wind conditions.
- Using and maintaining internal haul roads.
- To protect adjacent roads and property owners:
- Lower speed limits to decrease dust stirred up from unpaved roads and lots.
- Add surface gravel to reduce the source of dust emission. The amount of fine particles should be limited to 10 to 20%.
- Use geotextiles to increase the strength of new roads or roads undergoing reconstruction.
- Encourage use of alternate paved routes if possible.
- Encourage use of internal haul roads and maintain as required.

- Restrict use by tracked vehicles and heavy trucks to prevent damage to the road surface and base.
- Apply chemical dust suppressants.
- Pave unpaved permanent roads.

Note: Work such as stripping and grading, or other work involving large equipment, must be stopped during extreme windy conditions where excessive dust is being generated.

BMP 23	CONSTRUCTION DEWATERING ACTIVITIES	Sediment Control

Note: Persons or companies wishing to discharge impounded water from a construction site or private land to storm or sanitary sewer must obtain prior written permission (a permit) from The City of Calgary, Water Resources. Dewatering activities must not result in erosion or the discharge of sediment or other contaminants into storm or sanitary sewers or water bodies. Permits have strict conditions that regulate the quality and quantity of water that may be released. For further information, contact The City of Calgary at 3-1-1.

Description and Purpose

- **Disposal of trapped groundwater and surface water from ponded areas and excavations (typically to storm sewer)**

The term dewatering encompasses various methods used to remove and discharge excess water from a construction site. The most common method is to pump water out of areas where it does not otherwise drain off (i.e. excavations, sediment basins and traps). Water pumped out of cofferdams, excavations, footings and other areas where water can accumulate may contain high concentrations of suspended solids. The solids are sometimes already suspended in the water, or construction or pumping activities can mix the solids into the water. In all cases, adequate sediment control (i.e. using diversion structures, well points, filter sump pits, sediment traps, sedimentation tanks, flocculants or coagulants) must be provided before the pumped water is discharged.

Suitable Applications

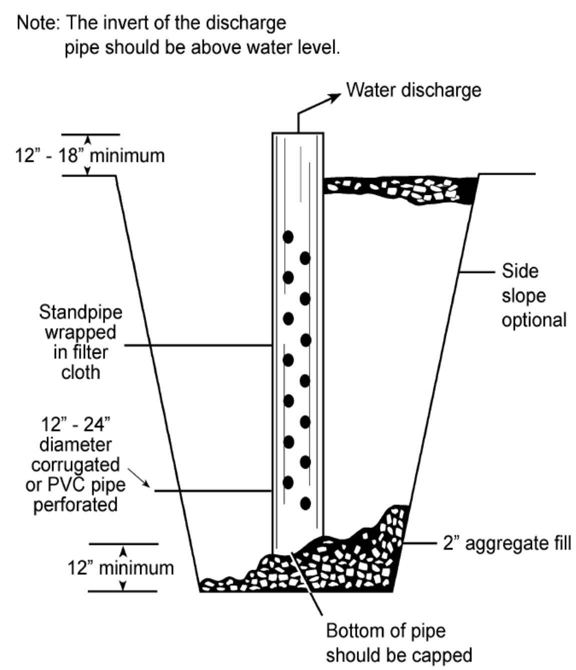
- Good dewatering practice must be implemented for the discharge of impounded surface water, groundwater and shallow seepage from construction excavations and depressed areas.

Limitations

- Dewatering requirements are site specific: Site conditions will dictate design and use of dewatering operations. Consultants and contractors must be familiar with dewatering best practices and may often need to apply a combination of source controls and sediment controls (treatment train) to be effective.
- Many dewatering controls only address sediment and not other contaminants such as metals and hydrocarbons. Detailed information on-site history and baseline water quality is often required before a drainage or dewatering permit is issued.
- Fine sediment is very difficult to filter or settle using conventional means. As in all cases, sediment is best controlled at the source using a combination of run-on, run-off and erosion controls. In addition to conventional filtering and settling practices, it may be necessary to use suitable flocculants or coagulants to promote settling of fine silt and clay-size material.
- Dewatering to a City storm or sanitary sewer requires prior written permission (permit). Application requirements must be met and all conditions adhered to at all times.

Implementation

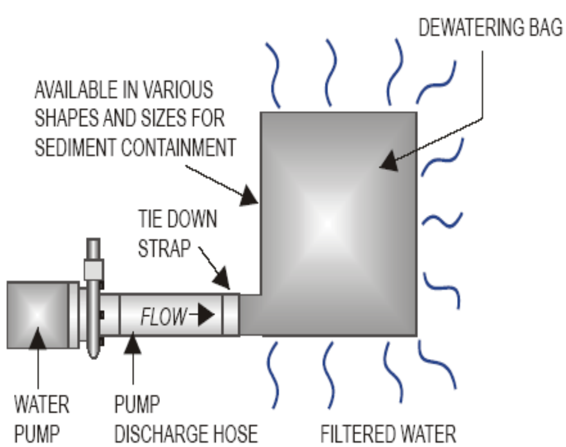
Dewatering practices are site and soil specific. It is always most effective to control sediment at the source (divert clean run-on away from disturbed areas, stabilize site soils and drainage channels, collect water in well point or filter sump systems). Particularly in the case of fine suspended sediment in water, a combination of treatment options are usually required. The following provides some basic, generic information on possible collection and treatment options. Many of the best practices discussed in other sections could also be applied to provide effective dewatering.



Sump Pits

- A sump pit is a temporary pit placed to collect water in an excavation, cofferdam, sediment trap or basin so as to minimize contamination of water with sediment.
- A perforated standpipe wrapped in an appropriate geotextile designed to minimize plugging is placed in the center of the pit and the excavation is backfilled with 40 – 50 mm filter gravel.
- Water that collects in the pit flows through the gravel into the standpipe and is generally pumped to a filtering or settling control for additional treatment.
- Constructing a suitable sump pit provides a simple method for collecting water in an excavation, cofferdam, sediment trap or basin. A sump pit may be used for dewatering where space is limited (common on urban construction sites). It should generally be used only for small flows and volumes.

Source: U.S. Environmental Protection Agency (EPA), 1992



Gravity Bag Filters (Dewatering Bags)

- A gravity bag filter, also referred to as a dewatering bag, is a square or rectangular bag made of non-woven geotextile fabric that can filter sand and coarse silt from sediment-laden water. Note: Dewatering bags do not remove fine silt and clay-sized material.
- Water is pumped into one side of the bag and seeps through the bottom and sides of the bag.
- A secondary barrier, such as a rock filter bed or straw/hay bale barrier, must be placed beneath and beyond the edges of the bag to capture sediments that escape the bag.
- Frequent inspection of the flow conditions, bag condition, bag capacity, and the secondary barrier is required.
- Replace the bag when it no longer filters sediment or passes water at a reasonable rate.

Weir and Clarifier Tanks

- The addition of weirs or plates to a settling tank increases retention time (prevents bypass from inlet to outlet) and, in the case of slanted plate clarifier tanks (a new technology being used in Calgary), provides a large surface area for the attachment and settling of very fine particles (often pre-treated with a coagulant).

- To achieve high levels of flow, multiple tanks can be used in parallel. If additional treatment is desired, the tanks can be placed in series or as pre-treatment for other methods.
- Suitable tank size will depend on flow volume and the residency period required.
- Periodic cleaning will be required to keep the system functional.

Pressurized Bag Filters

- A pressurized bag filter is a unit composed of single filter bags made from polyester felt material. The water filters under pressure through the unit and is discharged through a header.
- Pressurized bag filters do not remove fine clay-size material, so turbidity in the discharge water may exceed water quality requirements. Where fine clay-size material is an issue, it may be necessary to pre-treat the water with addition and mixing of a suitable dosage of flocculant or coagulant, followed by settling in a weir or clarifier tank.
- The filter bags require replacement when the pressure differential equals or exceeds the manufacturer's recommendation.

Inspection and Maintenance

- Sediment removed during the maintenance of a dewatering system may be either spread on-site and stabilized, or disposed of at a suitable disposal site.
- Sediment that is commingled with other pollutants must be disposed of in accordance with all applicable laws and regulations.
- Conduct frequent turbidity monitoring, upstream and downstream of the dewatering activity (including at the discharge point), with a calibrated, handheld turbidity meter. Implement mitigation or contingency measures if turbidity in the discharge exceeds allowable values.
- Avoid dewatering areas where fresh concrete has been placed. Ensure pH of discharge water meets regulatory requirements.

Photo 17: Uncontrolled dewatering of this sediment trap to a storm sewer resulted in a sediment release and the cancellation of the drainage permit for the construction site.

Photo 18: Inclined Plate Clarifier Tank commonly used for construction dewatering sediment removal in Calgary. The tank inlet is on the right and the outlet on the left.

Photo 19: Monitoring discharge turbidity during construction dewatering or drainage is critical. The discharge in the photo is in downtown Calgary and is entering a storm sewer catchbasin that drains to the Elbow River. Given river background levels of 3 to 4 turbidity units (NTU), this water (345 NTU) is too turbid to be discharged to storm. Typical Drainage/Dewatering Permit conditions require that a dewatering discharge to a catchbasin should never exceed 50 NTU.

BMP 24	SEDIMENT TRAPS AND BASINS	Sediment Control

Description and Purpose

- **All Stages of Construction**
- **Note that ponding must be on lots or undeveloped land once surface work commences in subdivisions**
- **Storm Ponds cannot be used for construction sediment control once underground is constructed**

Sediment traps and basins are sediment containment systems designed to provide containment storage volume for sediment-laden run-off, create still conditions to promote the deposition of sediment and to discharge water at a controlled rate. The capture and temporary detention of run-off is created by excavating a pond, constructing an embankment and installing a suitable outlet. Temporary basins/traps are especially suitable for capturing and treating sediment-laden run-off from sites that are stripped and/or graded. Note: This practice must be used in combination with practices for controlling run-on/run-off and erosion.

Sediment traps refer to simple containment intended to capture and treat run-off from disturbed areas of 2.0 ha or less (pond surface area is generally < 500 m^2). Sediment traps vary from small excavated depressions to v-ditches and berms (created by a grader blade) to small basins with designed storage volume, settling depth and an outlet.

Sediment basins are suitable for disturbed drainage areas greater than 2.0 ha (pond area is generally > 500 m^2). Due to the size and volume and potential damage that could result from failure and inherent safety considerations, sediment basins must be designed by qualified engineering consultants. Design considerations include: Sizing for required particle size removal, sediment storage and settling volume, length:width ratio and baffles.

On most construction sites, **retention** of all run-off (i.e. 100 % efficiency) is nearly impossible (requires large storage volume, with sufficient seepage and evaporation; permanent water retention will also make maintenance difficult). Instead, containment systems are designed to **detain** run-off so as to capture “design-size” sediment, while still being able to drain. Minimum storage volumes for construction site run-off in Calgary are based on run-off from a 2 year, 24-hour design storm, and assuming 100 % run-off: this equates to approximately 25 mm depth of run-off, totaling **250 m^3/ha**

Note: Since sediment basins and traps must generally be designed as detention (not retention) systems, 100 % suspended sediment removal will not be possible. Therefore, it is always necessary to implement effective erosion and run-off controls (source control) in combination with sediment controls.

Suitable Applications

- Sediment traps and basins supplement erosion control by detaining sediment-laden run-off and providing settling conditions.
- Traps and basins are generally used as a temporary measure during construction.
- Depending on upstream soil texture, and if properly designed, installed and maintained, traps and basins can remove 70 to 80 % of the sediment from detained run-off. Sediment finer than the medium silt-size fraction is difficult to settle using temporary detention, so will likely pass through the structure untreated.

- The use of a skimmer device connected to an outlet improves sediment-trapping efficiency by regulating the filling and draining of a basin better than conventional methods (using perforated risers or stone).
- To decrease sediment settling time, the controlled addition and mixing of an approved chemical flocculant may be considered. Excess flocculant must not be allowed to enter a storm sewer or receiving water. Only products that are proven to be non-toxic to fish and aquatic invertebrates may be used.
- Traps or basins can be installed at the site perimeter, as well as intermediate points, to retain concentrated, sediment-laden run-off. Perimeter sediment containment must be installed prior to commencement of site stripping, grading and other earthwork.
- Sediment basins are used for disturbed drainage areas greater than 2.0 ha (typical design life is 12 to 18 months). Sediment basins are ideally constructed at the future location of wet or dry ponds.
- Sediment traps are used for disturbed drainage areas of 2.0 ha or less (typically used for up to one year, or until the contributing upstream area is stabilized).

Limitations

- Traps and basins are generally limited to removal of medium silt and larger particles (due to space and storage constraints). Increasing detention time may allow removal of smaller fractions.
- Where accessible, traps and basins are attractive and dangerous to children, requiring protective measures such as fencing.
- Excessive retention of stagnant water can provide mosquito breeding areas, as well as reducing storage available for subsequent storms. In addition to infiltration and evaporation, it may be necessary to conduct approved dewatering of the structure or to design more detention than retention (i.e. device or outlet for slowly draining the structure).
- Traps must <u>not</u> be located in live streams.
- Periodic removal of accumulated sediment is required.

Design and Construction Considerations

- Sediment traps can vary from simple excavations or low areas designed to capture run-off, V-ditches with ditch checks and wheel-compacted berms (created along contours using the blade on a grader) to traps designed similar to basins (storage volume, settling depth, length:width ratio, etc.)
- Sediment basins must be designed and constructed to provide two zones: A sediment storage zone (at least 0.3 m depth) and a sediment settling zone (at least 0.6 m depth), with a detention time of 24 to 40 hours.
- Sediment basins must have a length:width ratio of more than 6:1 (otherwise baffles, such as silt fence or rock, should be installed to prevent short-circuiting). Length:settling depth ratio must not exceed 200.
- All excavating must be conducted in a manner that minimizes/prevents erosion or water pollution.
- Construct sediment traps and basins at the construction site perimeter prior to wet season and construction activities
- Locate traps so as to maximize storage benefit from the terrain and for ease of clean-out and disposal of trapped sediment.
- This control should be installed as close to the sediment source as possible.

- Wherever possible, run-on/run-off from stabilized areas should be diverted away from the trap.
- Where practical, contributing drainage areas should be subdivided into smaller areas and multiple sedimentation traps installed.

