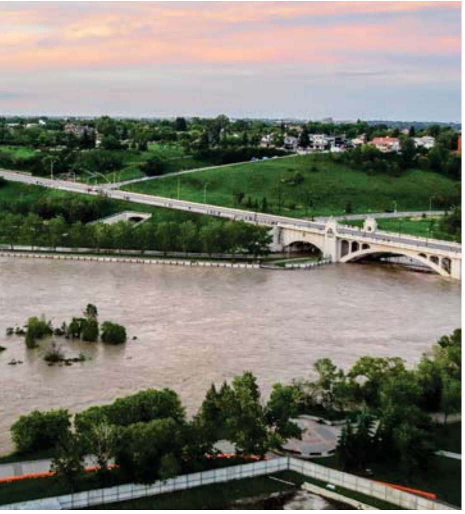
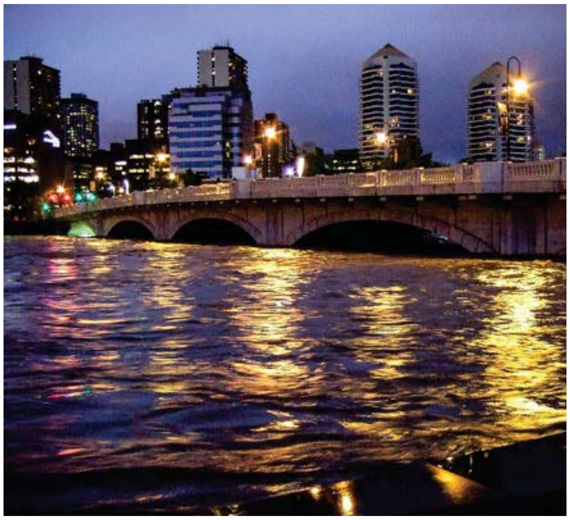
SUPPORTING DOCUMENTATION

1. IBI Report





Benefit/Cost Analysis of Flood Mitigation Projects for The City of Calgary and Environs on the Elbow River with Emphasis on MC1 and SR1

Prepared for Government of Alberta ESRD – Resilience and Mitigation
by IBI Group
106441 | August 2017

Benefit/Cost Analysis of Flood Mitigation Projects for The City of Calgary and Environs on the Elbow River with Emphasis on MC1 and SR1

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August 2017

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August 21, 2017

Mr. Syed Abbas
Director, Water Management Section
Government of Alberta - Transportation
2nd Floor, Twin Atria Building
4999 - 98 Avenue
Edmonton, AB T6B 2X3

Dear Mr. Abbas:

BENEFIT/COST ANALYSIS OF FLOOD MITIGATION PROJECTS FOR THE CITY OF CALGARY AND ENVIRONS ON THE ELBOW RIVER WITH EMPHASIS ON MC1 AND SR1

Enclosed please find the updated report for the aforementioned assignment. The report describes in detail a comparison of project benefits to determine if the projects under consideration are economically viable, and which one provides the most economically-efficient solution.

Costs have been updated for both projects. Based on the information received, both projects attained positive benefit/cost ratios. The ratio for SR1 is 1.68, while the ratio for MC1 is 0.24 lower at 1.44.

Should you have any questions or require additional information please do not hesitate to contact the undersigned.

Yours truly,

IBI GROUP

Stephen Shawcross
Director

David Sol
Senior Planner

SS/mp

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Memo

March 30, 2017

Re: Flood Mitigation Measures Assessment

The Flood Mitigation Options Assessment (2017) was prepared for The City of Calgary ("The City") by IBI Group Professional Services (Canada) Inc. ("The Consultant"), in accordance with the contract awarded under RFP#15-1617. The report describes the development and use of the Updated Rapid Flood Damage Model ("The Model"), which was created for The City by The Consultant based on the previous model developed for the Government of Alberta[1].

Conditions described in the above report, which apply to the development of The Model, are based on information obtained during the assessment conducted and on the state of development and the rivers' condition at the time of the assessment. This report and Model were prepared, based in part, on information provided by The City of Calgary. The information, data, recommendations and conclusions contained in the report are subject to the limitations described in the report, and were limited to the scope and schedule of the project. They represent the Consultant's professional judgement in light of the limitations, current regulatory context, and industry standards.

For those interested in this work, pertinent points may include, but are not limited to:

- The flood damage model was updated with The City's most up to date (2015) hydraulic modelling at the time of the study, as described in the report. Flood frequencies and associated depths reflect the results of this hydraulic model.
- Groundwater inundation modelling was based on limited subsurface data, a simplified modelling methodology, and was adjusted using professional expertise.
- Neither groundwater inundation nor flood damage estimates were fully validated or calibrated to historic events, due to a lack of data to complete such analyses.
- The monetized costs and benefits captured in the damage model included those impacts that were judged by The Consultant to be applicable and quantifiable, but did not represent an exhaustive list of all financial, social and environmental impacts (positive and negative) related to flooding and mitigation measures. Further details on parameters that were and were not included in the model are described in the Phase 1 section of the report.
- Given the point above, the benefit-cost results should be taken into consideration alongside the Triple Bottom Line (TBL, also called the "sustainability analysis") results, which provide a more fulsome analysis of mitigation measures based on expanded social, environmental and implementation feasibility criteria.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and within the specific regulatory context at the time. Regulations are subject to interpretation and change, and should be reviewed over time. If new information is discovered during

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[1] IBI Group. *Provincial Flood Damage Assessment Study.* Prepared for Government of Alberta ESRD – Resilience and Mitigation. Feb 2015. Available at: http://aep.alberta.ca/water/programs-and-services/flood-mitigation/flood-mitigation-studies.aspx

future work, the conclusion of this report, and/or the applicability of The Model, should be re-evaluated prior to any reliance upon the information presented herein.

Any use of this Report is subject to the above qualifications and limitations. The City of Calgary makes no commitment to maintaining, updating or training on The Model. Any damages arising from improper use of the Report or Model shall be borne by the party making such use.

In the interest of ensuring consistent and accurate interpretation of the embedded limitations of the model and information derived from it, The City considers it warranted for parties using or interpreting the Model or related information to advise and confer with the City prior to any public communication or redistribution of same. As the model relies on and contains information prepared within the realm of Professional Engineering practice, relevant Codes of Ethics and standards of practice may apply to the responsible use and distribution of the Model or related/derived information.

This memo outlining qualifications and limitations is attached to and forms part of the Report.

Sincerely,

Frank Frigo, P.Eng.
Project Sponsor, Flood Mitigation Measures Assessment
Leader, Watershed Analysis, Water Resources
City of Calgary
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Attachments: 1 – IBI Group Professional Services (Canada) Inc. *Flood Mitigation Options Study.* Prepared for The City of Calgary. Feb 2017.

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Executive Summary

Introduction

Background

The previous benefit/cost studies of these projects were based on conceptual facility designs and their associated costs along with damage assessments based on hydrology and hydraulic studies that have since been updated. In light of the evolving dynamics of the floodplain and the proposed solutions, it was considered prudent to re-examine the benefit/cost analysis with emphasis on McLean Creek flood storage project (MC1) and Springbank flood storage project (SR1).

Purpose

The purpose of the benefit cost analysis is to provide a comparison of project benefits, in terms of damages averted, to project costs including capital and operating costs, to determine if the projects under consideration are economically viable, and which one provides the more economically efficient solution.

Scope

For the purposes of this study, benefits are restricted to economic benefits accruing within the study area, which is identified as the flood hazard area within the City of Calgary boundaries. The study utilizes current damage estimates based on updated stage-damage curves along with updated flood risk mapping. Project costs are based on current estimates prepared specifically for this analysis and elaborated upon within the report.

Benefits

Both projects are assumed to achieve the same benefits once completed. The annual benefit is the average annual damages (AAD) averted, which is estimated at $27,736,265. This amount is the reduction in AAD from the existing mitigation condition on the Elbow River below the Glenmore Reservoir.

Project Costs

Project costs are illustrated in the accompanying tables.

SR1 Cost Opinion

Component	Cost
General*	$38,486,000
Diversion Structure	$51,147,000
Diversion Channel	$78,686,000
Off-stream Storage Dam	$38,643,000
Contingencies	$31,045,000
Utility Relocation	$15,705,000
Engineering, Permitting, Admin	$38,000,000
Project Total	**$291,712,000**

*includes mobilization, care of water, utility and road work, etc.

MC1 Cost Opinion

Component	Cost
Mobilization	$12,000,000
Care of Water	$3,000,000
Dam Construction	$188,000,000
Highway 66 Relocation	$34,341,000
Facility Relocation	$22,853,000
Wetland Compensation	$708,000
Aquatic Habitat Management Plan	$10,000,000
Engineering/Environment/Engagement	$54,180,400
Contingencies	$81,270,600
Project Total	**$406,353,000**

Total Costs

The total cost assumptions are detailed in the following table:

Cost	SR1	MC1
Construction Total	$291,712,000	$406,353,000
Land	$80,000,000	n/a
Total	**$371,712,000**	**$406,353,000**
Annual Operation/Maintenance (1% of Dam Construction Cost)	$1,685,000	$1,880,000
Annual Lease-Back Potential	-$714,610	n/a

Timing

The analysis was performed using the net present value of benefits and costs over a 100-year period at a discount rate of 4%. Assumptions regarding timing are as follows:

SR1:

- land costs are incurred in year 1
- costs are split 50/50 between years 1 and 2
- annual benefit, operation and maintenance, and lease back amounts begin in year 3

MC1:

- costs are spread between years 1-5 as follows: 5%, 10%, 15%, 35%, 35%
- annual benefit and operation and maintenance amounts begin in year 6

Benefit/Cost Results

The results of the benefit/cost calculation are detailed in the following table:

Indicator	SR1	MC1
PV Benefits	$653,008,000	$578,997,000
PV Costs	$388,943,000	$402,999,000
Net Present Value	$264,065,000	$175,998,000
Benefit/Cost Ratio	1.68	1.44

As evidenced, both projects yield a positive benefit/cost ratio with SR1 scoring higher than MC1 by a margin of 0.24 (1.68 vs 1.44). *If a land value was included in the MC1 costs, the BC ratio would decrease to 1.26.*

Benefits Beyond the Study Area

An analysis of any potential benefits downstream of the City was outside the scope of this analysis. Needless to say, it is anticipated that benefits downstream of the City of Calgary would be marginal in any event.

Triple Bottom Line Considerations

Traditional economic analyses of flood mitigation alternatives have generally assumed a straightforward objective of maximizing the net benefits (total benefits minus total costs) that accrue to a project. Society however, has other goals besides economic efficiency. These goals or objectives are the results of outcomes that society desires and have more recently been described as triple bottom line objectives which include, in addition to economic objectives, considerations of environmental and social impacts. In relation to flood mitigation projects, the following criteria are often considered in the evaluation process:

- Disaster prevention:
  - reduces current losses
  - reduces future losses
  - potential residential loss of life
  - potential non-residential loss of life
- Environmental impact:
  - biophysical impacts
  - social impacts
  - aesthetic impacts
- Implementation:
  - complexity
  - flexibility of integration with other measures
- Incidental benefits:
  - recreation
  - drought mitigation
  - other

This study was concerned solely with economic efficiency and consequently does not include a full analysis of the aforementioned non-commensurable criteria. The intangible impact on households, however, was included as an adapted willingness-to-pay amount per affected household.

1 Introduction

1.1 Background

The flood of 2013 was a devastating event for southern Alberta and the City of Calgary. The flood event had the largest economic impact of any extreme weather event in Canada to date. As part of the response to protect communities from future flood damage, the province of Alberta commissioned a study through the Flood Mitigation Advisory Panel to provide engineering assessments and practical solutions on possible flood mitigation measures. In October 2013 AMEC Environment and Infrastructure (AMEC) was contracted to provide a flood mitigation feasibility study for the Elbow River and Old Man river basins.

A number of mitigation schemes were considered for the Elbow River upstream of the City of Calgary, including an off-stream flood storage project at McLean Creek, and an off-stream flood storage project in Springbank.

In March of 2014 the City of Calgary retained Hatch Mott Macdonald (HMM) to prepare a detailed feasibility study to provide recommendations on a preferred tunnel diversion from Glenmore Reservoir aimed at routing flood flows away from that portion of the Elbow River between Glenmore Reservoir and the confluence of the Bow River.

As part of the subsequent Provincial Flood Damage Assessment study, IBI Group was commissioned by the Government of Alberta ESRD Operations, Resilience and Mitigation Branch to undertake a benefit/cost analysis of the three projects: McLean Creek Flood Storage Project, Springbank Flood Storage Project and the Glenmore Reservoir Diversion. On the basis of the benefit cost analysis, in addition to factors relating to environmental impact, duration of construction and uncertainty, the Springbank off-stream flood storage project was selected for implementation.

The previous benefit cost studies were based on conceptual facility designs and their associated costs along with damage assessments based on hydrology and hydraulic studies that have since been updated. In light of the evolving dynamics of the floodplain and the proposed solutions, it was considered prudent to re-examine the benefit cost analysis with emphasis on McLean Creek Flood Storage Project (MC1) and Springbank Flood Storage Project (SR1).

1.2 Purpose

The purpose of the benefit cost analysis is to provide a comparison of project benefits, in terms of damages averted, to project costs including capital and operating costs, to determine if the projects under consideration are economically viable, and which one provides the more economically efficient solution.

1.3 Scope

For the purposes of this study, benefits are restricted to economic benefits accruing within the study area, which is identified as the flood hazard area within the City of Calgary boundaries. The study utilizes current damage estimates based on updated stage-damage curves along with updated flood risk mapping. Project costs are based on current estimates prepared specifically for this analysis and elaborated upon within the report.

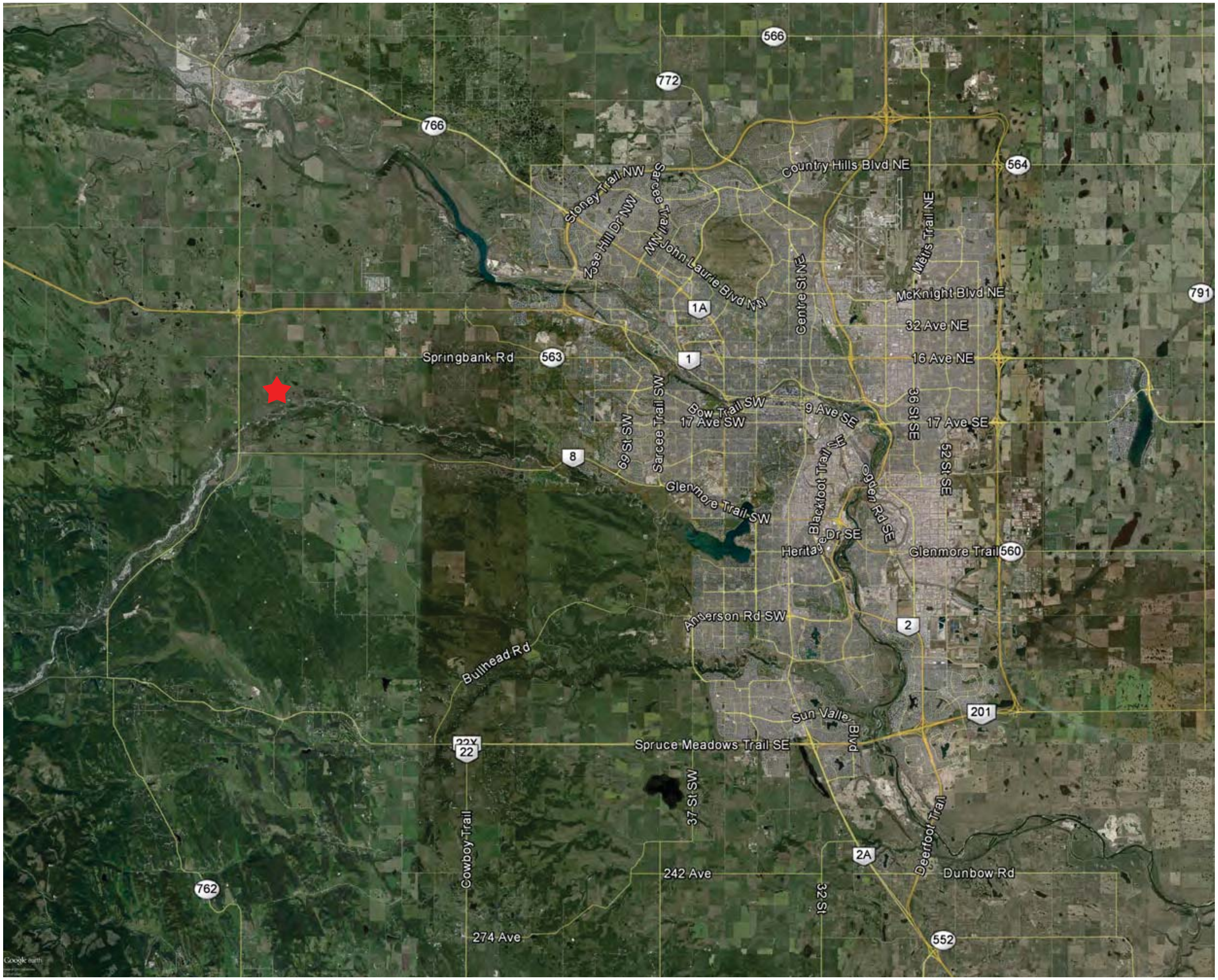
2 Context

Exhibits 2.1 and **2.2** illustrate the regional and local setting of the proposed SR1 project, while **Exhibits 2.3** and **2.4** illustrate the same for MC1.

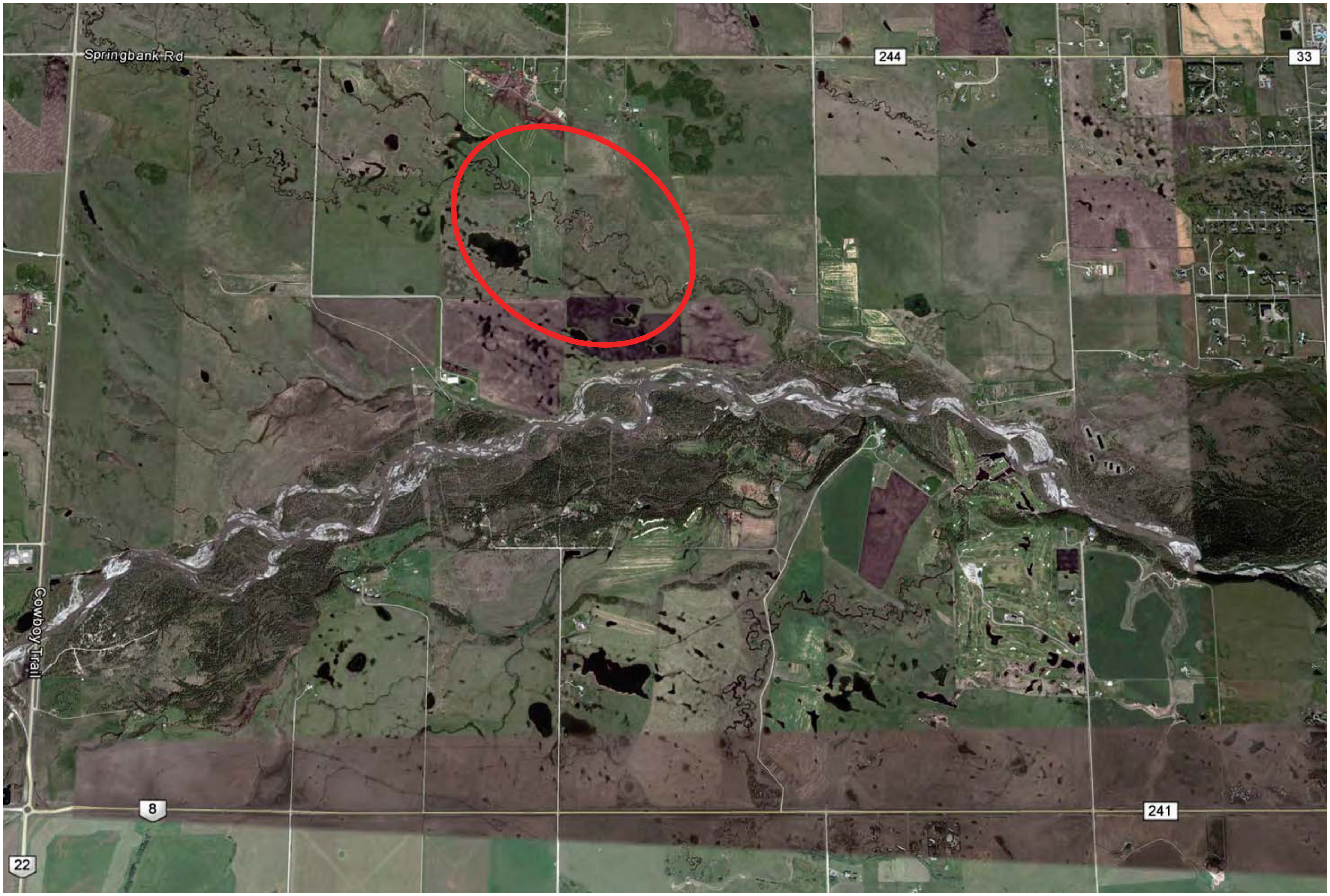
SR1 is situated approximately 15 km upstream of the City of Calgary within the Springbank area of Rocky View County.