Construction

- The use of temporary diversion berms, channels or other means of diversion may be necessary to divert run-off from disturbed areas into traps or basins.
- Clear all vegetation, roots and debris from the footprint area of the trap/basin and embankments and dispose of properly.
- Stockpile topsoil in appropriate location and stabilize against erosion.
- Construct the trap/basin by excavating, constructing embankments, or a combination of the two (as per the drawing specifications).
- The trap/basin bottom must be flat or gently sloping towards the outlet.
- Embankment slopes must not be steeper than 2H:1V and must be well-compacted
- Construct a berm using moist, clean, suitable soil free of rocks, roots and other debris. Construct the berm using multiple small lifts of soil not exceeding 200 mm in thickness and compacted to a minimum of 95% Proctor. The berm height should be a maximum of 1.5 m, with a minimum top-width of 1.5 m. Side slopes must be 3H:1V or flatter.
- Excavate the main outlet structure at the farthest possible point from inlet. The outlet should be placed on firm, smooth ground and should be backfilled to 95% SPD.
- Install proper inlet and outlet protection to protect from scour. The outlet pipe should consist of corrugated steel pipe to protect against pinching and blockage
- Construct an outlet apron on level grade and extend it a minimum of 1.5 m beyond the toe of the embankment.
- Line the spillway, spillway slopes and apron with a non-woven geotextile fabric.
- Install a well-graded stone mix with a minimum D_{50} of 250 mm (10") and maximum D_{50} of 0.35 m (14"), ensuring a minimum stone depth of 500 mm on the sides of the spillway.
- The top of the spillway should be a minimum of 0.45 m (18") below the top of the compacted berm.
- Consider using a skimmer device (rather than conventional riser or rock outlet structures). Conventional outlet structures poorly control the inflow and outflow of run-off from sediment basins. A skimmer drains a basin from the top (reduced turbidity) and in a controlled, slow manner. The Faircloth Skimmer (patented) is available from local suppliers.
- 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 riprap. The spillway crest should be depressed at least 0.15 m below the embankment. Ensure the spillway width is adequate for the drainage area.
- Set a stake in the trap or basin to indicate one third design depth. Sediment should be removed from the trap when it reaches this depth.
- Stabilize the berm against erosion (by seeding, mulch, tackifier, blankets, etc.) immediately following construction.

Inspection and Maintenance

- Inspect sediment traps and basins a minimum of every seven (7) days and after significant rainfall (> 12 mm rainfall within a 24 hour period) or snowmelt. Immediately repair any damage to the berm and or the outlet/spillway/apron.
- Ensure that sediment is removed when it reaches one third (1/3rd) the design depth of the trap or pond. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed of at a suitable location.
- Inspect the sediment trap or basin for area of standing water during every visit. Traps and basins that do not dewater within a few days can reduce storage volume for the next run-off event and may need to be manually dewatered.
- Permission is required from The City of Calgary to dewater to a storm or sanitary sewer and suitable treatment for sediment or other contaminants must be implemented. Contact 3-1-1 for further information. Adhere to all permit conditions.
- Once construction is complete and the drainage area is stabilized, remove the berm, grade the area to surrounding grade and immediately topsoil and vegetate/stabilize.

Construction Details

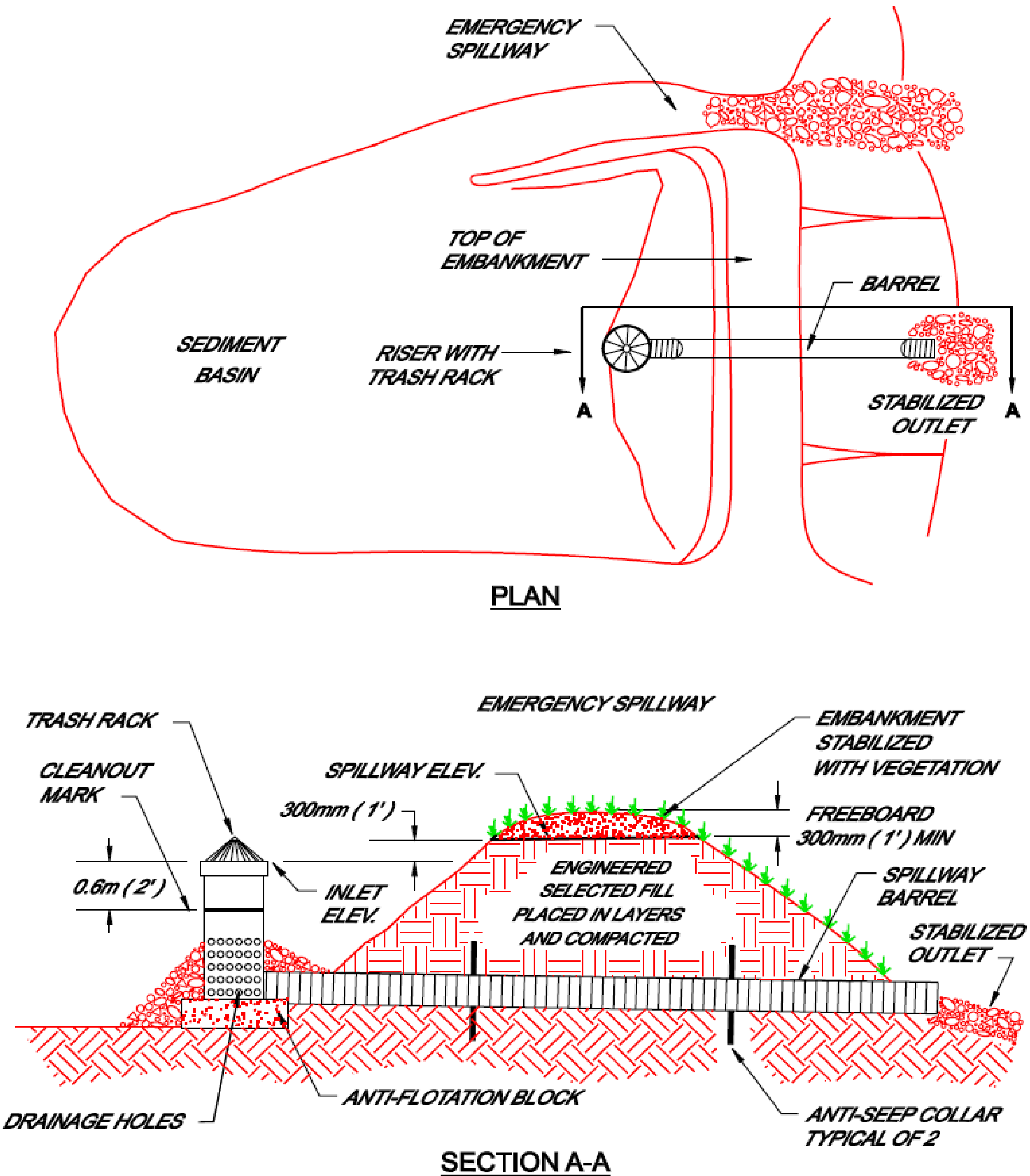
Refer to:

Figure 32: Typical Sediment Basin Construction

Figure 33: Sediment Basin with Baffles and Skimmer Outlet

Figure 34: Faircloth Sediment Basin Skimmer Outlet

Photo 20: Simple sediment trap, with stabilized inlet and outlet and application of an erosion control blanket to protect side slopes.



NOTES:

1. *THE TEMPORARY SEDIMENT BASIN, DESIGNED BY A QUALIFIED PROFESSIONAL, IS REQUIRED FOR DISTURBED AREAS GREATER THAN 5 ACRES WITHIN A DRAINAGE AREA LESS THAN 100 ACRES.*
2. *THE SEDIMENT BASIN WILL BE REMOVED WITHIN 3 YEARS.*

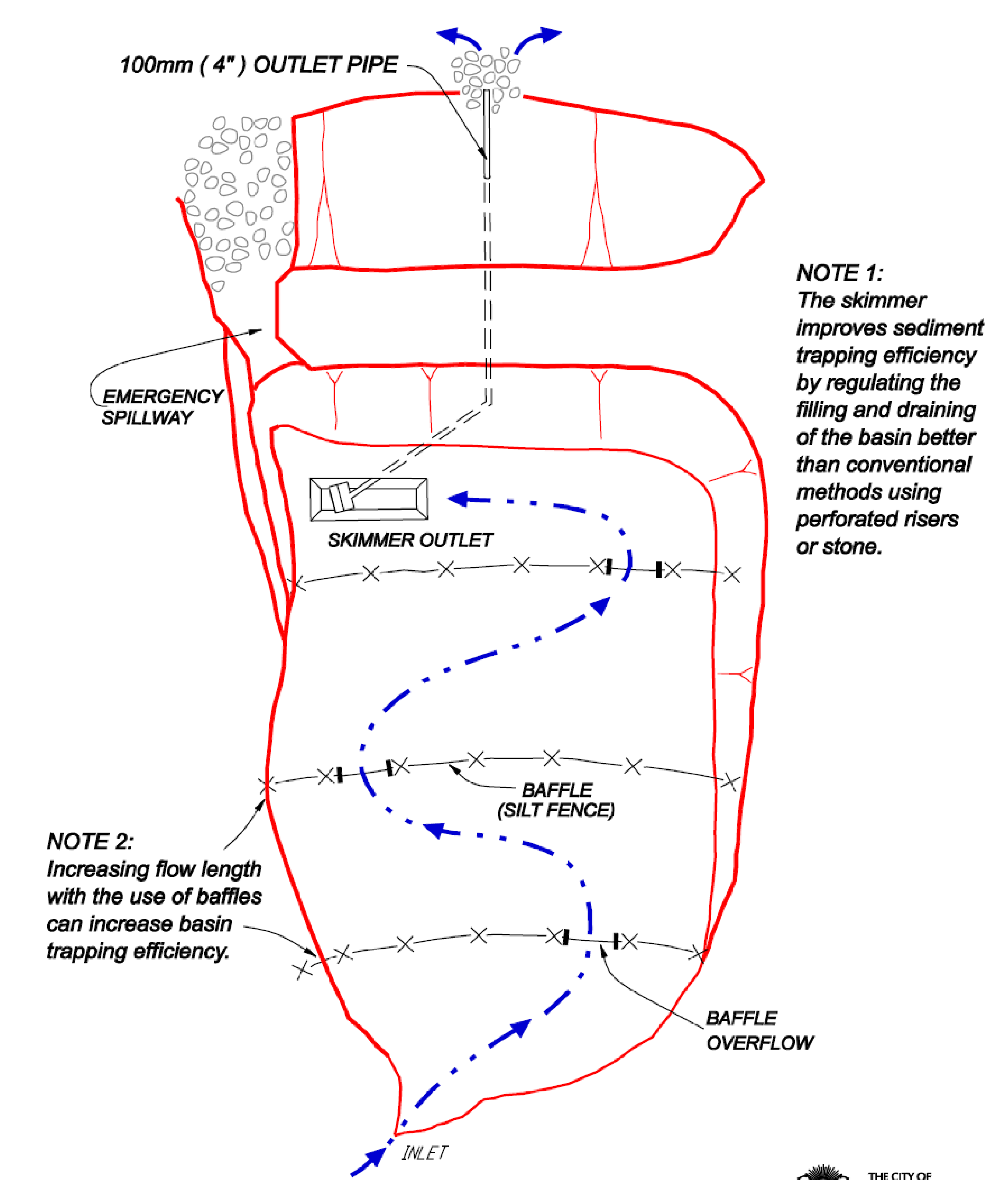
THE CITY OF CALGARY WATER SERVICES

Typical Sediment Basin

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
© 1994 JOHN McCULLAH FILE: sedbasin.dgn

Figure 10-24: Typical Sediment Basin Construction



Sediment Basin with Baffles and Skimmer Outlet

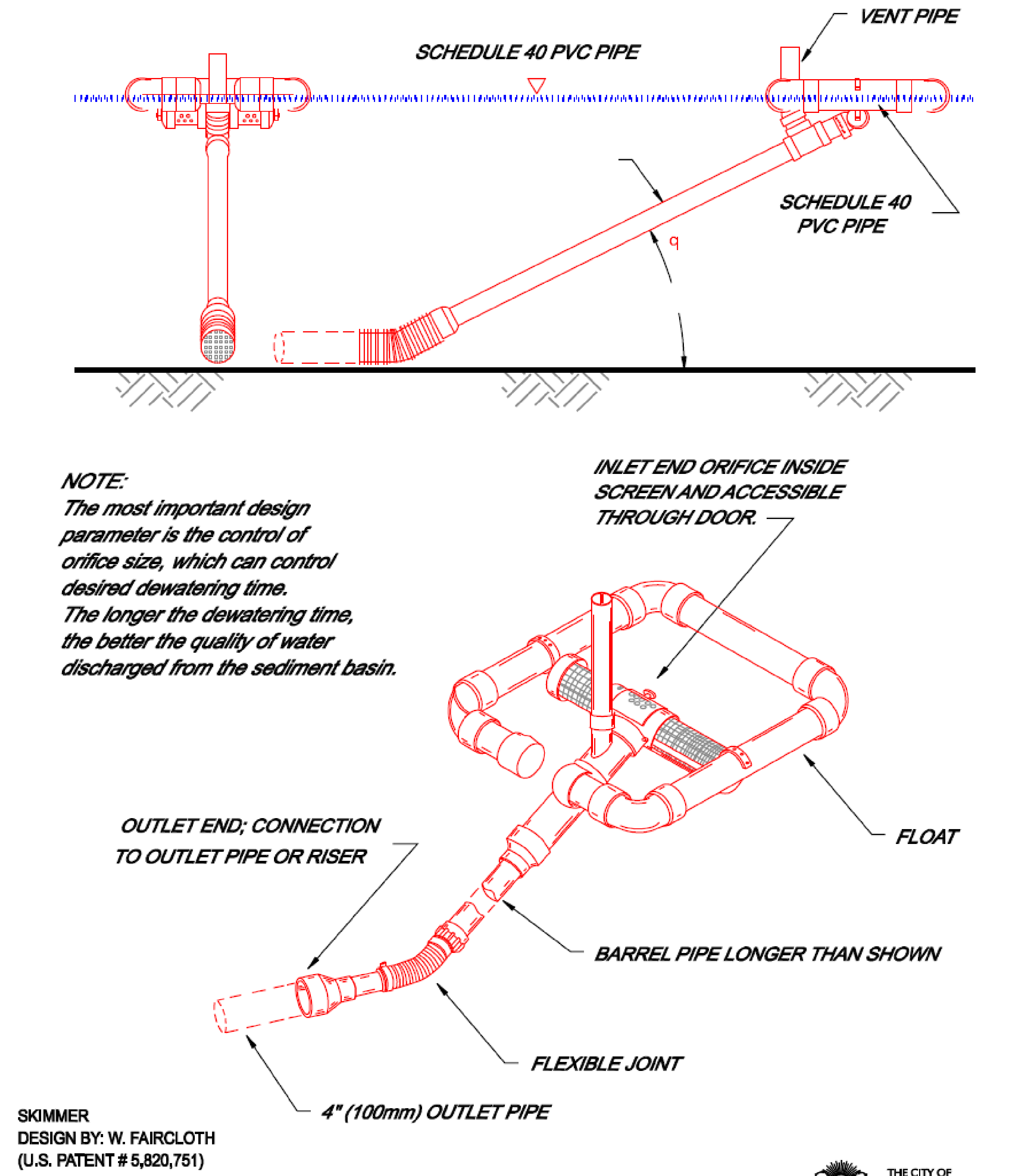
THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0

 FILE: sediment_basin.dgn

Figure 10-25: Sediment Basin with Baffles and Skimmer Outlet



Skimmer Sediment Pond Outlet	THE CITY OF CALGARY WATER SERVICES
Erosion & Sediment Control Guidelines 2011	Source: Salix Applied Earthcare - Erosion Draw 5.0 © 2001 JOHN McCULLAH FILE: skimmer.dgn

Figure 10-26: Faircloth Sediment Basin "Skimmer" Outlet

BMP 25	COMPOST BERMS AND SOCKS	Sediment Control

Description and Purpose

- **All Stages of Construction**
- **Slopes, Stockpiles, Site Perimeter**

A compost filter berm is a trapezoidal berm, usually constructed with a berm building machine fed by a supply of compost from a pneumatic blower truck. A compost filter sock is basically a compost filter berm contained in a mesh tube (the mesh provides added support and integrity to the structure). Filter socks vary from 200 mm to 600 mm in diameter. Both berms and socks provide an effective three-dimensional structural matrix that allows the temporary detention and filtering of construction site run-off.

Note: Compost Quality: All compost **sold** in Canada must comply with the requirements of the Federal *Fertilizers Act and Regulations*. The City of Calgary requires that compost **applied** in compost blankets, compost berms and compost filter socks must be rated *Category A* quality in accordance with all criteria identified in the Canadian Council of Ministers of the Environment (CCME) document *Guidelines for Compost Quality* (October 2005, and as amended from time to time). The CCME document can be purchased online at www.ccme.ca/publications.

Applications and Advantages

- Vegetated berms/socks: A suitable seed mix can be incorporated into berms and socks during construction. Vegetation roots into the soil, providing effective erosion control and filtering of stormwater.
- Berms/socks can be installed at the base of slopes with gradients of 2H:1V or less (for steep slopes, berms/socks can be installed, on contour, to reduce slope length).
- Berms/socks are installed perpendicular to sheet flow, allowing run-off to be intercepted, detained and filtered. Filter socks can be staked in channels (as temporary check dams) to reduce the velocity of low to moderate flows (control channel erosion).
- Filter socks are flexible and can be filled in place or filled and moved into position, making them especially useful on steep or rocky slopes.
- A range of biodegradable and synthetic mesh casing is available for compost socks. Mesh encased compost socks can be constructed in a variety of diameters and lengths, as dictated by the specific application. Compost socks provide added structural stability to the compost, allowing application for areas such as steeper slopes, low flow channels and for stream bank/shoreline bioengineering projects.
- Compost is organic, biodegradable, renewable, and can be left onsite. This is particularly important adjacent to water bodies or other environmentally sensitive areas (where re-entry to remove or maintain the berm/sock can cause additional disturbance). The added cost of removing and disposing of silt fence can be high.
- The flexibility, continuity and weight of berms and filter socks allows for good conformity and surface contact with site soils, reducing the potential for undermining.
- Installation does not require disturbing the soil surface, which reduces erosion potential.

- Compost retains a large volume of water, which results in reduced erosion potential and aids in vegetation establishment.
- The gradation of particle sizes in compost berms and socks provides more effective filtration of sediment-laden run-off than traditional controls such as silt fence (which often becomes clogged with sediment, creating a dam).
- In addition to retaining sediment, compost can adsorb stormwater contaminants such as heavy metals, nutrients, pesticides and hydrocarbons. Microorganisms in the compost matrix can further reduce nutrients and hydrocarbons by decomposition.

Limitations

- Only suitable for detention and filtration of sheet run-off or (for socks) low to moderate channel flow.

Implementation

Design Considerations:

- Use only sanitized, mature compost that meets all local, provincial and federal (CCME Category A) requirements.
- To maximize effective filtration, compost should consist of both large and small fragments. Finer grades (screened through 10 – 15 mm) have increased nutrient availability, promoting vegetative cover. Inclusion of coarser grades (up to 75 mm) promotes filtration and improves the structural integrity of berms exposed to wind, rainfall and run-off. A 1:1 ratio of coarse:fine material is recommended for berms.
- For application, a moisture content of 25 – 40% is optimal: Compost that is too dry is harder to apply, while wet compost is heavier and expensive to transport.
- Compost must be free of weeds, weed seeds, pesticide residues and garbage.

Construction Considerations:

- For *compost berms*, ensure that the base is about twice the height of the berm. For berms installed at the toe of 3H:1V or gentler slopes, install a compost berm 0.3 m high and 0.6 m wide at the base. For steeper slopes, or where additional berms are installed on the slope, typical berm dimensions are 0.45 m high x 0.9 m base. Where additional structural stability and integrity is required, a *compost sock* should be considered.
- Berms/socks installed on a slope are typically spaced at 5 – 9 m and are often used in conjunction with a suitable compost or mulch blanket.
- Berms/socks must be placed so as to detain and filter run-off (use “smile” or “J-hook” configurations). On steeper slopes, berms/socks may be installed along the contour (perpendicular to flow) at intervals down the slope (to reduce slope length, thereby reducing the potential for rills to develop). At the base of slopes, berms/socks are best placed at least 2 m from the slope toe.
- Ensure upstream run-off is captured and diverted away from exposed slopes or safely conveyed down the slope in a suitable channel or slope drain.
- Compost socks applied as check dams in low flow channels must be adequately staked in place, with scour protection installed immediately downstream. Ensure the ends of socks are adequately extended up the sides of the channel to prevent water flowing around these controls.

Inspection and Maintenance

- Except during freeze-up and prior to permanent stabilization of the contributing area, compost berms/socks must be inspected a minimum of every seven days and following significant rainfall or snowmelt likely to cause erosion. Any necessary repairs should be completed as soon as possible.
- Additional erosion protection should be installed on slopes experiencing rill erosion.
- Sediment retained by the berm or sock must be removed when it has reached 1/3rd of the exposed height of the berm.
- Berms can be left onsite and vegetated, or spread out in place as a soil amendment. Likewise, socks can be vegetated and left in place, or the mesh split, removed and the compost spread out.

Photo 21: Combination of compost socks and a compost blanket applied to control erosion adjacent to a sensitive creek. A design seed mix was incorporated with the application, resulting in long-term erosion control. Biodegradable compost sock liners are also available.

BMP 26	SILT FENCE	Sediment Control

Note: Silt fence is a **sediment control practice** (occasionally used as a temporary diversion structure) intended to supplement appropriate upstream run-off and erosion controls.

- **All Stages of Construction**
- **Perimeter Control for Stockpiles, Slopes and Small Site Perimeters**

Definition and Purpose

- Silt fence is a permeable geotextile barrier installed vertically on support posts and entrenched in the ground. Silt fence is installed along contours and in "smile" and "J-hook" patterns designed to detain sediment-laden sheet flow from small, disturbed areas.
- Properly designed, installed sections of silt fence can capture sand and coarse silt-size particles (while silt fence may provide some limited filtering of sediment-laden water, it is most effective at providing temporary detention of sediment-laden run-off, allowing settling of coarse sediment).
- In combination with upstream erosion and run-off controls, silt fence can be an effective way to capture and settle coarse sediment from small areas subject to sheet flow.
- Silt fences generally have a useful life of one up to season (dependant on the amount of maintenance required).

Applications and Advantages

- Silt fence is only suitable for detaining sediment-laden flow from locations generating low volume overland sheet flows.
- Silt fence is most effective for trapping larger particle sizes (coarse silt to sand): Finer-size material (fine silt and clay-size) is not detained.
- Silt fence is a suitable practice for the toe of short, exposed cut and fill slopes, as a contour boundary between a construction site and off-site critical areas such as streets, storm sewer inlets and environmentally sensitive areas and as a stockpile perimeter control.

> Silt Fence Slicing Machines
>
> Silt fence machines install silt fence by slicing through the soil, removing the need for excavating and backfilling. Sliced in fence requires one pass on each side with a tractor tire. Compacted soil resists water infiltration and moisture saturation, reducing the risk of washouts. Slicing machines are capable of turning in a short distance. Turning enables installation of upturns on the ends of silt fence runs. Slicing generally works well in Calgary area soils, except excessively rocky ground.

Limitations

- Improperly applied or installed silt fence can increase erosion.
- Failure to properly plan, install, inspect and maintain silt fence can result in major sediment releases.
- Silt fence is a temporary sediment control practice, requiring a high degree of inspection and maintenance. As a temporary practice, silt fence must be removed when the contributing area is stabilized.
- Silt fence should be considered, wherever possible, as a "last line of defence". There is no substitute for controlling upstream run-off and erosion.
- Long, continuous runs of fence concentrate run-off and commonly lead to failures.
- Do not install silt fence at locations where concentrated run-off occurs or may occur. Silt fences are not designed to withstand high heads of water. Concentrated flows rapidly undercut silt fence or knock it over, a common cause of fence failure and a major cause of off-site sediment releases.

- Silt fence is not effective unless properly sliced or entrenched and compacted into the ground.
- Silt fence must not be designed to impound sediment or water more than 0.5 m high.
- Silt fence does a poor job of controlling clay and fine silt in sediment-laden run-off: Run-off is usually not detained long enough to allow settling of fine soil particles (designers must consider site soils and include appropriate source and detention controls to prevent releases of sediment off-site). Clays and fine-silts can have extremely deleterious impacts on receiving water-courses and off-site areas.
- Installation – by trenching or slicing – can be difficult in compacted or rocky ground or where there is dense vegetation and roots.
- Do not place silt fence on a slope. Unless intended as a diversion, long runs of silt fence that do not follow a contour can cause diversion of run-off, resulting in washouts at low spots.

Implementation

- Clean run-off must be diverted away from sediment containment controls such as silt fence.
- Always determine how run-off volume is going to exit. Contributing drainage area (followed by soil type) is the primary consideration when determining silt fence suitability, location and quantity.
- Ensure the maximum area draining to silt fence is 0.1 ha (1/4 acre) per 30 m of fence: This area should be reduced when silt fence is installed at the toe of steep slopes.
- Maximum sedimentation behind the fence must not exceed half the fence height or 0.3 m.
- Silt fences are not to be constructed in areas where flow velocity is expected to exceed 0.03 m/sec.
- Steel posts (minimum 2 kg/m with projections for fastening fence), driven 600 mm into the ground are recommended. Wood posts (100 mm in diameter, with a minimum length of 1.35 m) are an alternative, but may be difficult to drive 600 mm into the ground or may not be reusable.
- Adequate post spacing and proper entrenchment of fence are the two most critical installation requirements.

> Note: Avoid using wire backing for fence reinforcement: Wire backing is unnecessary for properly located and installed silt fence and is an added expense to install, remove and dispose of. For suitably located silt fence, the proper entrenchment and compaction of the fence material into the ground and the use of steel T-posts, driven 600 mm into the ground and spaced at 2 m intervals are critical. Silt fence can be supported by clipping the top of the fence to a horizontal support wire between posts.

Location Requirements:

- Contributing drainage area must not exceed 0.1 ha per 30 m of fence.
- The run-off path length above a fence must not exceed 30 m.
- Maximum slope gradient upstream of a fence must not exceed 2H:1V.
- Unless intended as a temporary diversion structure, silt fence must be installed along a contour, with ends of the fence pointed upslope.

- Silt fence installed around a construction site perimeter must have a suitable number of J-hooks installed so that contributing drainage area is limited to 0.1 ha per 30 m of fence.

- Fence must be installed at least 2 m from the toe of a slope.
- Fence must not be used in drainage swales, except for very low volume swales (flow velocity $<$ 0.03 m/sec) with grades not exceeding 2% and contributing areas not exceeding 0.8 ha.

- The designer must consider the erodibility of the exposed soil in determining silt-fence requirements and suitability (for example: silty sand may result in more silt fence maintenance and need for more source control than a less erodible clayey soil).

Installation Requirements:

- Silt fence must be firmly entrenched and anchored into the soil.
- Fence height must not exceed 0.9 m. However, the ponding height of water must not exceed 0.5 m (install stabilized overflow sections on long runs of fence).
- Silt fence must be firmly attached to posts (steel T-posts or 100 mm (4") diameter wood stakes), driven at least 600 mm into the ground on the downstream side of the fabric.
- Minimize joints by installing fence from a continuous roll. Where joints are required, construct at least a 0.4 m overlap and wrap the end posts together.
- Run-off detention requires storage space behind the fence. Fences constructed on a slope have considerably less retention capacity. Always install the fence at least 2 m from the toe of slopes.
- The maximum length of each run of silt fence should generally not exceed 40 m.
- To ensure the stability of the fence, and provide safe overflow, install one or more reinforced outlets. The distance between the outlet posts should not exceed 1.2 m. Install a 50 mm x 100 mm (2 x 4 ") wood brace horizontally between the posts. Install a splash pad on the down-slope side of the outlet by using riprap or a small section of erosion control blanket.
- When replacing or removing silt fence, ground disturbance can be reduced by cutting the fence at ground level, leaving the trenched-in portion of fence in the ground.
- Seed and mulch any areas of soil disturbed by fence replacement or final removal.

There are two methods of keying the fence into the ground: Trenching and mechanical slicing:

Trenching Method:

- Excavate a trench approximately 0.15 m deep by 0.15 m wide for the entire length of the fence.
- Drive the support posts 600 mm into the ground, with 2 m maximum post spacing, on the downstream side of the fence.
- Attach the fabric (using wire ties) on the upstream side of the posts, with at least 0.3 m of fabric laid in the trench. Fence material can be clipped to a horizontal support wire run between posts
- Backfill the trench and compact with a machine tamper or tractor tire, taking care not to damage the fence.

Mechanical Slicing Method:

- The slicing method for silt fence installation utilizes an implement pulled behind a tractor to "plough" or slice the silt fence material into the soil. Slicing minimally displaces the soil, creating an optimal condition for future mechanical compaction. Compacted soil resists water infiltration and moisture saturation, reducing the potential for undermining.
- Use this method to slice fence at least 0.15 m into the ground. Provide compaction by running a tractor tire along both sides of the fence.
- Follow the same guidelines as trenching for support posts, fabric attachment and compaction.