MC1 is located in the green zone on Crown land within Kananaskis Provincial Park, approximately 10 km upstream of the Town of Bragg Creek and immediately upstream of the confluence of McLean Creek with the Elbow River.

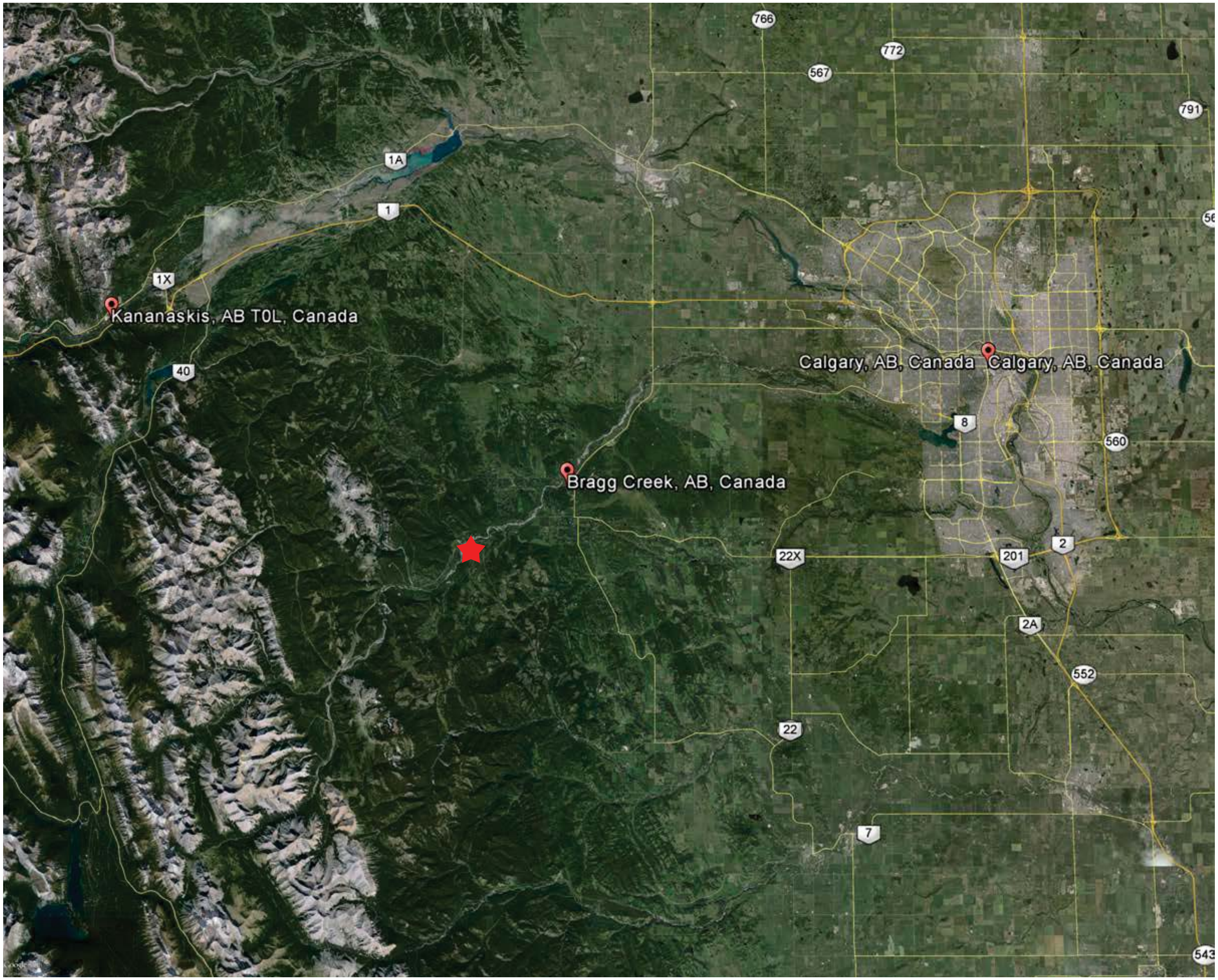
Springbank Off-Stream Flood Storage Site - Regional Setting



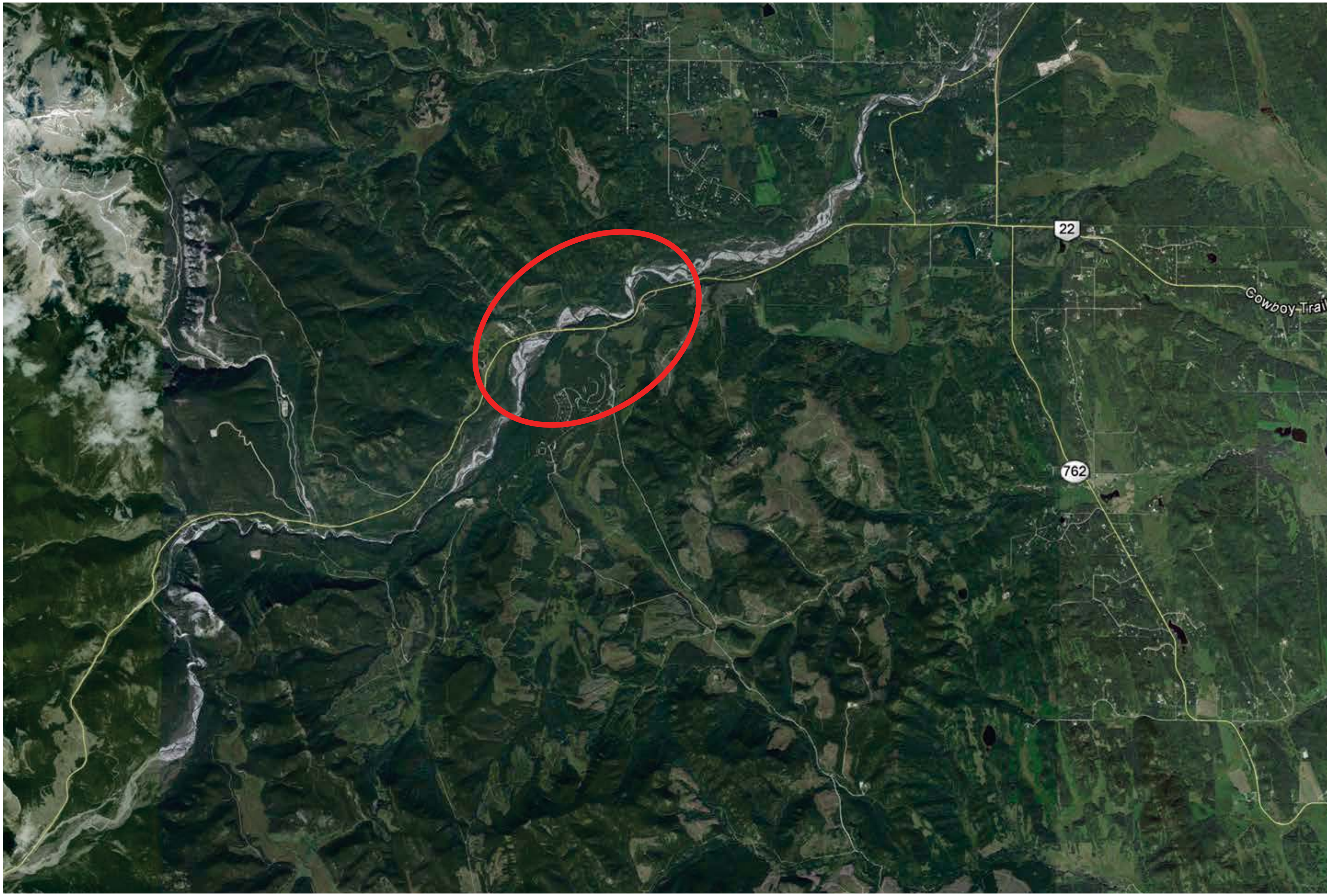
Springbank Off-Stream Flood Storage Site - Local Setting



McLean Creek Flood Storage Site - Regional Setting



McLean Creek Flood Storage Site - Local Setting



3 Project Description

3.1 SR1

3.1.1 Description of SR1

The Springbank Off-Stream Storage Project (SR1) is a flood diversion system comprised of a diversion structure, a diversion channel and dry storage reservoir (no permanent pool). When in operation, SR1 will divert and temporarily store excess floodwater from the Elbow River and release it back into the river system in a controlled manner when the risk of flooding has subsided. SR1 will work in tandem with the Glenmore Reservoir to limit flood flows downstream of Glenmore to less than 160 m^3/s, up to SR1's design event of the 2013 flood, or equivalent. The 2013 flood was approximately a 1 in 200-year event and was the flood of record on the Elbow River.

The SR1 diversion structure is located on the main channel and floodplain of the Elbow River upstream of Highway 22. The diversion structure's gates control how much water is diverted into the diversion channel during a flood event and how much is to continue downstream. The diversion channel conveys that diverted floodwater approximately 4 km to the off-stream storage reservoir located north of the Elbow River Valley. The floodwater is held in that storage reservoir until the flood has passed and the water can be returned to the Elbow River.