Inspection and Maintenance

- Inspect this sediment control practice a minimum of every seven days and after significant rainstorm/snowmelt events sufficient to cause surface run-off.
- Ensure silt fences are providing the required detention of run-off and sedimentation.
- Except where used as a temporary diversion, ensure silt fence is installed on contour (or in effective “smile” or “J-hook” configurations), with end sections of fence pointed upstream.
- Do not accept long, linear runs of silt fence installed without J-hooks or “smiles”.
- Check all sections of fence for adequate entrenchment by pulling firmly upwards on the fence (fence which moves is not adequately trenched/sliced and compacted).
- Check all sections of fence are firmly secured to posts. Ensure post spacing does not exceed 2 m.
- Ensure stabilized overflows are installed at least every 30 m on long runs of fence. Ponded water must not exceed 0.5 m depth.
- Remove accumulated sediment when it reaches 50% of impoundment height (i.e. 0.25 m).
- Replace damaged fabric and address flow-around and/or undermining problems immediately.
- Silt fence is a temporary sediment control practice: Remove and appropriately dispose of fence as soon as the contributing area is stabilized.

Construction Details

Refer to:

Figure 35: Traditional Trenching Method for Silt Fence Installation

Figure 36: Typical Installation Detail for Silt Fence

Figure 37: Silt Fence Placement on Complex Slopes

Figure 38: Silt Fence Placement for Perimeter Control

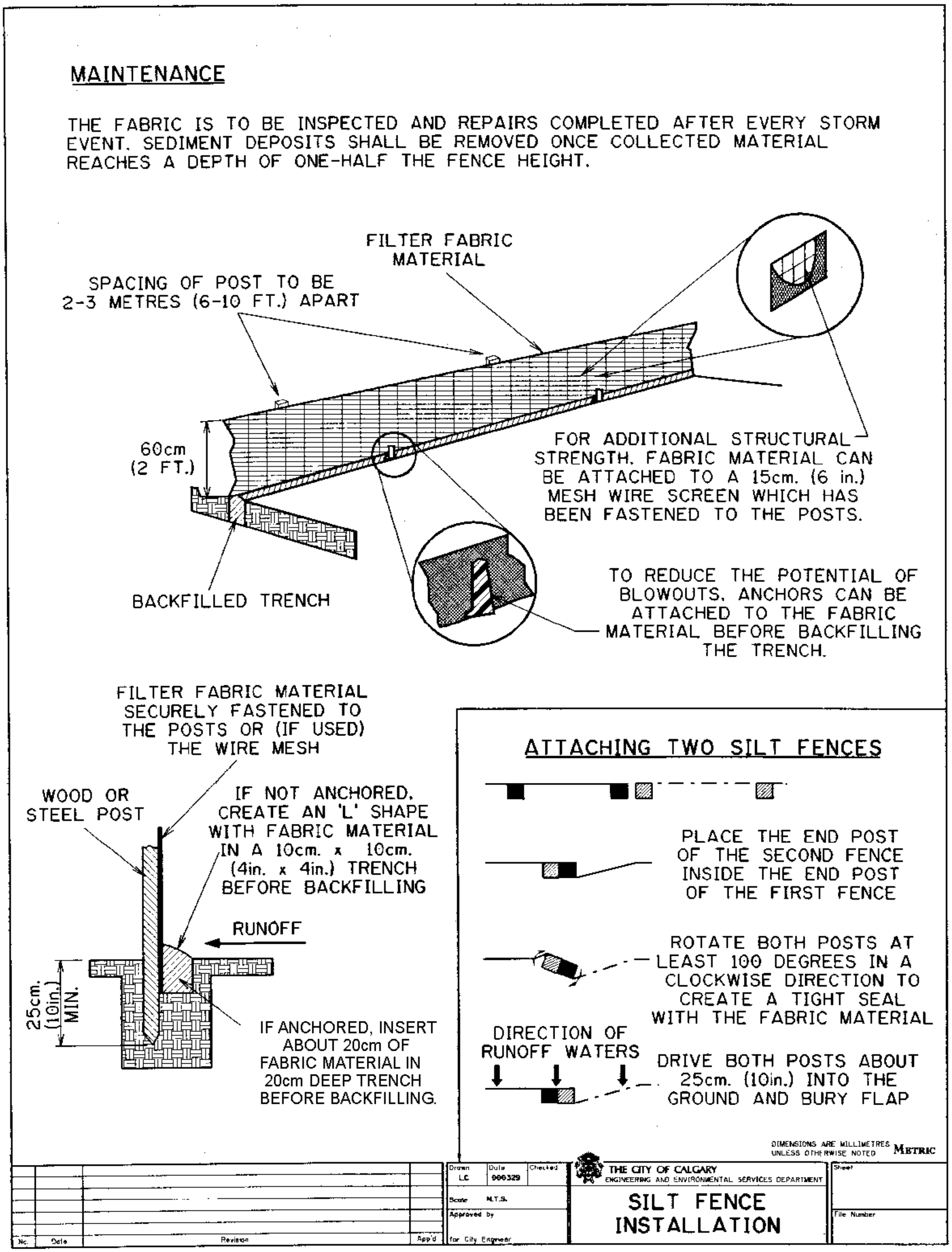
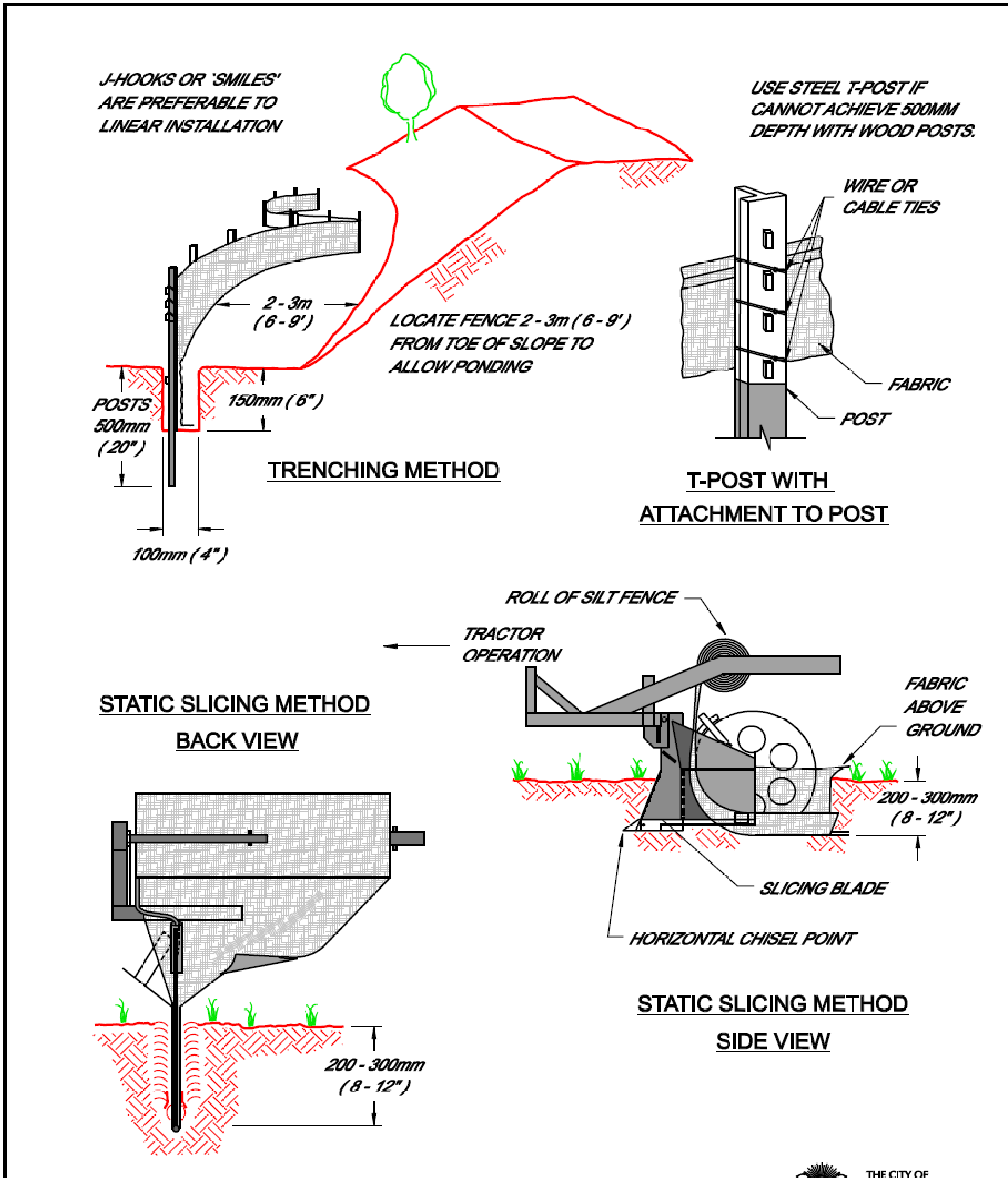


Figure 10-27: Traditional Trenching Method for Silt Fence Installation



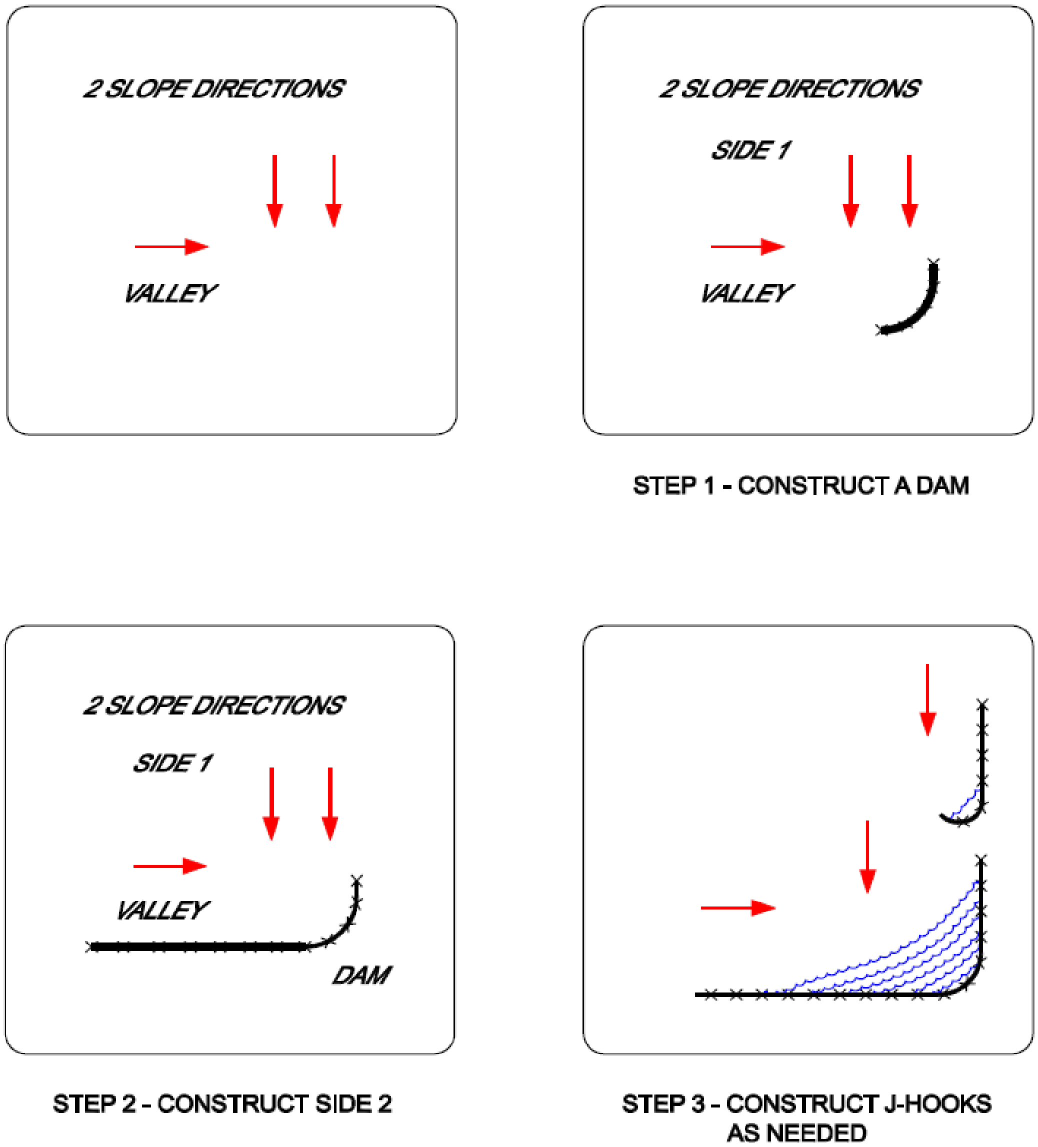
Silt Fence Installation

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
© 2001 JOHN McCULLAH FILE: sf_methods.dgn

Figure 10-28: Typical Installation Detail for Silt Fence



INSTALLATION WITH J-HOOKS WILL INCREASE SILT FENCE EFFICIENCY AND REDUCE EROSION-CAUSING FAILURES.