The diversion structure has the capacity to divert up to 600 m^3/s of flow from the Elbow River to the off-stream storage reservoir. The off-stream storage reservoir can hold 77,000,000 m^3 of water as active flood storage. Flows in excess of the diversion capacity will pass the diversion structure and be stored within Glenmore Reservoir, up to its allocated flood storage capacity of 10,000,000 m^3. The total storage capacity of 87,000,000 m^3 that the SR1 system provides exceeds the amount of water that overtopped Glenmore during the 2013 event and caused damage from overland flooding downstream.

3.1.2 Operation of SR1

SR1 is designed to activate when flows in the Elbow River exceed 160 m^3/s. This target coincides with the design capacity of the low-level-outlet on Glenmore Dam. AEP Operations will be in communication with the City of Calgary in advance of flood season (and throughout) and each party will have an understanding of the system's status heading into flood season. The need to operate SR1 will be identified through this advanced communication, and will be informed by forecasted and measured flows on the Elbow River upstream, and at SR1.

When in operation, the river gates in the diversion structure's service spillway will raise to start building backwater (hydraulic head) behind the diversion structure. At that time the gates on the diversion inlet (vertical lift gates on river left of the diversion) will open and excess flood flow will begin to divert into the diversion channel, to be stored in the off-stream reservoir. The service spillway will limit flows on the Elbow River, downstream of SR1, to approximately 160 m^3/s. This downstream release rate will be maintained until the flow rate on the Elbow River, which is arriving at SR1, begins to exceed 760 m^3/s. This is approximately a 100-year flood for this location of the Elbow River. If flows on the Elbow River exceed 760 m^3/s then the service spillway gates (river gates) will begin to lower and allow more flow to be released downstream, while maintaining the 600 m^3/s diversion capacity. The service spillway can control this release up to 1900 m^3/s (an estimated 1000-year flood) at which time the backwater will overcome the service spillway and the auxiliary spillway (adjacent to the service spillway) will activate allowing the diversion structure to pass flows up to the Probable Maximum Flood (Flow Rate 2770 m^3/s).

The flood flow that SR1 diverts is conveyed in the diversion channel to the off-stream dry storage reservoir. There the water is held until: either the flood risk has passed and it has been determined by the operators that it is appropriate to release; or, until the reservoir is full and storing 77,000,000 m^3 of floodwater. When the storage is full, the diversion inlet gates will close, ending the diversion and allowing remaining flood flow in the Elbow River to continue downstream to Glenmore Reservoir. Since SR1 began diverting when flows on the Elbow River (at SR1) exceed the low level outlet capacity at Glenmore, there will be 10,000,000 m^3 of active flood storage available in Glenmore to capture the residual floodwaters, up to its allocated capacity.

An emergency spillway is provided along the diversion channel near the off-stream reservoir. The emergency spillway would activate should excess flows enter the diversion channel while the reservoir is at capacity. This spillway would prevent overfilling of the reservoir and potential overtopping of the dam. When activated the emergency spillway would discharge back into the Elbow River via an excavated channel and natural drainage way.

The floodwaters stored in the reservoir will be held until the risk of flooding has passed. The operators will determine when the stored water can be released, and in consultation with the City of Calgary. When it is decided that the water can be released, the gate within the low level outlet of the storage dam will open and the outlet will discharge the stored floodwater, in a controlled manner, into the Unnamed Creek channel, which will convey it back into the Elbow River.

3.2 MC1

3.2.1 Description of MC1

The MC1 project will include an earthfill dam across the Elbow River valley, immediately upstream of the confluence of McLean Creek. The dam is designed to have a relatively small permanent pond in front of the dam and capacity to contain the June 2013 flood. The normal river flow will be released and controlled through two gated, 6 m diameter tunnels located in the south river bank. In the event of a flood event slightly larger than the June 2013 even, the un-gated Service Spillway located at the north end of the dam abutment, will activate. If the probable maximum flood (PMF) event occurs, the Auxiliary Spillway located along the south abutment will be activated. The PMF is defined as the most severe flood that may be reasonably expected to occur at a location. The probability of such a flood occurring is very low (e.g., once in some tens of thousands of years). **Exhibits 3.1 - 3.4** illustrate the key components of the project.

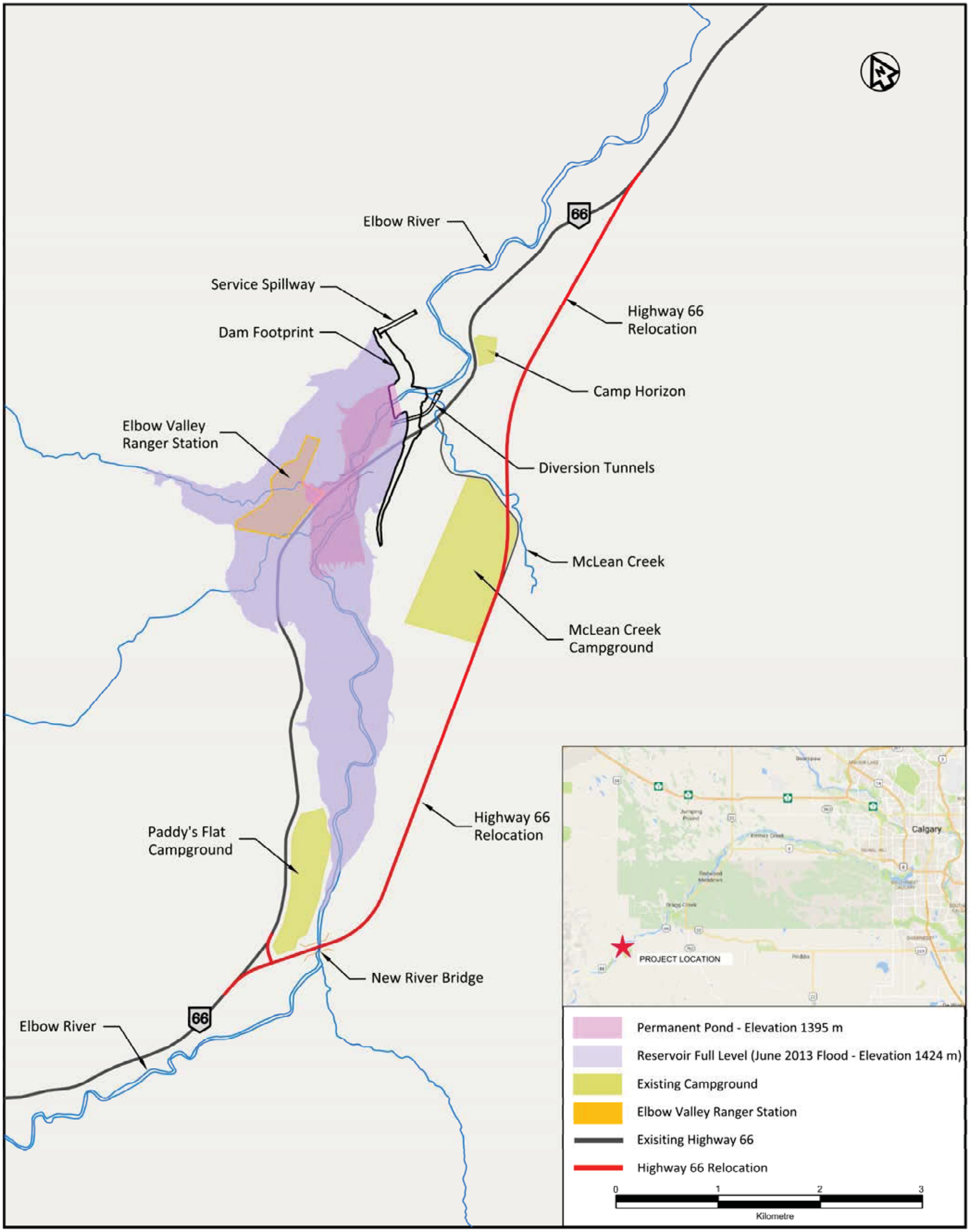
3.2.1.1 Main Dam

The purpose of the main dam is store water with diversion tunnel flow restricted to 220 m^3 for flood events up to the June 2013 event and this would protect the downstream environment from an event like the 2013 flood event. The main dam is an earth embankment with a clay core. The height of the main dam is approximately 50 m with 3:1 slopes. The main river dam width is approximately 200 m wide with the entire length of the dam and abutments being approximately 2400 m.

3.2.1.2 Diversion Tunnels

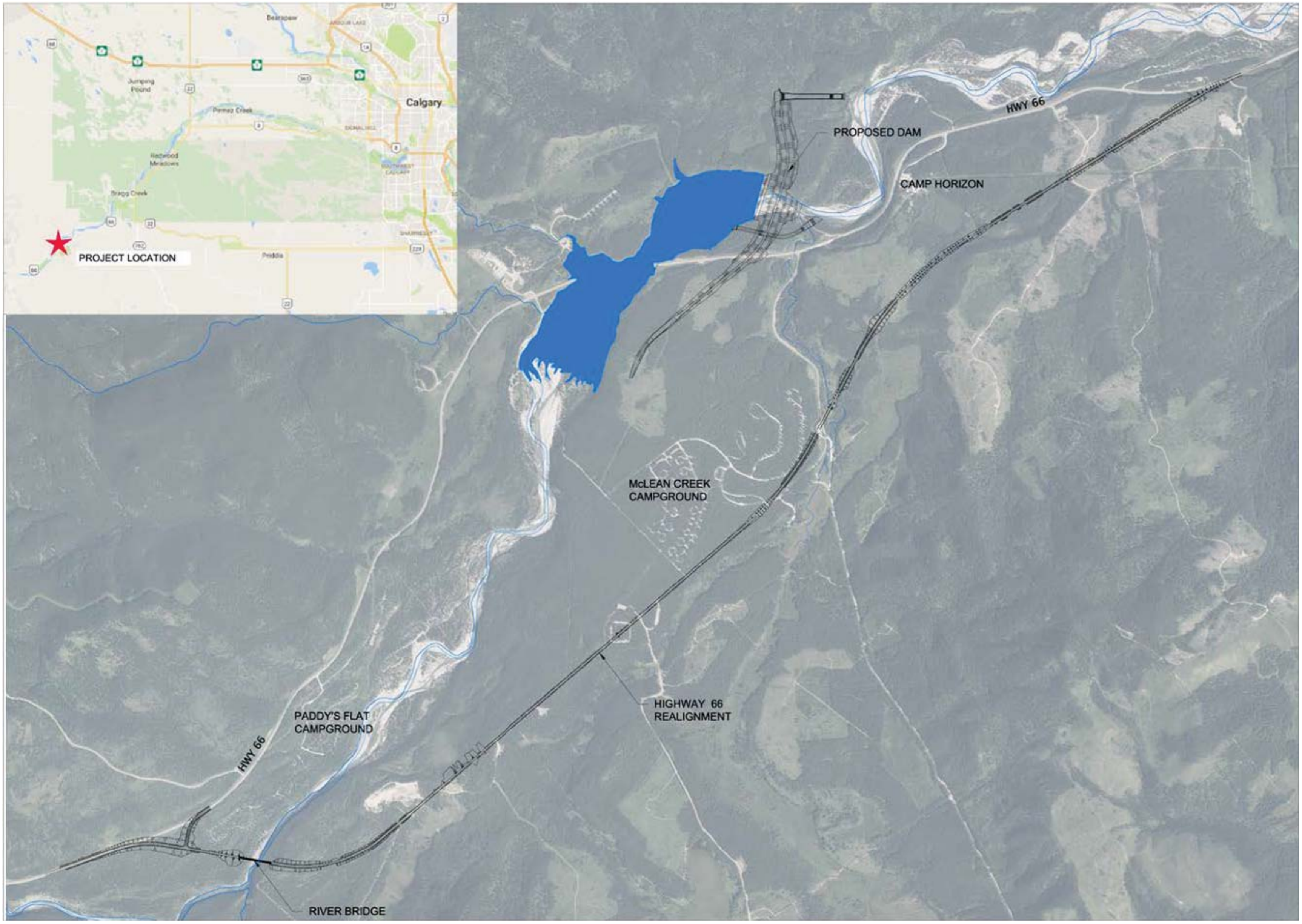
The diversion tunnels are two, 6 m tunnels which are approximately 450 m long. Each of the tunnels will have a gate which will be operated to maintain the permanent pond, ideal river flow downstream, and protection during flood events. The tunnels would be constructed first to provide the diversion and flow for the normal river flow during the dam construction. Post-construction, the purpose of the diversion tunnels is to pass normal river flows, up to 220 m^3 for flood events up to the June 2013 event, and great flows during more extreme flood events.

Overview Plan - MC1



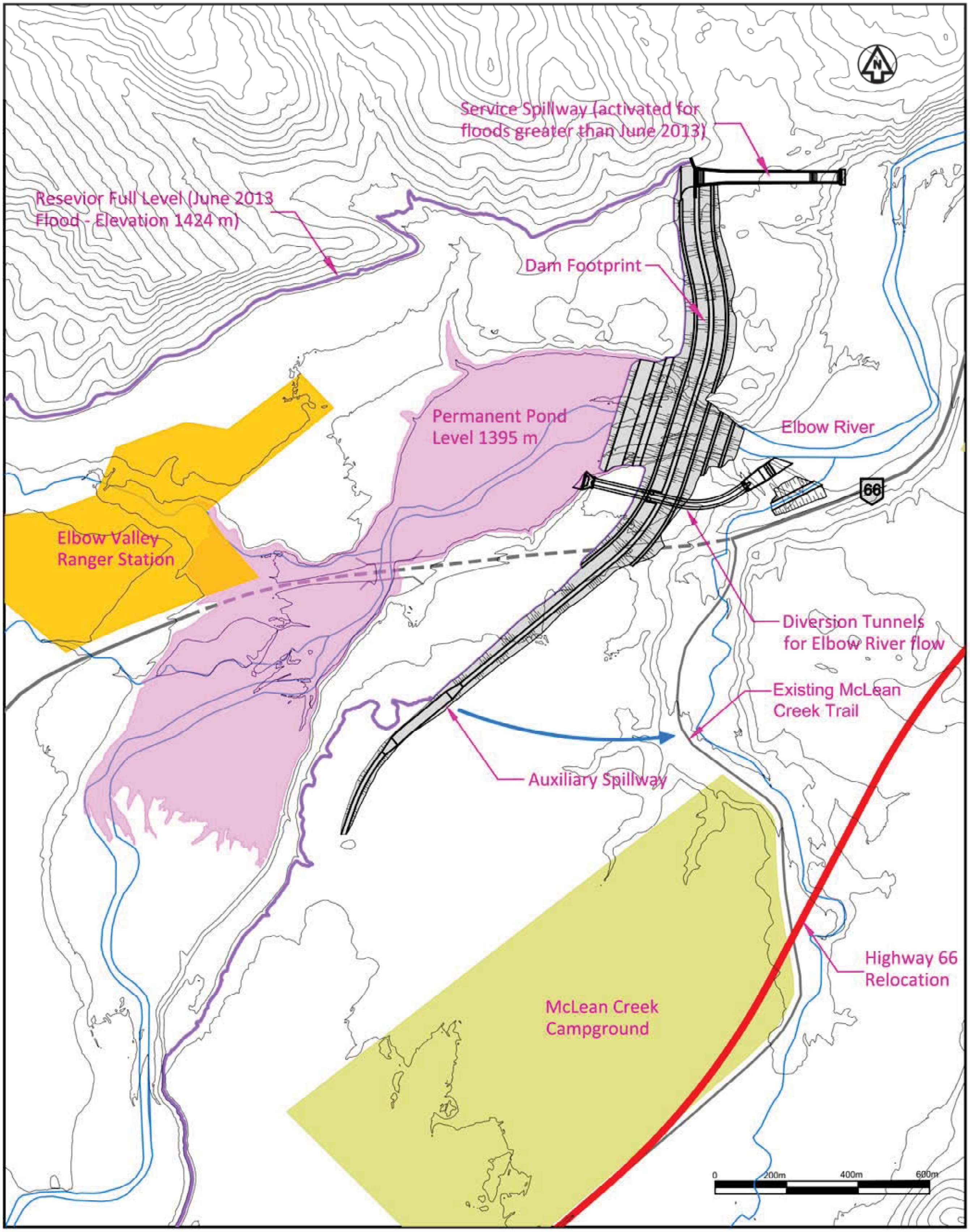
Source: OPUS

Overview Plan with Aerial Photograph - MC1



Source: OPUS

Dam Arrangement - MC1



Source: OPUS

Dam Layout - MC1

Source: OPUS

3.2.1.3 Dam Construction Rock Groin (in River)

After the tunnels are constructed, the existing and additional rock will be orientated to form “rock groins” to channelize the river flow into the tunnel in order to construct and protect the main upstream cofferdam. The inlets of the diversion tunnels are 4 m above existing stream bed. Thus, water must pool more than 4 m before the tunnels will become activated. During construction, the tunnels will be fully opened during construction to allow for water to freely pass through them.

The initial purpose of the main upstream portion of the dam is to act as a cofferdam to divert water into the tunnels to allow for construction of the main dam. The cofferdam, with diversion tunnels fully open, will provide protection from a 1:50-year flood event. The cofferdam is an earth embankment with a clay core, the height of the cofferdam is approximately 15 m with 3:1 slopes.

3.2.1.4 Permanent Pond

The purpose of the permanent pond is to manage bedload by providing still water upstream of the dam. The permanent pond will have an elevation of 1395 m, with a surface area of less than 1 km^2.

3.2.1.5 Highway 66 and Facility Relocations

The construction of MC1 option would require approximately 10 km of Highway 66 be relocated, including a new bridge crossing of the Elbow River and new crossing of McLean Creek. With a MC1 dam in operation, other facilities in the area would be impacted during a similar June 2013 event, and therefore the following additional facilities relocations would be needed:

- Elbow Valley Ranger Station and its water/wastewater treatment facilities.
- McLean Creek Campground: Lots 1-70, the store and its lift station.
- Wastewater force main which connects dump sites and the McClean Creek Campground to the existing EVRS treatment facility.
- Various power and communication lines.

3.3 Other Mitigation Options Considered

Since the 2013 flood, the City of Calgary (The City) and the Government of Alberta (The Province) have been evaluating and reviewing several flood mitigation options. The City has been implementing flood mitigation measures and evaluating potential flood mitigation options within the city limits, including the following:

1. Bank stabilization and erosion protection works at various locations throughout the city;
2. The Glenmore Reservoir diversion tunnel;
3. The identification and design of additional permanent flood barriers throughout the city;
4. Replacing gates on at the Glenmore Dam to increase its storage capacity;
5. Evaluating how changes in land use policy could limit the damage during a flood event; and
6. Updating the flood emergency response plan including design of temporary barriers.

The Glenmore diversion tunnel was analyzed in considerable detail; however, is no longer under consideration given more economically-efficient alternatives with less uncertainties. Several new barriers have been designed and constructed within the City limits in addition to the installation of outfall gates on the Bow and Elbow Rivers to prevent backup into communities. In a number of areas, river channel constrictions (debris and select gravel bars) have been removed and improvements to storm and sanitary lift stations implemented.

In light of the changing dynamics of the floodplain and The City's desire to better understand flood risks, as well as costs and benefits of a range of structural and non-structural flood mitigation options, IBI Group and Golder Associates were retained by The City in July of 2015 to undertake the Flood Mitigation Options Assessment Study.

The main objectives of the study were to:

1. Develop and apply a reliable, transparent and repeatable calculation process to understand and quantify flood risks across Calgary including aspects related to public safety, community planning and function, damage to buildings and infrastructure, service disruption, direct and indirect economic impacts, and the environment.
2. Provide guidance on what levels of protection are appropriate (i.e., what return period to protect to) for various flood affected communities in consideration of the costs and benefits of various flood mitigation options.
3. Analyze and compare which individual or combined flood mitigation options (i.e., flood mitigation scenarios) are the most cost beneficial at specified levels of service (e.g., 1:50, 1:100, 1:200 or 1:350-year flood protection level).
4. Provide a Triple Bottom Line evaluation of the various flood mitigation scenarios to support prioritization of key structural and non-structural investments and actions to increase flood resiliency.
5. Provide guidance in prioritizing structural and non-structural flood mitigation measures.