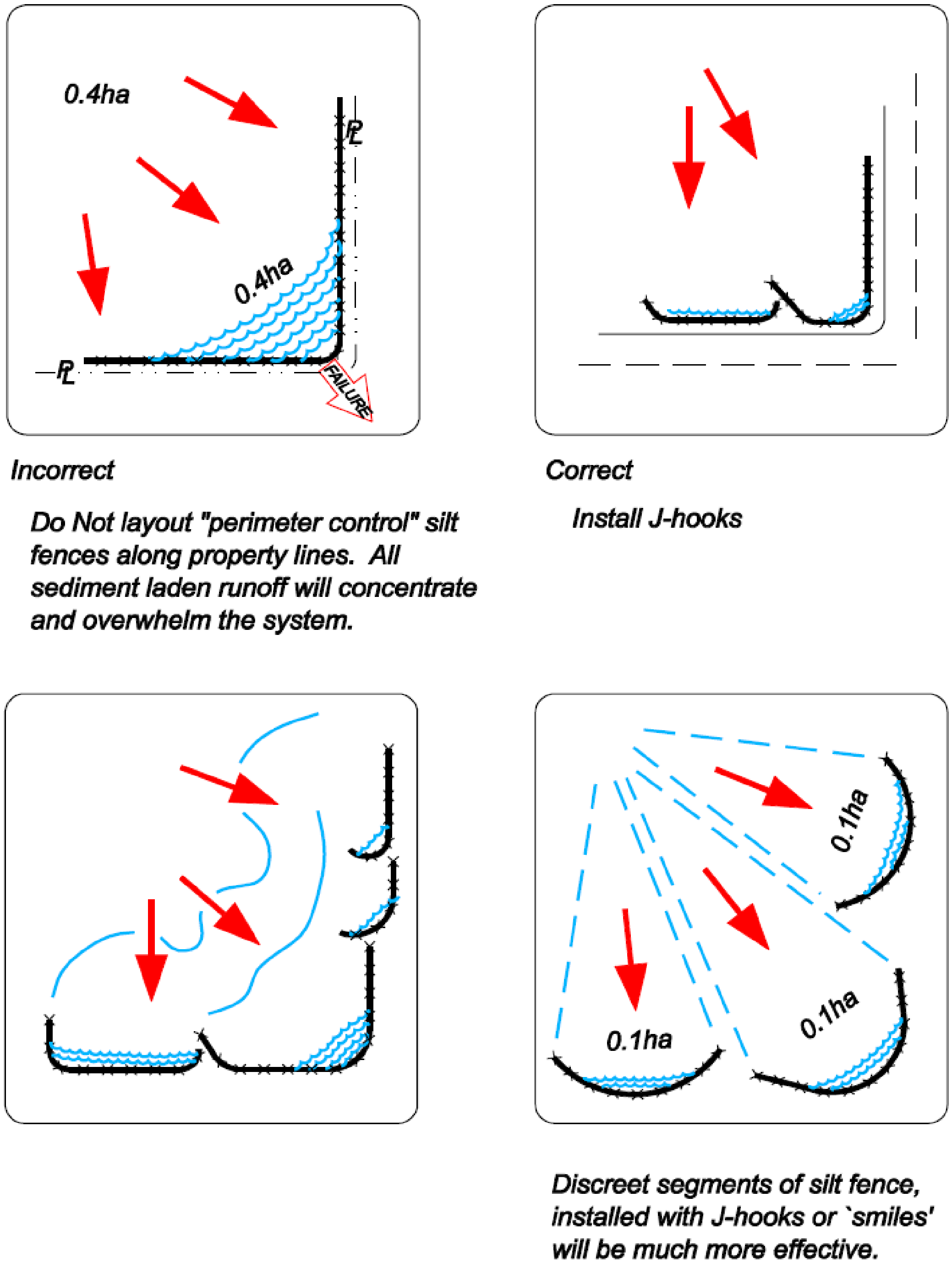
Silt Fence Typical Placement - Two Slopes

THE CITY OF CALGARY WATER SERVICES

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
© 2001 JOHN McCULLAH FILE: sf-two_slopes.dgn

Figure 10-29: Silt Fence Placement for Complex Slopes



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Silt Fence Placement for Perimeter Control

Erosion & Sediment Control Guidelines 2011

Source: Salix Applied Earthcare - Erosion Draw 5.0
 FILE: sf-perimeter_control.dgn

Figure 10-30: Silt Fence Placement for Perimeter Sediment Control

BMP 27	STORM INLET SEDIMENT CONTROL	Sediment Control

Description and Purpose

- **Limit to Stages of Construction and Operations where Source Controls and Other Sediment Controls are not Fully Adequate**
- **Get Permission to use from Water Resources via Approved ESC Documents or Drainage/Dewatering Permit**

As a last-line of defence, and to minimize transport of sediment into sewers, temporary sediment control structures may be selectively installed at storm drain inlets draining small, disturbed areas or on sewer (storm and sanitary) manholes following underground installation and prior to final stabilization. These controls can provide some limited temporary ponding and filtering of run-off during minor rainfall or snowmelt events.

Note that, as of 2010, the use of sediment control devices on or in catch basins on, or adjacent to, streets is subject to restrictions under The City's Drainage Bylaw. Approval to use these devices can be obtained in an approved ESC report/drawings, via a Drainage/Dewatering Permit or by contacting Water Resources (Erosion and Sediment Control).

Applications and Advantages

- At storm drain drop inlets and catchbasins (draining small contributing areas) and sewer manholes (storm and sanitary) on exposed areas (prior to final stabilization).
- Use where the storm drain system is functional (i.e. for drop inlets, catchbasins and manholes that are connected into the system) prior to stabilization of the small, disturbed areas with vegetation, asphalt or other non-erosive cover.

Limitations

- Inlet control is a temporary practice. It is not a substitute for proper design and implementation of upstream run-off, erosion & sediment control.
- Controls are generally only effective at providing temporary detention and filtering of run-off resulting from minor rainfall or snowmelt. Controls will be overwhelmed and ineffective and may cause excess back-up or diversion of run-off during moderate to large rainfall or snowmelt events.
- Very frequent inspection and maintenance is required.
- Silt fence and straw bales are generally not effective materials for storm inlet sediment control.

Note:
- Construction site storm inlet and manhole sediment control is limited to contributing drainage areas less than 0.4 ha and flow rates less than 0.015 m^3ésec. Prior to final stabilization of the contributing areas, and in addition to any on-site traps, basins or other temporary storage and sediment control, at least 25 m^3 of storage (per disturbed 0.4 ha) must be provided at the inlet. This may require excavation of a shallow detention basin. A compacted earthen berm may need to be constructed immediately downslope of the sediment control structure to prevent bypass of run-off.
- Catchbasin sediment control is only effective at discharge rates of less than 0.01 m^3ésec and only where water can safely pond.

- Sediment bags installed under a catchbasin grate are not permitted for use in Calgary. These devices have very limited effectiveness and are unlikely inspected, maintained and removed when no longer required.
- During moderate to high run-off conditions, inlet control can cause downstream diversion of run-off (which could cause dangerous flows, flooding and damage). It is critical to ensure high flows can be contained and pass into the inlet.
- Excessive ponding of water on travelled roadways must be avoided, especially where water could freeze.

Implementation

There are a number of proprietary devices marketed by local suppliers for temporary sediment control at drop inlets, manholes and catchbasins. Generic installation notes are provided for two common practices. Consult manufacturers and local suppliers for additional information on proprietary products.

Block and Gravel Method (prior to paving or other stabilization around inlet)

This temporary practice is limited to active drop inlets, catchbasins and manholes (storm and sanitary) on disturbed areas less than 0.4 ha and prior to final stabilization (vegetation, paving, etc.).

Provide at least 25 m^3 of storage around the inlet (adequate storage may be available prior to paving or excavation of a shallow retention basin may be required.

Ensure moderate to heavy run-off can safely enter the inlet (may require construction of an earthen berm to prevent diversion around the inlet).

Place concrete blocks one to two block high around the inlet such that block cavities face the direction of flow.

Place filter fabric and wire mesh on the outside face of the blocks.

Place minimum 20 mm gravel around the entire inlet (0.6 – 1.0 m wide) and slope the gravel away from the top of the concrete blocks to form a gravel doughnut.

Sediment Control for New and Existing Catchbasins (following paving and prior to stabilization of contributing area)

Note: Due to the competing need to allow design flows to enter catchbasins and to control sediment (detention and filtering) from disturbed contributing areas, catchbasin sediment control is difficult and of very limited effectiveness. It is important to focus as much effort as possible on upstream control of run-off, erosion and sediment. Socks and donuts are commonly applied in Calgary. Where safe to install, block and gravel inlet protection is also a suitable means of temporary catchbasin sediment control. Short sections of compost sock should also be considered, along with other products entering the market.

Donuts typically consist of a donut-shaped foam core attached to a porous mat. Remove the inlet grate and use the ties to secure the donut on the grate. Replace the grate.

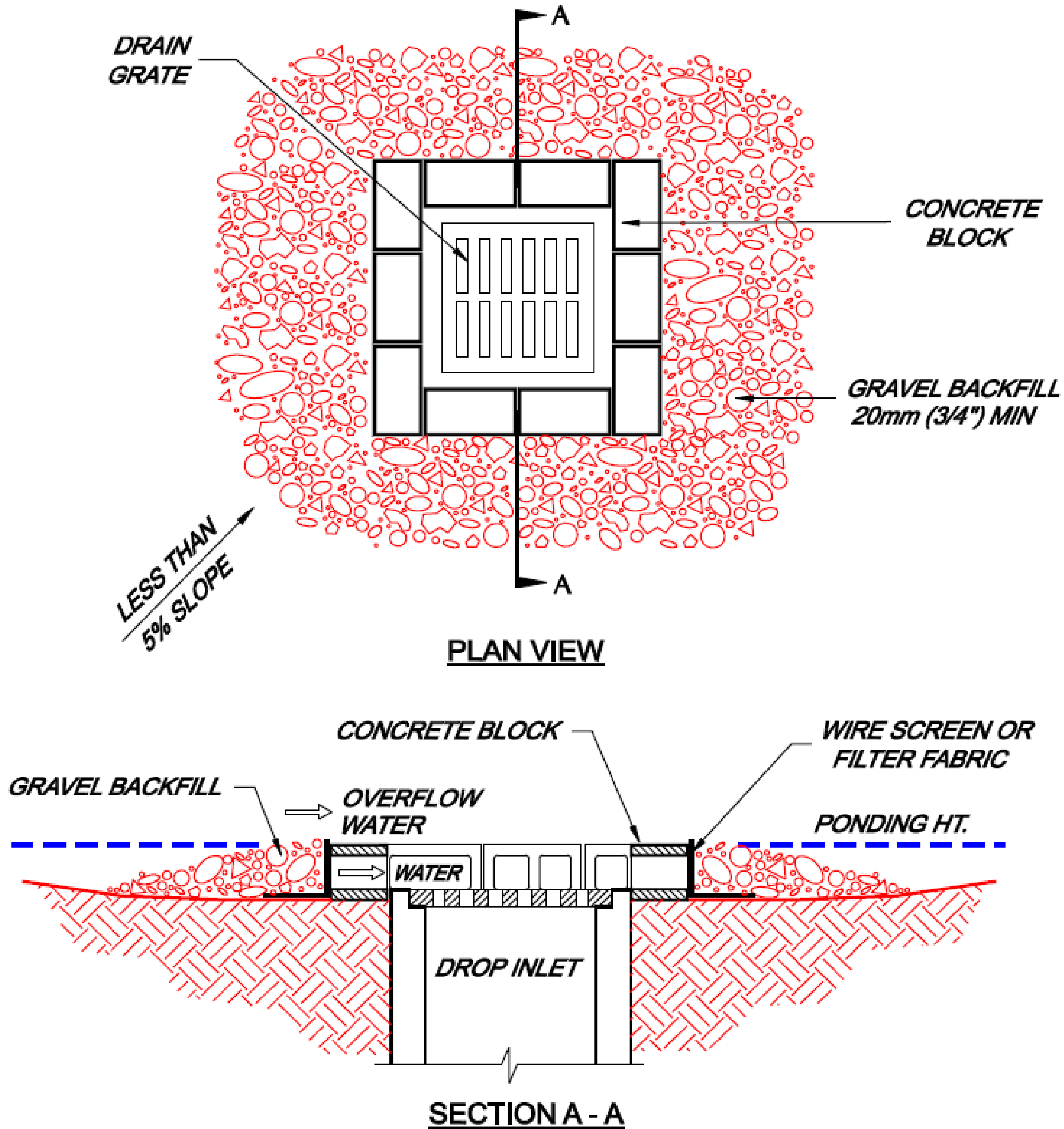
Socks are typically heavy-duty mesh material filled with a core of woodchips or gravel. They can be attached to catchbasin storm backs or used to temporarily pond or divert run-off in gutters. Socks with dry woodchips may become buoyant, so need to be secured in place.

Socks and donuts must not cause downstream diversion of run-off during heavier flows or excessive ponding of run-off onto travelled roads or other public or private property.

Short sections of compost sock can provide a similar function.

Inspection and Maintenance

- Inspect inlet sediment controls at least weekly and during and after all rainfall or snowmelt events sufficient to cause run-off in street gutters.
- Ensure heavier flows are overflowing into the inlet and are not diverted downstream.
- Remove all devices from public roadways prior to ground freeze-up. Ensure contributing areas are stabilized prior to winter and be ready to reinstall devices prior to significant spring run-off conditions.
- Sediment generally needs to be removed after each run-off event and disposed of to a location where it cannot be re-entrained and transported. Excess sediment build-up indicates a need to better control erosion and sediment within the contributing area.
- For block and gravel inlet controls, replace gravel that becomes clogged with sediment.
- Promptly remove all temporary sediment control devices when the contributing area is stabilized.



NOTES:

1. *ONLY SUITABLE ON CONSTRUCTION SITES (NOT PUBLIC ROADS) PRIOR TO FINAL GRADING AND PAVING.*
2. *DROP INLET SEDIMENT BARRIERS ARE TO BE USED FOR SMALL, NEARLY LEVEL DRAINAGE AREAS. (LESS THAN 5%)*
3. *EXCAVATE A BASIN OF SUFFICIENT SIZE ADJACENT TO THE DROP INLET.*
4. *THE TOP OF THE STRUCTURE (PONDING HEIGHT) MUST BE WELL BELOW THE GROUND ELEVATION DOWNSLOPE TO PREVENT RUNOFF FROM BYPASSING THE INLET. A TEMPORARY DIKE MAY BE NECESSARY ON THE DOWNSLOPE SIDE OF THE STRUCTURE.*

Block and Gravel Drop Inlet Sediment Barrier	THE CITY OF CALGARY WATER SERVICES
Erosion & Sediment Control Guidelines 2011	Source: Salix Applied Earthcare - Erosion Draw 5.0 © 1994 JOHN McCULLAH FILE: bgsedbar.dgn

Figure 10-31: Typical Inlet Sediment Control Detail Prior to Paving

Photo 22: Storm inlet protection, such as the device shown in this picture, will fail if source controls (erosion, run-on and run-off controls) are not properly planned or implemented. There are no source controls implemented on the construction site shown in this photo.

Photo 23: Release of sediment-laden water from a construction site into a storm sewer during a minor rainfall event. In addition to potential enforcement by provincial and federal regulators, the specified penalty under The City of Calgary *Drainage Bylaw 37M2005* for causing a release of a Prohibited Substance (sediment) is $3,000 per offence (each day constitutes a separate offence). Court imposed fines can go up to $10,000 per offence.

Photo 24: This storm inlet sediment control device has been installed on a grade, resulting in downstream diversion of sediment-laden run-off during a snow melt event. Construction site soils left exposed over winter must be stabilized and run-off from construction sites controlled at all times. Storm inlet sediment controls must not be placed such that they could cause downstream diversion, flooding or other hazardous conditions.

Photo 25: Rock weepers can increase the effectiveness of other temporary inlet sediment controls.

BMP 28	FLOCCULANTS AND COAGULANTS	Sediment Control

Description and Purpose

- **Construction Dewatering**
- **Temporary Erosion Control**

Fine silt and clay-size particles typically carry a negative charge, causing particles to repel each other and further increasing particle settling time (due to their small size and repulsion, they are commonly referred to a colloids). Low dosage of chemicals known as flocculants and coagulants (containing highly charged polymer chains or ions) destabilises negative charges on fine particles, allowing material to aggregate and settle. Two classes of flocculant and coagulant chemicals that are commonly used for erosion control and water clarification in Calgary will be discussed.