3.3.1 Modelling and Evaluation of Flood Mitigation Scenarios

Thirteen flood mitigation scenarios were developed and evaluated, each with multiple individual components, some common to several. A summary of each scenario is included in **Appendix A**. Measures included:

- new flood storage facilities along with updated operating rules to the existing hydro facilities and reservoirs in the Bow River Basin;
- permanent barriers along the Bow River;
- permanent barriers along the Elbow River;
- stormwater and drainage improvements;
- groundwater flood control measures at select locations;
- temporary flood barriers at various locations as part of the Emergency Response Plan;
- selective buy-out of flood affected houses;
- flood insurance; and
- a variety of contingency measures along with modifications to the floodplain regulations and grant programs related to the installation of sump pumps and backflow preventers.

3.3.1.1 Evaluation and Rating of Scenarios Employing Triple Bottom Line Criteria

Traditional economic analyses of flood mitigation alternatives have generally assumed a straightforward objective of maximizing the net benefits (total benefits minus total costs) that accrue to a project. Society however, has other goals besides economic efficiency. These goals or objectives are the results of outcomes that society desires and have more recently been described as Triple Bottom Line objectives which include considerations of economic, environmental and social impacts. The purpose of Triple Bottom Line evaluation is to account for these various goals in the evaluation process.

Past precedents were examined with respect to flood mitigation evaluation criteria along with evaluation procedures.

For the purposes of this study, the criteria, objectives and weightings were selected by assessing priorities identified by community engagement, Community Advisory Group, City subject matter expertise, the IBI Group draft evaluation criteria and the City's sustainability appraisal tool.

Criteria were subdivided into four basic categories:

1. Social Criteria: Community Well-Being
2. Environmental Criteria
3. Scenario Implementation
4. Economic Criteria

Each category was assigned an equal weighting of 12 points and then each individual criteria was scored from -6 to +6, depending upon its achievement of the stated Triple Bottom Line objective. Scores were tallied for each scenario under each category rendering a total score and then a rank with respect to the other scenarios. Scoring was carried out by the entire project team, representing a variety of departments and expertise. The scoring was undertaken collectively in two separate sessions with discussion as to how each of the scenarios responded to the criteria by category. Essentially, this process resulted in a consensus score following the round table discussion.

Exhibit 3.5 details the criteria and objectives of the Triple Bottom Line analysis, and **Exhibits 3.6** and **3.7**, the results of the scoring. Scenario 7, which included flood storage reservoirs along the Bow and Elbow Rivers, was the highest ranked scenario and spawned a number of hybrid scenarios aimed at enhancing the flood damage reduction attributes. These are currently being considered for implementation by the City of Calgary.

Flood Mitigation Evaluation Criteria

Goal	Criteria	To what extent does the scenario help achive the following objectives, **compared to the baseline existing condition?** (refer to **Exhibit 3.10**)
Social	Complete communities	**Maintains community fabric** *Preserves existing communities, homes and heritage. Maintains opportunities for revitalisation/densification (eg. East Village). Amenities and transportation choices are not negatively impacted.*
	Equitable protection	**Provides equitable protection from flooding** *across communities, the city and does not negatively impact upstream or downstream*
	Vulnerable populations	**Protects vulnerable populations** *Risk-sensitive development, protection of Calgarians who because of age, disability or other circumstances are at greater risk.*
	River aesthetics	**Maintains community and river aesthetics** *River views from private and public property, natural-looking river*
	Recreation access	**Maintains or enhances accessibility and recreation opportunities** *Protects/provides access to the river, riparian areas, natural areas, and parks.*
	Emergency access	**Protects connectivity and ease of access and departure during flooding or other emergencies/disasters** *Does not negatively impact emergency response, reduces residential and non-residential loss of life*
	Risk transparency	**Increased transparency/visibility of risk** *For property owners/prospective buyers regarding flooding risk*
Environmental	Water security	**Protects/provides water supply security** *Promotes efficient, sustainable water management so that the region's water supply meets the current and future needs of a growing city and region of users (municipalities and irrigation districts).*
	Riparian health and ecosystem functions	**Protects riparian health and species habitat and allows natural ecosystem functions** *Protects/enhances riparian areas and health of aquatic and terrestrial species. Lets the floodplan flood, provides room for the river, allows the river to flood*
	Water quality and contamination prevention	**Protects river water quality and prevents contamination of air, land, and water** *Does not have a short or long term detrimental impact on water quality and prevents contamination from spills, stormwater and groundwater flooding, transportation of goods, construction of scenario.*
Implementation	Timeliness of Implementation	**Contributes to orderly implementation of investments.** - *Timeliness and ease of implementation. How quickly can it be implemented and does it complement future measures?*
	Adaptability/Flexibility	**Contributes to flexibility of implementation.** How ***adaptable*** *the solution is - ease of future adaptability and flexibility (can it be raised/improved, can it address climate change issues?)*
	Jurisdictional control	***How easy it is for the City to implement.*** *Jurisdictional ability of The City to implement; financial ability for The City to implement; dependent on other jurisdictions to commit to/implement/fund.*
	Regulatory complexity	**Complexity of regulating land use and development with respect to different structural mitigation measures.** *(City: bylaws; At the Provincial and Federal levels: environmental and land/building regulations, mapping, funding, disaster relief programs)*
Economic	Economic Environment	**Indirect Protection of Calgary's economic engine** *Protects the downtown and business continuity. Protects critical infrastructure and essential services, transportation corridors.*
	Economic Efficiency	*Benefit/Cost Ratio*
	Damages Averted	*Total Benefits*
	Total Cost	*Present Value of deveopment and operating costs*

TBL Scenario Scoring

Goal	Criteria	Objective To what extent does the scenario help achive the following objectives, **compared to the baseline existing condition?**	Scenario Rating (-6 to +6)												Weight (1-6)	Highest Ranked Scenario by Criteria
			0a Non-structural	**1** SR1	**1a** SR1 + DT barrier	**2** SR1 + Bow Res	**3** Bow Res + Elbow barriers	**3a** 3 w/ GW	**4** SR1 + Bow barriers	**4a** 4 w/ GW	**5** Barriers on Bow+ Elbow	**5a** 5 w/ GW	**6** Flood-way buyouts	**7** SR1, Bow Res, Select barriers		
Social	Complete communities	**Maintains community fabric** *Preserves existing communities, homes and heritage. Maintains opportunities for revitalisation/densification (eg. East Village). Amenities and transportation choices are not negatively impacted.*	-1	3	4	6	-4	-4	-5	-5	-6	-6	-5	5	2	2
	Equitable protection	**Provides equitable protection from flooding** *across communities, the city and does not negatively impact upstream or downstream*	1	-4	-5	3	-2	-2	2	2	5	5	-3	4	3	5
	Vulnerable populations	**Protects vulnerable populations** *Risk-sensitive development, protection of Calgarians who because of age, disability or other circumstances are at greater risk.*	0	3	4	5	2	2	2	2	1	1	-1	5	1	2
	River aesthetics	**Maintains community and river aesthetics** *River views from private and public property, natural-looking river*	-1	5	1	5	-5	-5	-4	-4	-6	-6	6	4	2	6
	Recreation access	**Maintains or enhances accessibility and recreation opportunities** *Protects/provides access to the river, riparian areas, natural areas, and parks.*	1	5	-1	5	-4	-4	-5	-5	-6	-6	3	4	2	1
	Emergency access	**Protects connectivity and ease of access and departure during flooding or other emergencies/disasters** *Does not negatively impact emergency response, reduces residential and non-residential loss of life*	2	3	2	3	-1	-1	-1	-1	-2	-2	-2	3	1	1
	Risk transparency	**Increased transparency/visibility of risk** *For property owners/prospective buyers regarding flooding risk*	2	1	2	1	3	3	3	3	4	4	1	3	1	5
		TOTAL Community Well-Being score	**5**	**21**	**1**	**50**	**-28**	**-28**	**-18**	**-18**	**-18**	**-18**	**-3**	**49**	12	2
Environmental	Water security	**Protects/provides water supply security** *Promotes efficient, sustainable water management so that the region's water supply meets the current and future needs of a growing city and region of users (municipalities and irrigation districts).*	0	1	1	6	6	6	1	1	0	0	0	6	6	2
	Riparian health and ecosystem functions	**Protects riparian health and species habitat and allows natural ecosystem functions** *Protects/enhances riparian areas and health of aquatic and terrestrial species. Lets the floodplan flood, provides room for the river, allows the river to flood*	1	-1	-1	-1	-4	-4	-4	-4	-6	-6	1	-2	4	0a
	Water quality and contamination prevention	**Protects river water quality and prevents contamination of air, land, and water** *Does not have a short or long term detrimental impact on water quality and prevents contamination from spills, stormwater and groundwater flooding, transportation of goods, construction of scenario.*	-1	-2	-2	0	2	2	-2	-2	0	0	0	0	2	3
		TOTAL Environmental score	**2**	**-2**	**-2**	**32**	**24**	**24**	**-14**	**-14**	**-24**	**-24**	**4**	**28**	12	2
Implementation	Timeliness of Implementation	**Contributes to orderly implementation of investments.** - *Timeliness and ease of implementation. How quickly can it be implemented and does it complement future measures?*	-2	5	4	-3	-5	-5	1	1	-4	-4	-1	-2	4	1
	Adaptability/Flexibility	**Contributes to flexibility of implementation.** *How **adaptable** the solution is - ease of future adaptability and flexibility (can it be raised/improved, can it address climate change issues?)*	1	2	2	4	3	3	2	2	-1	-1	3	5	3	7
	Jurisdictional control	***How easy it is for the City to implement.*** *Jurisdictional ability of The City to implement; financial ability for The City to implement; dependent on other jurisdictions to commit to/implement/fund.*	4	0	1	-3	-2	-2	1	1	3	3	2	-2	3	0a
	Regulatory complexity	**Complexity of regulating land use and development with respect to different structural mitigation measures.** *(City: bylaws; At the Provincial and Federal levels: environmental and land/building regulations, mapping, funding, disaster relief programs)*	-3	-2	-2	3	-3	-3	-3	-3	2	2	-1	4	2	7
		TOTAL Implementation score	**1**	**22**	**21**	**-3**	**-23**	**-23**	**7**	**7**	**-6**	**-6**	**9**	**9**	12	1
Economic	Economic Environment	**Indirect Protection of Calgary's economic engine (attracts businesses, business continuity)** *Protects the downtown and business continuity. Protects critical infrastructure and essential services, transportation corridors.*	-1	3	5	5	2	2	2	2	2	2	-1	5	3	1a
	Economic Efficiency	*Benefit/Cost Ratio*	6	5	0	-2	-4	-4	2	0	-1	-2	-6	-3	3	0a
	Damages Averted	*Total Benefits*	-6	3	4	6	3	5	5	7	3	6	-5	6	3	4a
	Total Cost	*Present Value of deveopment and operating costs*	6	5	2	-4	-5	-6	2	1	1	-2	-3	-4	3	0a
		TOTAL Economin score	**15**	**49.19**	**33.4**	**13.73**	**-9.231**	**-8.53**	**35.9**	**29.13**	**14.69**	**12.42**	**-44.1**	**12.94**	12	1
		Total Score	**23**	**90.2**	**53.4**	**92.7**	**-36.2**	**-35.5**	**10.9**	**4.13**	**-33.3**	**-35.6**	**-34.1**	**98.94**		**7**
		Rank	5	3	4	2	12	10	6	7	8	11	9	1		

TBL Scenario Ranking

Scenario		0a	1	1a	2	3	3a	4	4a	5	5a	6	7
Goal	Criteria	Non-structural	SR1	SR1 + DT barrier	SR1 + Bow Res	Bow Res + Elbow barriers	3 w/ GW	SR1 + Bow barriers	4 w/ GW	Barriers on Bow+ Elbow	5 w/ GW	Flood-way buyouts	SR1, Bow Res, Select barriers
Social	Complete communities Equitable protection Vulnerable populations River aesthetics Recreation access Emergency access Risk transparency	4	3	5	1	11	11	7	7	7	7	6	2
Environmental	Water security Riparian health and ecosystem functions Water quality and contamination prevention	6	7	7	1	3	3	9	9	11	11	5	2
Implementation	Timeliness of Implementation Adaptability/Flexibility Jurisdictional control Regulatory complexity	7	1	2	8	11	11	5	5	9	9	3	3
Economic	Economic Environment Economic Efficiency Damages Averted Total Cost	5	1	3	7	11	10	2	4	6	9	12	8
	Overall Rank	**5**	**3**	**4**	**2**	**12**	**10**	**6**	**7**	**8**	**11**	**9**	**1**

4 Cost Estimate

4.1 SR1

4.1.1 Introduction

Stantec has prepared a Draft Construction Cost Opinion for the Preliminary Design of the SR1 project. A summary is provided in **Exhibit 4.1**. This Cost Opinion is still in progress and is currently undergoing a third-party review. A revision to the Cost Opinion will be submitted with the Preliminary Design Report.

Exhibit 4.1: SR1 Cost Summary

Component	Cost
General*	$38,486,000
Diversion Structure	$51,147,000
Diversion Channel	$78,686,000
Off-stream Storage Dam	$38,643,000
Contingencies	$31,045,000
Utility Relocation	$15,705,000
Engineering, Permitting, Admin	$38,000,000
Project Total	**$291,712,000**

*includes mobilization, care of water, utility and road work, etc.

This Cost Opinion is consistent with the requirements of a Type B Estimate as defined in the Alberta Transportation (AT) Engineering Consultant Guidelines for Highway, Bridge and Water Projects. Unit prices were developed utilizing published AT cumulative unit price averages from the three lowest bidders on recent tenders, weighted by bid quantity. Fiscal year 2016 (August 1, 2015 to July 31, 2016) and 2017 (August 1, 2016 to February 1, 2017) average tenders were evaluated to establish pricing for most items. Estimated prices for items unavailable in the recent tenders were developed based on local construction industry experience, and engineering judgement.

The pay item structure is broken into major project components to delineate and define items associated with each feature. Pay item units are consistent with AT Civil Master Works Specifications, AT Standard Specifications for Highway Construction, and generally accepted industry standard methods of measurement.

4.1.2 Land Acquisition

4.1.2.1 Introduction

The land acquisition costs form an integral part of the project's overall cost estimate and economic viability. While voluntary negotiations are typically the preferred means in which to acquire lands for public works, the larger the project, the less possibility there is to realize a voluntary level of efficiency. In cases involving fragmented ownership which needs to be consolidated in order to accommodate a major work, an initial portion of the lands may be acquired from voluntary vendors, but eventually, a threshold will be met where the proponent of the works will be required to enter into expropriation proceedings. Moreover, it is imperative that the proponent is diligent in their initial acquisitions, as purchases at the upper end or above current market values can (and will) be used against the expropriating authority as valuation evidence.

The process adopted for the valuation of the lands required for the works was predominately a Direct Sales Comparison methodology, where recent sales of similar lands are analyzed in an effort to value the various components of the property required for the works. The term "similar lands" in this case refers to many characteristics of a land parcel, the main ones which include location, size, soil quality and suitability for agriculture, access, serviceability of rural requirements such as power, view potential from the homesite as well as the "First Parcel Out" for a second residence and other intrinsic characteristics.

The human behaviour of Sales Comparison takes place in many everyday forms such as buying an automobile or purchasing a home. It can be utilized by sellers in the same way it can be used by buyers or appraisers. Adjustments are made for perceived differences in desirability based of both facts and subjective judgement. Superior characteristics of comparables when compared to the subject require negative adjustments, whereas inferior aspects require positive adjustments to arrive at a value for the subject. This process was followed to the extent possible in arriving at a value estimate for the various subject properties comprising the works.

One of the most beneficial aspects of the valuation process was the similarity in use potential for the majority of the properties required for the works. Oftentimes, it is a difference of opinion in use potential which leads to the high variance in value estimates between buyers and sellers – especially in the case of expropriation. As the bulk of the properties in the project area had agricultural use potential, it was most meaningful to utilize agriculturally classified land parcels for comparison purposes. Selected parcels along the Elbow River also had recreational use potential. These parcels were valued using somewhat different comparables, or adjusted more aggressively due to their physical characteristics, which made them potentially more suitable for large, residential estates.

Finally, the value of the improvements on the various holdings was based on a review of the assessed values as provided by Rocky View County, which was further correlated to sales involving improved properties. The correlation between the values realized in the open market and the assessed values for improved properties was very strong, with an average difference of some three percent.

The detailed valuation approach utilizing the methodology outlined in the Introduction follows.

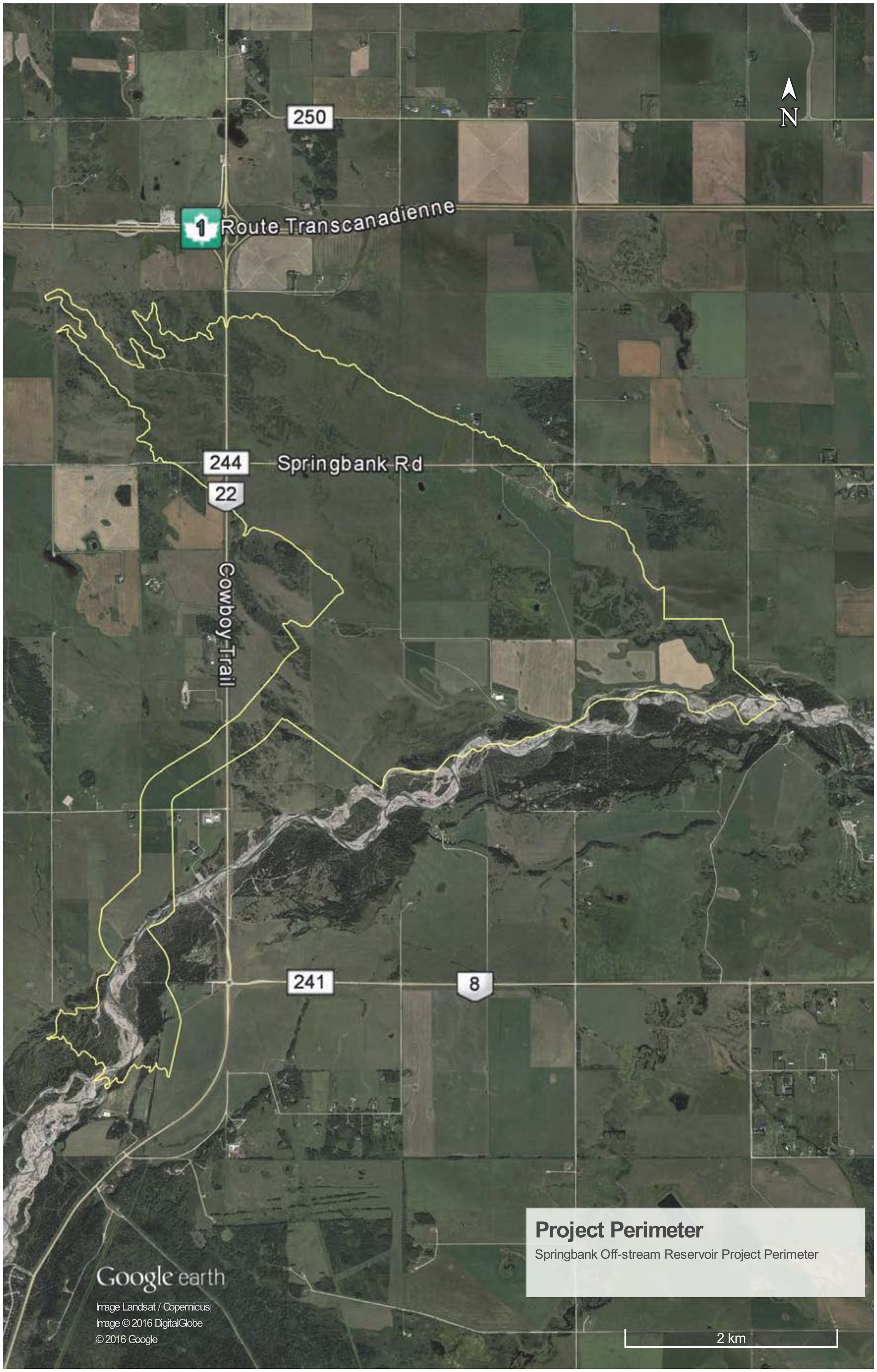
4.1.2.2 Total Land Requirement

The current Project Perimeter outlined by Stantec was defined based around the combined components of the Project Footprint. These components include:

- An In-stream Diversion Structure Area, taking up approximately 93 ha (230 ac) of land at the southern-most point of the project area;
- A Diversion Channel Area, 136 ha (336 ac) including the current footprint of the channel as well as a buffer on either side to accommodate any possible changes in channel width and alignment;
- The Dam and Outlets Area, 348 ha (860 ac) of land allowing for drainage, a discharge route, and an emergency spillway; and
- The Reservoir Area, the largest and northernmost portion, consisting of 884 ha (2,185 ac) of land, 789 ha (1,950 ac) of which will be flooded when SR1 is in operation.