***Anionic** polyacrylamides* (PAMs) are a class of synthetic water-soluble polymer (composed of long chains of acrylamide monomer) flocculants. Anionic PAMs are available in dry powder form, liquid emulsion, and gelatinous blocks. Anionic PAMs increase the aggregation of clay and fine silt-size particles, improving soil structure and permeability and reducing particle detachment and entrainment by raindrops, run-off and wind. Anionic PAMs can be applied to exposed soils in dry granular form, dissolved in water or as an emulsion. In addition, anionic PAMs are available as slow-dissolving gel blocks for *in situ* removal of fine solids from water. Care should be taken to always consult with the manufacturer and distributor to ensure any product will be used in a way that will not result in any adverse impacts to downstream receiving waters. Also be sure to check that independent toxicity data is available and check that products are non-toxic.

Chitosan Based Products are manufactured from chitosan, a flocculant derived from shrimp shells. Chitosan has very low solubility in water and sometimes needs to be solubilized in solutions such as lactic acid or acetic acid. Care should be taken to always consult with the manufacturer and distributor to ensure any product will be used in a way that will not result in any adverse impacts to downstream receiving waters. Also be sure to check that independent toxicity data is available and check that products are non-toxic. Chitosan combines with phosphorus, suspended solids, metals, and other dissolved and suspended matter (flocculation). The insoluble precipitates that are formed from this process are stable. Even if chemical is added at a dosage in excess of that required for effective removal of solids and nutrients, the dissolved aluminium is still reduced very rapidly to a low concentration with no serious toxicity implications.

Note: To optimize performance, flocculants and coagulants are generally applied at very low, calculated doses. Preliminary site-specific assessment (requiring basic soil and water sampling and analysis) is generally required (to determine dosing rate, method and maintenance requirements).

Applications and Advantages

- Chitosan is commonly used as a flocculant in long-term construction dewatering activities in Calgary (to complement other dewatering practices when fine silt and clay-size material is unavoidably suspended in water).
- Anionic PAMs are intended for use on areas that contain high amounts of fine silt, clay, or colloidal soils. PAMs can be soil applied (to improve soil structure and reduce erosion by wind or water) or to treat sediment-laden water upstream of retention or detention controls. Anionic PAMs complement the use of other ESC practices when the timely establishment of vegetation may not be feasible or

adequate, or where conventional temporary ESC is limited (i.e. limited by other construction requirements).

- Chitosan and Anionic PAMs – selected on the basis of site-specific soil and water quality information and applied at low dosages - are non-toxic to aquatic life.
- Aggregation improves the resistance of fine-grained soils to particle detachment and entrainment by wind (dust control) and water, providing temporary protection for exposed soils prior to final stabilization.
- In situ flocculation or coagulation of fine silt and clay-size particles enhances particle settling and complements other sediment control practices.

Limitations

Note: Cationic PAM products must never be used as they are toxic to fish at extremely low levels (bind to fish gills and cause suffocation).

- Product effectiveness is affected by soil texture and – to a degree – soil chemistry: This requires site-specific soil information. This may limit product bulk ordering or reuse on multiple sites. Soil sampling and analysis may take several days to complete.
- For effective in situ water treatment, mechanical mixing or agitation may be required after introduction of the product to water.
- Flocculants and coagulants may enhance precipitation of fine sediments in downstream sediment control structures, increasing maintenance requirements (removal of sediment).
- Over-dosage of product can cause dispersion of fine particles, negatively impacting soil structure and particle settling in water.
- Flocculants and coagulants are intended to complement conventional ESC practices and are not a substitute for timely planning and implementation of suitable ESC practices.
- The effectiveness of some products can be affected by temperature. The manufacturer must account for this when providing specific product and dosing rate recommendations.

Implementation

Chitosan Product Requirements

- Product must be environmentally benign, harmless to fish, aquatic organisms, wildlife, and plants.
- Product must be non-combustible.
- Must not change soil or water pH.
- An expiration date must be provided with the product.
- Products must be accompanied by MSDS and toxicity information from the manufacturer confirming that the product and any required additives cause no acute or chronic toxicity to aquatic biota.
- Products and any required additives must be on the Canada Domestic Substances List (have an CAS registry # from Environment Canada). The manufacturer or supplier must be able to provide CAS numbers.
- To ensure proper product selection, site preparation, application, inspection, maintenance, storage and safe use, products must be accompanied written instructions from the manufacturer.

Anionic PAM Product Requirements

Only Anionic PAM products meeting the following criteria are acceptable for use:

- Anionic PAM mixtures must be environmentally benign, harmless to fish, aquatic organisms, wildlife, and plants.
- Anionic PAM mixtures shall be non-combustible.
- PAM copolymer formulation must be anionic (negatively charged), with a charge density of 8 to 35% by weight (15-18% is typical) and ultra high molecular weight of 6 to 24 mg/mole (preferably 12-15 mg/mole).
- Product must be water-soluble and linear (not cross-linked).Residual acrylamide monomer must not exceed 0.05 % by weight.
- Must not change soil or water pH.
- An expiration date must be provided with the product.
- Products must be accompanied by MSDS and toxicity information from the manufacturer confirming that the product and any required additives cause no acute or chronic toxicity to aquatic biota.
- Products and any required additives must be on the Canada Domestic Substances List (have an CAS registry # from Environment Canada). The manufacturer or supplier must be able to provide CAS numbers.
- To ensure proper product selection, site preparation, application, inspection, maintenance, storage and safe use, products must be accompanied written instructions from the manufacturer.

Site-Specific Testing Requirements

- To ensure that the product, additives and the application are tailored to site-specific soil and water quality and conditions generally requires sampling and analysis of site soils or water.
- For anionic PAM to work effectively there must be a source of divalent cations (i.e. Ca^{2+}). Gypsum ($CaCl_2$) is a common source. The divalent cation source may be in the anionic PAM mix, in the soil, or applied directly to the soil. Soil tests should be conducted to determine whether additives are necessary.

Application

- Always follow product handling guidelines provided by the manufacturer (MSDS and other information).
- For in situ water treatment, products must always be incorporated and mixed with water prior to a pre-constructed sediment trap or settling tank. Never apply products directly to slopes that drain directly to a water body or directly into sediment tanks, basins, traps or storm ponds that drain to a storm or sanitary sewer or water body.
- For in situ water treatment, Chitosan can be introduced in a solid form (by running water to be treated through tubes containing belts of the slowly soluble product) or injected (by controlled dosage) into a pipe or mixing chamber in the sedimentation tank. Set-up and monitoring of the system generally requires the expertise of a water treatment specialist.
- Do not over-dose or over-apply product. Excessive application can disperse fine particles, de-stabilizing soil aggregates and increasing in situ particle settling time in water.
- Avoid using PAM products on paved surfaces as slippery conditions can result.
- Do not add water to powdered Anionic PAM. Add Anionic PAM powder slowly to water to the desired concentration and mix for 3 to 5 minutes. If water is added to PAM, globs may form that can clog dispensers.
- Including tackifiers, mulch, seed, and fertilizer in the final Anionic PAM mixture is recommended to improve performance and provide additional permanent protection beyond the useful life of the
- Anionic PAM. However, Anionic PAM should always be the final additive to the mixture.

- Effectiveness of PAM has been shown to decrease if too much time passes between mixing and application.
- Anionic PAM may be sprayed on bare soil using standard irrigation equipment, hydroseeding/hydromulching equipment, water trucks, or other spraying devices that have a mechanical agitator, mixing apparatus, or recirculation.

Inspection and Maintenance

Note: Prior permission (a permit) is required to discharge impounded water from a construction site to a storm or sanitary sewer. Permits have strict conditions that regulate the quality and quantity of water that may be released. For further information, contact The City of Calgary at 3-1-1.

- Monitor all areas treated with anionic PAM products after every precipitation event and until treated areas are permanently stabilized.
- All equipment must be maintained so as to provide the required application or dosage rates. Rinse all equipment used to mix or apply Chitosan or Anionic PAM thoroughly with water to avoid formation of residues.
- Conduct frequent turbidity monitoring, upstream and downstream of the application, with a calibrated, handheld turbidity meter. Implement mitigation or contingency measures if turbidity in the discharge exceeds allowable values.
- Products may enhance precipitation of fine sediments in sediment settling structures. Accordingly, these structures should be inspected periodically and sediment removed in accordance with the maintenance schedule recommended for the particular measure. Never discharge from the site water that may contain excess product or material that could precipitate in pipes or a water body.

APPENDIX B

EXAMPLE RUSLE-FAC CALCULATION

11.0 APPENDIX C: SOIL LOSS ESTIMATION EXAMPLE

Note: One RUSLE calculation may be acceptable if the site is small and it can be shown that the worst case scenario has been addressed. If only one calculation is provided please include the justification for doing so.

RUSLE EQUATION: A= R*K*LS*C*P

A-Value
The A-Value is estimated annual soil loss in tonnes/hectare. The annual soil loss tolerance levels for construction sites in Calgary are:

A = 2 tonnes/hectare/year for sites where there is on-site or adjacent storm infrastructure.

A = 4 tonnes/hectare/year for sites where there is no on-site or adjacent storm infrastructure.

Indicate the estimated annual soil loss in tonnes/hectare, and provide the data used in the soil loss calculation.

Note: In addition to the interior site controls and practices accounted for in the cover and management practices components of the RUSLE calculation, additional sediment controls should be installed at critical sections of the site perimeter and at storm inlets subject to run-off containing eroded sediment.

R-Value
Provide an annual R-value or a value specific to the length of soil disturbance. The R-value is a numerical representation of rainfall erosivity. Local R-values are generally available as monthly and annual values. The R-Value is derived from historical data of rainfall intensity and duration records for individual storms. R-values are affected by storm energy and intensity, the amount of rainfall, snowfall and run-off that occurs during different seasons of the year. For Calgary, use 320.

K-Value

Provide the index for soil erodibility based on a specific soil's susceptibility to erosion. The K-Value represents the susceptibility of the soil to erosion from raindrop impact and overland flow and accounts for various soil characteristics. K-values shall be justified with copies of the applicable information from the site geotechnical and soils report (such as a description of the soil types onsite, grain size analysis, soil structure, permeability and test hole logs with the corresponding location plan). Explain what method was used to obtain the K-value and attach copies of the Soil Erodibility Nomographs.

LS-Value
The LS-Value is a numerical representation of the length, gradient and shape of a slope. Erosion potential increases with increasing slope length and gradient. On construction sites, support practices such as cat-tracking, furrowing, terracing, and installation of compost socks or fiber rolls/wattles along slope contours, reduce effective slope length. RUSLE provides LS-values for highly disturbed construction site slopes, based on input slope lengths and gradients. As construction sites can typically be split into areas of different topography, it is usually necessary to use some separate RUSLE calculations for each area: This will help to determine the level of ESC practices required for each area.

C-Value
The C-Value represents erosion control practices that provide temporary or permanent cover of exposed soils, thereby controlling erosion at the source (e.g. temporary and permanent vegetation, mulching, hydroseeding, rolled erosion control products). Provide details on what cover and management factors will be used and where the C-factor being used was referenced from.

P-Value

The P-value represents 'support practices' and provides credit for practices that are used to control construction site run-on and run-off or capture, settle and/or filter sediments and other contaminants from stormwater (e.g. sediment traps/basins, silt fence, terracing, cat-tracking, check dams, contour furrows). Provide details on what support practice factors will be used and where the P-factor being used was referenced from.

Background Information:

Site Size = 1.8 hectares
Site Location = Calgary
Construction Start-up Date = May 1
Completion Date (final stabilization) = September 30 (5 months)
Current Vegetative Cover = Site is stripped of topsoil and rough graded
Soil Type = Relatively uniform soil type across the site

Soil information

Based on soil sampling and texture/organic matter analysis, the soil on-site is a Clay Loam which has 0% organic matter and:

25% sand (*5% very fine* 0.05-0.10mm) / *40% silt* / *30% clay*

Additional field tests indicate soil structure and permeability are typically as follows:

Structure Type: *Prismatic (Class 4)*

Permeability Class: *Moderate (Class 3)*

Length and Slope Information

The site can be divided into two overland drainage areas: Run-off on the west side of the site flows south. Run-off on the east side of the site flows east.

The drainage area on the west side of the site is known as Area #1 and has a total area of 1.1 ha. The steepest longest slopes in this area are 3.5% uniform slopes that are measured at 82 m in length.

The east side of the site is known as Area #2 and has a total area of 0.7 ha. This site contains uniform slopes of 6.8% that measure 25 m in length as well as uniform slopes of 10% that measure 10 m in length.

Erosion & sediment controls:

Prior to stripping vegetation and topsoil from Areas #1 and #2, two sediment basins are constructed (as per standard sediment basin design criteria) – one for each area - to serve the entire site. The sediment basin in Area #1 can hold a volume of 275 m^3 (250 m^3/ha) while the basin in area #2 can hold 160 m^3 of water (225 m^3/ha). In addition, perimeter controls (silt fence and storm inlet controls) are installed where run-off has the potential to leave the site or enter a storm sewer inlet.

Sediment basins are to be constructed/maintained so that they do not lose capacity due to excessive standing water or sedimentation (water will be slowly drawn down using a skimmer-type outlet and drained to a vegetated perimeter buffer and silt fence; sediment will be periodically removed when the basins are dry and spread on a flat area of the site or hauled off-site with excavated material). In cases where basins are to be drained to a storm sewer, a drainage permit will be obtained from The City.

As vegetation and topsoil is stripped from the site, exposed slopes are roughened by cat tracking up and down the slope (so as to create cat tracks along slope contours) and furrowing flatter, exposed areas (using grader with soil ripper attachment). Compost socks are installed (on contour) on exposed slopes in Area #2 to reduce effective slope length, thereby reducing potential rill erosion. In addition, a temporary swale is constructed to capture and convey small, periodic run-off from Area #2 to the sediment basin (maximum swale grade is 2%). Temporary erosion protection in the swale consists of installing short sections of compost socks across the swale to act as check dams (socks are well staked and run up both sides of the swale to ensure run-off ponds and spills over the centre).

RUSLE Equation: **A = R * K * LS * C * P**

A-Value
A = Annual soil loss due to erosion in (tonnes/(hectare*year)).

R-Value
R = 320 is the rainfall erosivity index for Calgary.

This number was obtained by adding information from the Isoerodent map R-3a with the Adjustment for winter conditions R-3b (Source: *RUSLEFAC: Agriculture and Agri-Food, Canada 2002*).

K-Value
K = Index for soil erodibility based on a specific soil's susceptibility to erosion (based on analysis of texture, organic matter, structure and permeability).

Table …(Source: RUSLEFAC: Agriculture and Agri-Food, Canada 2002) indicates the K value for a clay loam with < 2% organic matter is estimated as 0.044.

Estimated K = 0.044

Table 11-1: K-Values Based on Soil Textural Class

TEXTURAL CLASS	ORGANIC MATTER CONTENT		
	< 2 %	> 2 %	AVERAGE
Clay	0.032	0.028	0.029
Clay Loam	**0.044**	0.037	0.040
Coarse Sandy Loam	-	0.009	0.009
Fine Sand	0.012	0.008	0.011
Fine Sandy Loam	0.029	0.022	0.024
Heavy Clay	0.025	0.020	0.022
Loam	0.045	0.038	0.040
Loamy Fine Sand	0.020	0.012	0.015
Loamy Sand	0.007	0.005	0.005
Loamy Very Fine Sand	0.058	0.033	0.051
Sand	0.001	0.003	0.001
Sandy Clay Loam	-	0.026	0.026
Sandy Loam	0.018	0.016	0.017
Silt Loam	0.054	0.049	0.050
Silty Clay	0.036	0.034	0.034
Silty Clay Loam	0.046	0.040	0.042
Very Fine Sand	0.061	0.049	0.057
Very Fine Sandy Loam	0.054	0.044	0.046

However, using the data provided at the beginning of this example, a more accurate K-value can be determined using the Soil Erodibilty Nomograph (Foster et al., 1981).

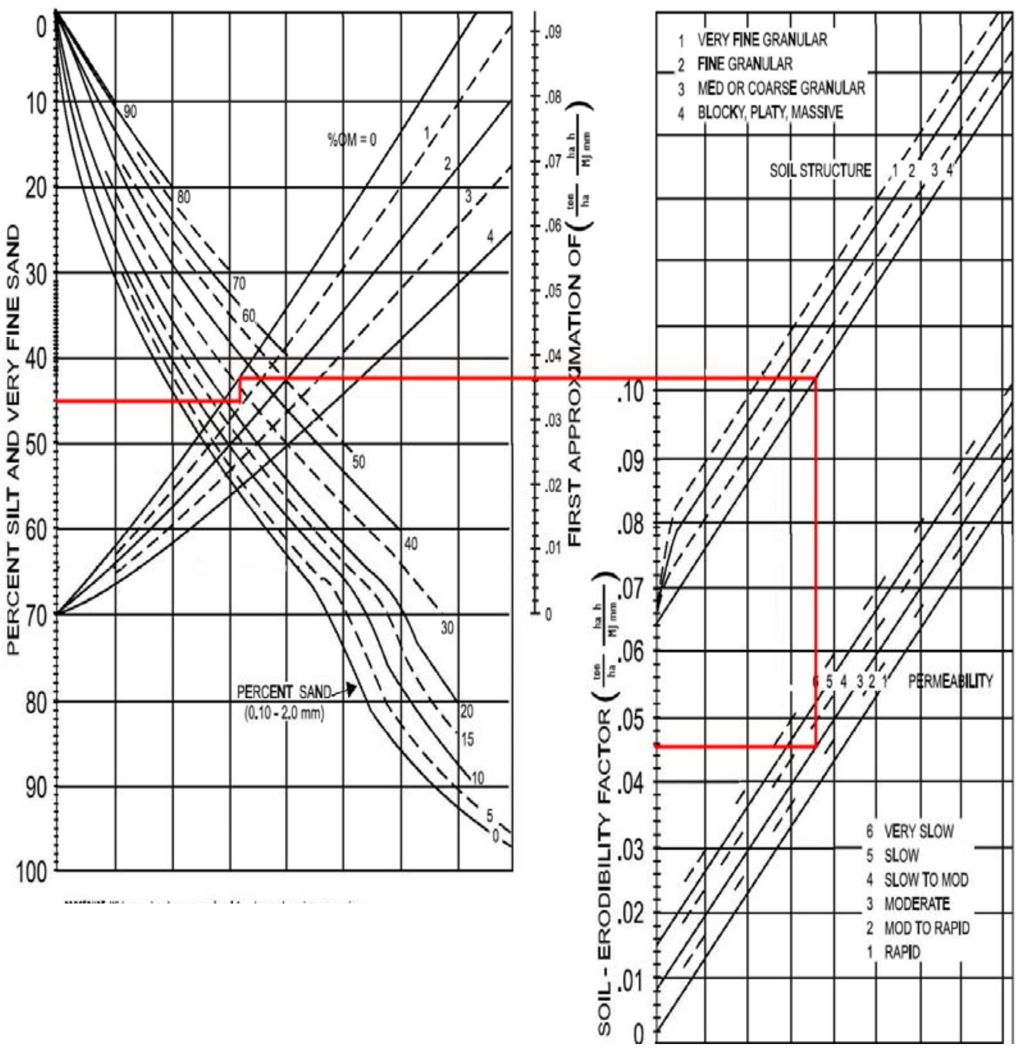


Figure 11-1: Estimation of K-Value Using Nomograph Method

<u>Data required for K-Value using nomograph:</u>

% Silt and very fine sand = 45% (40% silt + 5% very fine sand)
% Sand = 25%
% Organic Matter = 0%
Soil Structure = Prismatic (4)
Permeability = Moderate (3)

K = 0.045

Ideally, soil structure and permeability should be determined in the field by a qualified professional at the time that soil samples are collected. Where structure and permeability are not determined on-site, they can be roughly estimated using RUSLE-FAC soil structure and permeability charts (see Figure 48 below).

A sample containing 25% sand and 30% clay is classified as being a Clay Loam with a structure class of 4 and a permeability class of 4.

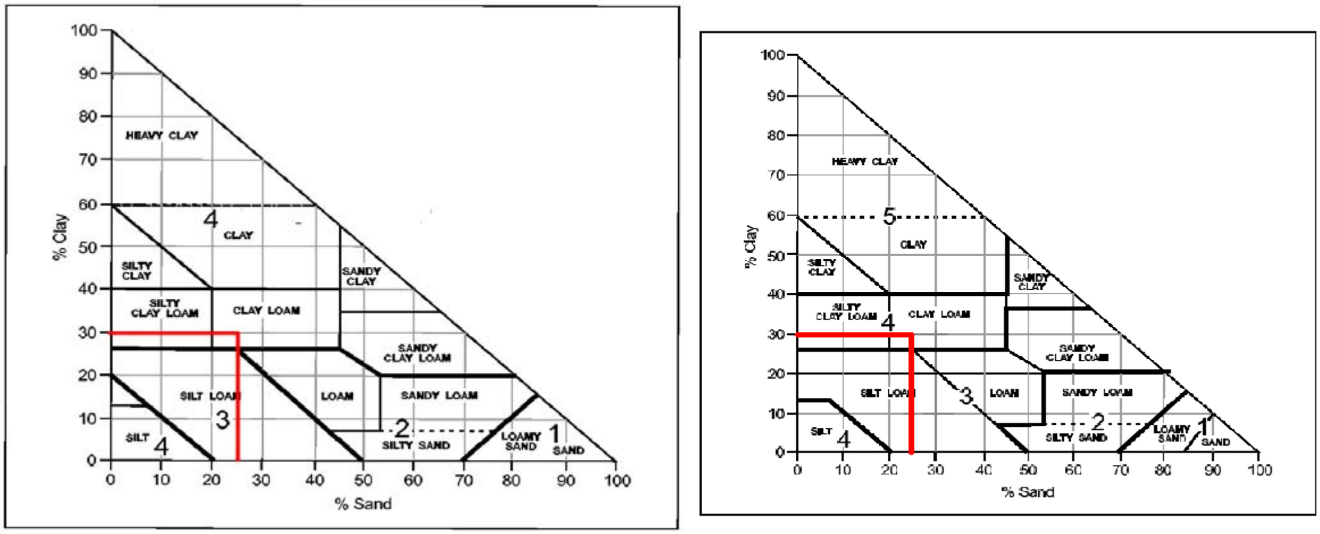


Figure 11-2: Approximation of Soil Structure and Permeability Using the Soil Texture Triangle

LS-Value

LS related to topographic factors specific to the length of the overland flow path times the steepness of the overland flow path.

There are a number of different LS charts to choose from when determining the LS factor. In this example, the site is stripped of topsoil and rough graded (is considered highly disturbed), therefore it is considered to have a high ratio of rill:inter-rill erosion and RUSLE-FAC Table LS-3 is used to determine LS-Values. (Source: *RUSLEFAC: Agriculture and Agri-Food Canada, 2002*).

Table 11-2: Values for Topographic Factor, LS, for High Ratio of Rill:Inter-rill Erosion

(Such as highly disturbed soil conditions and freshly prepared construction sites, with little/no vegetative cover (not applicable to thawing soils)

LS Values for High Ratio of Rill: Inter-Rill Erosion, such as highly disturbed soil conditions and freshly prepared Construction Sites, with little or no cover (not applicable to thawing soils)														
	Slope Length in meters													
Slope %	**1**	**2**	**4.57**	**5**	**10**	**15**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**
0.20%	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
0.50%	0.07	0.07	0.07	0.07	0.07	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.13
1.00%	0.09	0.09	0.09	0.09	0.11	0.12	0.14	0.17	0.19	0.20	0.23	0.24	0.26	0.27
2.00%	0.13	0.13	0.13	0.14	0.18	0.21	0.26	0.34	0.40	0.44	0.52	0.58	0.64	0.68
3.00%	0.17	0.17	0.17	0.17	0.24	0.29	0.37	0.52	0.63	0.72	0.88	1.01	1.12	1.22
4.00%	0.20	0.20	0.20	0.21	0.30	0.38	0.49	0.71	0.88	1.03	1.28	1.49	1.67	1.84
5.00%	0.23	0.23	0.23	0.24	0.36	0.46	0.61	0.91	1.14	1.35	1.70	2.01	2.28	2.53
6.00%	0.26	0.26	0.26	0.28	0.42	0.54	0.73	1.11	1.42	1.68	2.15	2.56	2.93	3.27
7.00%	0.29	0.29	0.29	0.31	0.48	0.61	0.85	1.31	1.69	2.03	2.62	3.14	3.61	4.05
8.00%	0.32	0.32	0.32	0.34	0.53	0.69	0.96	1.51	1.97	2.38	3.09	3.73	4.31	4.86
9.00%	0.35	0.35	0.35	0.37	0.59	0.78	1.09	1.73	2.27	2.75	3.61	4.37	5.08	5.73
10.00%	0.35	0.36	0.40	0.42	0.68	0.90	1.27	2.04	2.69	3.28	4.32	5.26	6.13	6.94
12.00%	0.36	0.40	0.49	0.53	0.86	1.14	1.64	2.67	3.56	4.36	5.80	7.11	8.32	9.46
14.00%	0.38	0.44	0.58	0.62	1.03	1.38	2.00	3.30	4.43	5.45	7.32	9.01	10.59	12.09
16.00%	0.39	0.47	0.67	0.72	1.20	1.62	2.36	3.93	5.31	6.57	8.86	10.96	12.92	14.79
20.00%	0.41	0.53	0.84	0.90	1.53	2.08	3.07	5.20	7.07	8.81	11.99	14.92	17.69	20.32
22.00%	0.43	0.57	0.92	0.99	1.69	2.31	3.42	5.82	7.95	9.93	13.56	16.92	20.09	23.11
25.00%	0.45	0.62	1.04	1.12	1.92	2.64	3.93	6.75	9.26	11.59	15.91	19.91	23.70	27.32
30.00%	0.48	0.69	1.24	1.33	2.30	3.18	4.77	8.26	11.40	14.33	19.77	24.84	29.65	34.27
40.00%	0.53	0.83	1.59	1.71	3.01	4.19	6.34	11.13	15.46	19.53	27.15	34.30	41.11	47.67
50.00%	0.58	0.95	1.91	2.06	3.65	5.09	7.75	13.72	19.17	24.29	33.93	43.00	51.68	60.05
60.00%	0.63	1.07	2.19	2.36	4.21	5.89	9.01	16.04	22.48	28.55	40.00	50.82	61.18	71.20

Area #1

Slope = 3.5%
Length = 82m

As the Table LS-3 does not provide values for 3.5% slopes at 82 m they need to be extrapolated.

Slope %	Slope Length in meters	
	75	100
3 (y)	0.63 (b)	0.72 (h)
3.5 (z)	L1	L2
4 (x)	0.87 (a)	1.02 (i)

(a – b = c) 0.87 - 0.63 = 0.24
(c ÷ e = d, where e = x – y *10) 0.24 ÷ 10 = 0.024
(d * f = g, where f = x – z * 10) 0.024 * 5 = 0.12
L1 = g + b L1 = 0.12 + 0.63
L1 = 0.75

For L2, do the same as L1 except substitute (a)(b) with (h)(i).

Slope %	Slope Length in meters		
	75	82	100
3.5	0.75	LS	0.87

Now that L1 and L2 have been determined, LS can be calculated for the 82 m long slope:

0.87 – 0.75 = 0.12
0.12 ÷ (100 – 75) = 0.0048
0.0048 * (82 – 75) = 0.0036
LS = 0.0036 + 0.75 = 0.78
LS = 0.78

Area #2

Slope 1 = 6.8%
Length 1 = 25 m

Slope %	Slope Length in meters
	25
6	0.72
6.8	0.816
8	0.96

LS = [(0.96 – 0.72) ÷ 20] * 8 + 0.72
LS = 0.816

Slope 2 = 10%
Length 2 = 10 m
LS = 0.64

As there are two separate and distinct ‘worst’ slopes in area #2, the area can either be broken up into two separate areas or the worst case LS value can be used to represent this area. As the limit of 2 tonnes/ha/yr can be reached using the higher LS (0.816) to represent the entire site the other LS (0.64) though determined is not used in this example.

C & P Factors
C = Cover/management factor (such as vegetation, mulch application)

P = Support practice factors (such as silt fence, compost socks, sediment basins)

A	R	K	LS	C	P1	P2	P3	Size (ha)
Area #1: No ESC Measures	320	0.045	0.78	0.0	0.0	0.0	-	1.1
Area #1: With ESC Measures	320	0.045	0.78	0.0	0.9	0.1	-	1.1
Area # 2 No ESC Measures	320	0.045	0.82	0.0	0.0	0.0	0.0	0.7
Area #2 With ESC Measures	320	0.045	0.82	0.0	0.9	0.3	0.6	0.7

C = No soil stabilizing cover such as vegetation, therefore no credit allowed for C
P1 = Surface roughening (cat tracking up and down the slope) related to % slope
P2 = Sediment ponds related to size and the area they serve
P3 = Compost socks installed on slope contours and in channels (only subject to minor, periodic flows).

Soil Loss Calculations:

A (Soil loss estimate in tonnes/ha/year) = R * K * LS * C * P

Area #1

No ESC Measures Installed:
A = 320 * 0.045 * 0.78
A = 11.23 tonnes/ha/yr
11.23 tonnes/ha/yr * 1.1 ha = 12.36 tonnes/yr

ESC Measures Installed:
A = 320 * 0.045 * 0.78 *0.9 * 0.1
A = 1.01 tonnes/ha/yr
1.01 tonnes/ha/yr * 1.1 ha = 1.11 tonnes/yr

Area #2:

No ESC Measures Installed:
A = 320 * 0.045 * 0.82
A = 11.81 tonnes/ha/yr
11.81 tonnes/ha/yr * 0.7 ha = 8.27 tonnes/yr

ESC Measures Installed:
A = 320 * 0.045 * 0.82 * 0.9 * 0.3 * 0.6
A = 1.91 tonnes/ha/yr
1.91 tonnes/ha/yr * 0.7 ha = 1.14 tonnes/yr

Area #1 + Area # 2

12.36 + 8.27 = 20.63 tonnes/yr
20.63 tonnes/yr ÷ 1.8 = *11.46* tonnes/ha/yr

1.11 + 1.14 = 2.25 tonnes/year

2.25 tonnes/yr ÷ 1.8 ha = *1.25* tonnes/ha/yr

The example illustrates that the planning and implementation of measures such as surface roughening, sediment basins and compost socks results in a very marked reduction in the site soil loss estimate.

APPENDIX C

GLOSSARY

12.0 APPENDIX D: GLOSSARY

The following words and terms are commonly used when dealing with erosion and sediment control and stormwater management. Some definitions are adapted from *Erosion & Sediment Control on Construction Sites* (Spring 2002) prepared by Dr. David Walker, CPESC. Some definitions were also adapted from the *Erosion & sediment control Participant's Handbook* (2005), Malaspina University College.

Abrasion	Erosion caused by particles carried by wind or water.
Angle of Repose	The steepest slope angle at which loose material can remain stationary.
Accretion	The outward growth of a bank or shoreline caused by sedimentation.
Alluvial Material	Deposits of clays, silts, sands, gravels and detritus transported by running water.
Aquifer	A water-bearing geologic formation that permits the movement of ground water.
Armour	Artificial surfacing of bed, banks, shore or embankment to resist erosion or scour.
Articulated	Made flexible by hinging (particularly of small rigid slabs adapted to revetment).
Backfill	Soil used to fill a trench or excavation.
Baffle	A structure built to deflect or check flowing water or to increase the effective length of sediment containment structures such as sedimentation basins and traps.
Base Flow	Stream flow during dry periods, predominantly due to groundwater recharge.
Bed Load	Sediment that moves by rolling, bouncing or sliding along a channel.
Benthic	Refers to the bottom of a water body.
Berm	A structure (generally compacted earthen material) built to contain or divert run-off or, in the case of a compost berm, to detain and filter run-off through stabilized organic material.
BFM	(Bonded Fibre Matrix): A thick, permeable three-dimensional continuous blanket-like covering that is applied with hydromulching equipment.
BMP	Control or practice implemented to protect water quality and reduce the potential for pollution associated with stormwater run-off.
Capacity	The effective carrying ability of a drainage structure (cubic meters per second).
Catchbasin	A drainage structure that collects stormwater.
Channel Erosion	Erosion of the bed or banks of a defined channel.
Check Dams	Small dams constructed in channels subject to periodic run-off with the purpose of reducing water velocity, channel gradient and erosion.
Clay	Inorganic particles 0.0002 to 0.004 mm in diameter.
Cohesion	The ability of individual soil particles to stick together.
Continuous Berm	A low profile berm constructed of compost, sand, gravel or soil wrapped in a geotextile or mesh sock.
CoR	The percentage of total rainfall that appears as run-off.
Conveyance	Any natural or man-made channel or pipe in which concentrated water flows.
Culvert	A closed conduit that allows water to pass under a road.
D_{50}	The median rock size (in a mixture of rock sizes; 50% of the rock is larger diameter and 50% is smaller diameter).
Deleterious	Deleterious substances, as defined in the Fisheries Act, are substances (or water containing a substance) that degrade or alter water quality so that it is, or is likely to be, rendered deleterious to fish, fish habitat or the use of fish by humans. Water that is treated, processed or changed from a natural state, and introduced to fish habitat could also harm fish, fish habitat or consumers of fish.
Denuded	Land stripped of vegetation.
Deposition	The settling of material due to gravity.
Design Storm	A rainfall event of specified size and return frequency (used to calculate the run-off volume and peak flow rate).
Detachment	The breaking of bonds holding a material together (i.e. by raindrop impact).
Detention	The temporary detention of stormwater for later release. This practice is often used in sedimentation traps and basins to promote the settling of sediment.
Discharge	A volume of water flowing out of a drainage structure or facility (measured in cubic metres per second or U.S. gallons per minute). May also refer to a discharge of water from an excavation as a result of dewatering.
Dissipate	To expend the energy of flowing water.
Disturbed Areas	Areas that have been purposefully cleared, grubbed, excavated, or graded. Ground surface that has been disrupted by construction activities, including construction access/roads, staging and storage sites; producing significant areas of exposed soil and stockpiles.
Ditch	A small artificial channel, usually unlined.
Diversion	The interception and conveyance of run-off into an unnatural channel (usually to protect a disturbed area).
Drainage Area	A defined area of the land surface off which run-off flows to a given location.

Due Diligence The legal expectation or requirement that individuals and companies will maintain a reasonable standard of care to protect worker safety and the environment.

Energy Dissipater A structure for the purpose of reducing the erosive forces present in any rapidly flowing, concentrated run-off.

Entrainment The picking up of soil particles after they are detached by erosive agents.

Erosion The physical removal or detachment of soil particles, followed by the entrainment and transport of the particles to another location.

Erosion Control The Stabilization of soils utilizing controls and practices such as vegetation cover, mulches, protective blankets, wattles, fascines or engineered materials.

Fascine A long bundle of live woody material bound together and used for biotechnical stabilization of river banks and slopes.

Fathom A measure of water depth equal to 6 feet.

Fertilizer Analysis The percentage of fertilizer, expressed in terms of nitrogen, phosphoric acid, and potash. For example, a fertilizer with a 6-12-6 contains 6% nitrogen (N), 12% available phosphoric acid (P_2O_5), and 6% water-soluble potash (K_2O).

Filter Fabric A woven or non-woven, water permeable material generally made of synthetic products such as polypropylene used in erosion & sediment control applications to trap sediment or prevent clogging of aggregates by fine soil particles.

Filter Layer A layer of even-graded rock placed between riprap and the underlying soil to prevent undercut erosion of the underlying soil or clogging of aggregates by fine particles.

Forb An herb other than grass.

Freeboard The vertical distance between the design water surface elevation and the maximum possible elevation before overtopping.

Gabion A wire basket or cage filled with stone and placed to protect a steep embankment, Gabion mattresses are similar structures that are installed to convey concentrated run-off in channels (similar to riprap lining).

Grade The slope of a roadway, channel, slope or natural ground.

Grading Earth disturbing activities including excavation, cutting, filling, stockpiling, or any combination thereof.

Grubbing Removing stumps, roots or brush.

Gully Erosion Results when numerous rills join to cut deeper, wider channels. In turn, gullying dramatically concentrates run-off and erosion rates.

Groundwater Subsurface water within a zone of saturated material (aquifer).

Hydrograph A graph showing the stage, flow rate, velocity or other property of water with respect to time.

Hydromulching Application of water-based slurry containing mulch (and tackifier) to the soil.

Hydroseeding Similar to hydromulching, but with the addition of seed, fertilizer and other specialized soil amendments.

Infiltration The movement of water through the soil surface into the ground.

Impoundment A natural or man-made containment for surface water.

Inlet The entrance into a ditch, culvert, storm drain or other water conveyance.

Lining Protective covering installed over a channel substrate or, in the case of a pond, to prevent the infiltration of water.

Loading Usually refers to the total contribution of sediment and other pollutants into stormwater and receiving waters from all sources.

Mulch A natural or artificial layer of plant residue or other material that covers the land preventing surface crusting, reducing erosion caused by wind and raindrop impact and – in many cases- aiding in establishing vegetation by preserving moisture and reducing temperature fluctuations.

NPS (Non-Point Source Pollution): Diffuse sources of contaminants (i.e. streets and driveways in a residential subdivision). These sources can add to a cumulative problem with serious health or environmental consequences.

Permeability The capacity for transmitting run-off through a material or into the soil. It is measured by the rate at which a fluid of standard viscosity can move through the material in a given interval of time, under a given hydraulic gradient.

Permit An authorization, license or a similar control document issued by The City of Calgary or another regulatory body to conform to the requirements of an environmental regulation or bylaw. Permits are usually issued based on the review of a written application and other information and have conditions that must be adhered to.

Piping Seepage or subsurface flow often causing removal of soil, eroding larger and larger pathways or “pipes”.

Pitrun Unprocessed and unsorted aggregate material.

Point Source (point source pollution): A pollutant emanating from a clearly identifiable source or discharge (i.e. discharge from a wastewater treatment plant).

Practicable Capable of being done within reasonable natural, social, and economic constraints (i.e. BMPs must be considered to be practicable as well as effective).

Precipitation The falling to ground of atmospheric moisture as rain, snow or hail, measured in depth or intensity.

Raindrop Erosion The dislodging of soil particles caused by the impact of raindrops.

RECPs	(Rolled Erosion Control Products): Biodegradable or synthetic soil coverings used to protect exposed soils from erosion. Classes of RECPs included erosion control blankets (ECBs), turf reinforcement mats (TRMs) and composite turf reinforcement mats (c-TRMs).
Retention	The holding of run-off in a basin without release except by means of evaporation, infiltration or emergency bypass.
Revegetation	The planting of indigenous plants to replace natural vegetation that is damaged or removed as a result of construction activity or other forces.
Rill Erosion	The formation of numerous, closely spaced streamlets due to the increased concentration and velocity of sheet run-off on slopes.
Riparian	Refers to the land area around a body of water that is critical in supporting aquatic habitat (cover, filtration and adsorption of pollutants, soil stabilization with roots, etc.). It is critical that riparian corridors are protected to prevent the degradation of water quality and aquatic habitat.
Riprap	Angular, durable rock meeting a design size gradation. Riprap is used to control erosion in high energy environments.
Riser	A vertical pipe extending from the bottom of a pond so as to control the discharge rate.
Run-off	A volume of surface water that exceeds the soil's infiltration rate and depression storage, thereby running over the land surface. The portion of precipitation that appears as flow in streams or drainage channels.
Sand	Inorganic soil particles 0.06 to 2 mm in diameter.
Scheduling	A written procedure identifying major construction and soil disturbing activities and the time allotted to each activity for completion.
Scour	Erosion caused by concentrated water flow, carrying away material by abrasive action. Scour can commonly occur at the toe of stream banks, often resulting in bank undercutting. Unprotected inlets and outlets at stormwater conveyances are also prone to scour if not adequately protected.
Sediment	Soil particles detached and mobilized by erosion.
Sedimentation	The gravitational deposit of transported material from flowing or standing water or air. Sedimentation occurs when the energy of the transport agent is less than gravitational forces acting on material.
Sediment Control	Capture (by settling or filtration) of sediment produced by erosion.
Seepage	The percolation of underground water through slopes, river banks or at the base of slopes. Seepage can often cause erosion or make the stabilization of seepage prone areas difficult.
Sequencing	An orderly list of all major land disturbing activities and the proposed ESC measures associated with each.
Settling Pond	Any pond used as a sediment basin or sediment trap.
Sheet Erosion	The removal (entrainment) of thin layers of soil by sheets of flowing water.
Sheet Flow	The movement of water in broad, thin sheets across a surface.
Silt	Soil particles 0.004 to 0.06 mm in diameter.
Slope Texturing	Roughening, tracking, furrowing, grooving or benching of slope surfaces so as to reduce flow path length, thus controlling run-off and reducing erosion potential.
Soil Stabilization	Vegetative or structural soil cover used to control erosion (i.e. permanent and temporary seed, mulch, sod, pavement, etc.).
Source Control	An effort to control pollutants (such as sediment at the source). Controlling run-on and run-off and quickly stabilizing exposed soils during construction activities are all examples of source control.
Storm Frequency	The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur.
Storm Sewer	A system of structures (such as catchbasins, underground pipe, manholes and outfalls) that collect and convey stormwater run-off to treatment structures (such as storm pond) or receiving water bodies. In many areas of Calgary, storm sewers connect directly to receiving water bodies, therefore it is especially important that controls and practices are developed and implemented to control point source and non-point source pollution in such drainage areas.
Stormwater	Run-off and ponded water resulting from precipitation, snowmelt and seepage.
Sub-drain	A conduit for collecting and disposing of subsurface water: Generally consists of a perforated pipe, wrapped in geotextile fabric or gravel, through which water can enter.
Suspended Solids	Organic or inorganic particles suspended in the water column (including sand, silt and clay particles).
Swale	A shallow channel intended to collect and convey water during run-off events.
Tackifiers	Non-toxic organic or polymer glues that bind mulch and other materials.
Topography	The physical features (natural and man-made) of a land surface (i.e. flat, rolling, mountainous).
TSS	(Total Suspended Solids): Usually expressed as mgéL, TSS represents the mass of suspended material in a given volume of water. High TSS can reduce light penetration into the water and fine solids can damage or destroy fish habitat by smothering spawning areas, feeding and shelter areas and fish gills. Coarse sediment can also clog water bodies and conveyances such as storm sewer pipes. TSS can also transport adsorbed contaminants such as heavy metals and nutrients into water bodies.
Turbidity	Increased turbidity is caused by increasing the amount of fine material (generally silt and clay sized particles) suspended in the water. High turbidity can negatively impact fish habitat and makes

drinking water sources difficult and expensive to treat. High turbidity in drinking water can also increase the risk of certain water-borne illnesses. Turbidity can easily be measured in the field using a handheld turbidity meter (measures light scattering). Results are expressed in NTU (nephelometric turbidity units).

Turbulence Occurs in flowing water agitated by cross-currents, uneven, shallow substrate and eddies.

Urban Run-off Run-off carried over impervious surfaces commonly found in urbanized environment. Sediment and other contaminants from sources such as roadways, driveways, construction sites and automobiles can reduce water quality of urban run-off. Increasing impervious surface cover dramatically increases the amount of urban run-off.

Water Body Surface waters including rivers, streams, lakes, and wetlands.

Water Table The surface of the groundwater below which the void spaces are completely Saturated with water. A perched water table can also occur when groundwater is impeded by a layer of dense material. It is common to run into perched water tables during deep excavation in Calgary.

Wetland An area that is inundated with surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation adapted to saturated conditions (swamps, marshes, bogs and similar areas).

Windbreak A barrier or line of trees intended to break or deflect the velocity of wind, thereby reducing wind erosion potential.

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