The total area within the Project Perimeter is 1461 ha (3,610 ac) and is outlined in **Exhibit 4.2**.

Springbank Dam Project Perimeter



In addition to the Project Perimeter, a total area of impacted parcels has also been considered in order to minimize damages for injurious affection[1], and other potential heads of compensation, as set out in the Expropriation Act of Alberta (Province of Alberta, 2014). The impacted parcels include all full quarter sections and subdivided parcels that are touched by the Project Perimeter. The total area of impacted parcels outside of the Project Perimeter is approximately 1537 ha (3,799 ac), as illustrated in **Exhibit 4.3**. The total area of impacted parcels, excluding those already owned by the Province of Alberta is approximately 2638 ha (6,518 ac).

For the purpose of the benefit/cost analysis, it is assumed that the land (residual) and improvements acquired outside the Project Perimeter would be re-sold at comparable values (acquisition prices).

4.1.2.3 Current Land Use

The impacted area within Rocky View County is located at the foothills of the Rocky Mountains, and consists mainly of prairie rangeland, with little vegetation. The majority of the land is used for cattle grazing with limited crop production. Structures include farmsteads and outbuildings relevant to the agricultural activities carried out on the land. Rocky View's Ranch and Farm (RF) land use designation applies to the majority of land in the Project Perimeter, a designation designed to accommodate agricultural activities as the primary land use on unsubdivided quarter sections of land. The municipality of Rocky View does, however, recognize emerging trends in agriculture, which allow for intensification of agricultural practices and the accommodation of smaller scale agricultural activities on parcels of land smaller than one quarter section.

Much of the land in the surrounding area is held in quarter section parcels or larger, plus four small Country-Residential subdivisions and two recreational facilities directly adjacent to the Project Perimeter: Kamp Kiwanis and Camp Gardner, which operate seasonal summer camps. The clusters of fragmented Country-Residential lots surrounding the project area are not included in any approved or future Area Structure Plans or Area Redevelopment Plans. These Country Residential lots have been assessed under the County Plan and are unlikely to be encouraged for further growth because they divide viable agricultural land and are fiscally inefficient in terms of their impact on the County. The County Plan provides policies for these areas (Rocky View County, 2013, pp. 46-51) which enables them to gradually transition to be part of a more productive and efficient rural community.

4.1.2.4 Municipal Development Plan and Growth Strategy

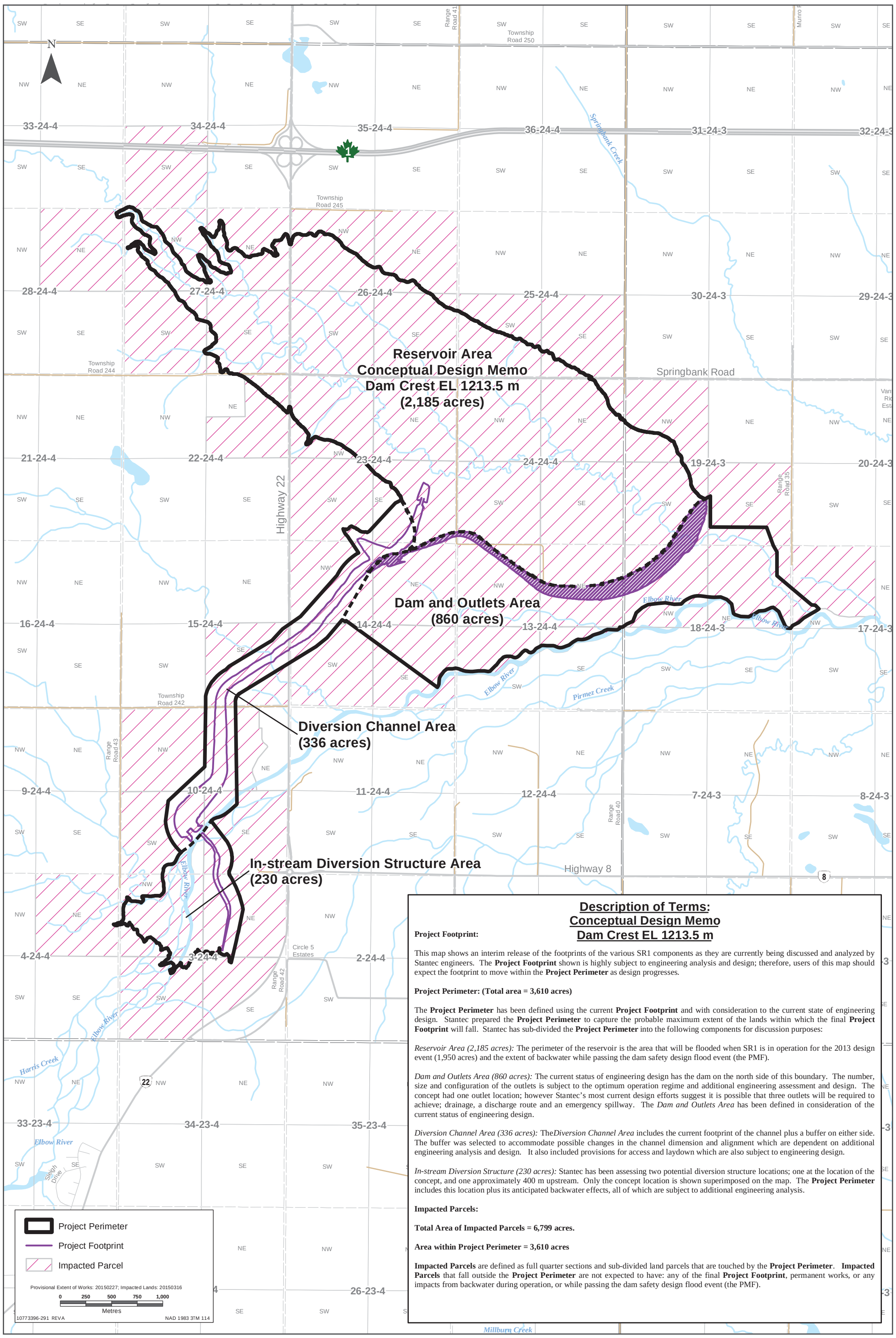
The current Rocky View Municipal Development Plan includes the following goals:

- The accommodation of growth and change in the Municipality in accordance with sound land use planning.
- The preservation of the agricultural land base of the Municipality.
- The facilitation and enhancement of agriculture and related industries.
- The facilitation of growth and development of residential areas and hamlets where appropriate.

According to the Municipal Development Plan (Department of Planning and Development & Building Services, 1998), the project area does not lie within any approved or suggested Area Structure Plans (ASPs) and Area Redevelopment Plans (ARPs), and is not in an area under development pressure, as seen in **Exhibit 4.4**.

[1] Damages for injurious affection relate to those damages that arise when the expropriating authority only requires a portion of someone's property, and it ends up being worth less as a result. In certain circumstances the purchasing authority can be required to purchase the whole parcel, or the land may be deeply discounted.

SR1 Springbank Off-Stream Reservoir Project Area Breakdown at 1213.5 m



Description of Terms:
Conceptual Design Memo
Dam Crest EL 1213.5 m

Project Footprint:

This map shows an interim release of the footprints of the various SR1 components as they are currently being discussed and analyzed by Stantec engineers. The **Project Footprint** shown is highly subject to engineering analysis and design; therefore, users of this map should expect the footprint to move within the **Project Perimeter** as design progresses.

Project Perimeter: (Total area = 3,610 acres)

The **Project Perimeter** has been defined using the current **Project Footprint** and with consideration to the current state of engineering design. Stantec prepared the **Project Perimeter** to capture the probable maximum extent of the lands within which the final **Project Footprint** will fall. Stantec has sub-divided the **Project Perimeter** into the following components for discussion purposes:

Reservoir Area (2,185 acres): The perimeter of the reservoir is the area that will be flooded when SR1 is in operation for the 2013 design event (1,950 acres) and the extent of backwater while passing the dam safety design flood event (the PMF).

Dam and Outlets Area (860 acres): The current status of engineering design has the dam on the north side of this boundary. The number, size and configuration of the outlets is subject to the optimum operation regime and additional engineering assessment and design. The concept had one outlet location; however Stantec's most current design efforts suggest it is possible that three outlets will be required to achieve; drainage, a discharge route and an emergency spillway. The *Dam and Outlets Area* has been defined in consideration of the current status of engineering design.

Diversion Channel Area (336 acres): The*Diversion Channel Area* includes the current footprint of the channel plus a buffer on either side. The buffer was selected to accommodate possible changes in the channel dimension and alignment which are dependent on additional engineering analysis and design. It also included provisions for access and laydown which are also subject to engineering design.

In-stream Diversion Structure (230 acres): Stantec has been assessing two potential diversion structure locations; one at the location of the concept, and one approximately 400 m upstream. Only the concept location is shown superimposed on the map. The **Project Perimeter** includes this location plus its anticipated backwater effects, all of which are subject to additional engineering analysis.

Impacted Parcels:

Total Area of Impacted Parcels = 6,799 acres.

Area within Project Perimeter = 3,610 acres

Impacted Parcels are defined as full quarter sections and sub-divided land parcels that are touched by the **Project Perimeter**. **Impacted Parcels** that fall outside the **Project Perimeter** are not expected to have: any of the final **Project Footprint**, permanent works, or any impacts from backwater during operation, or while passing the dam safety design flood event (the PMF).

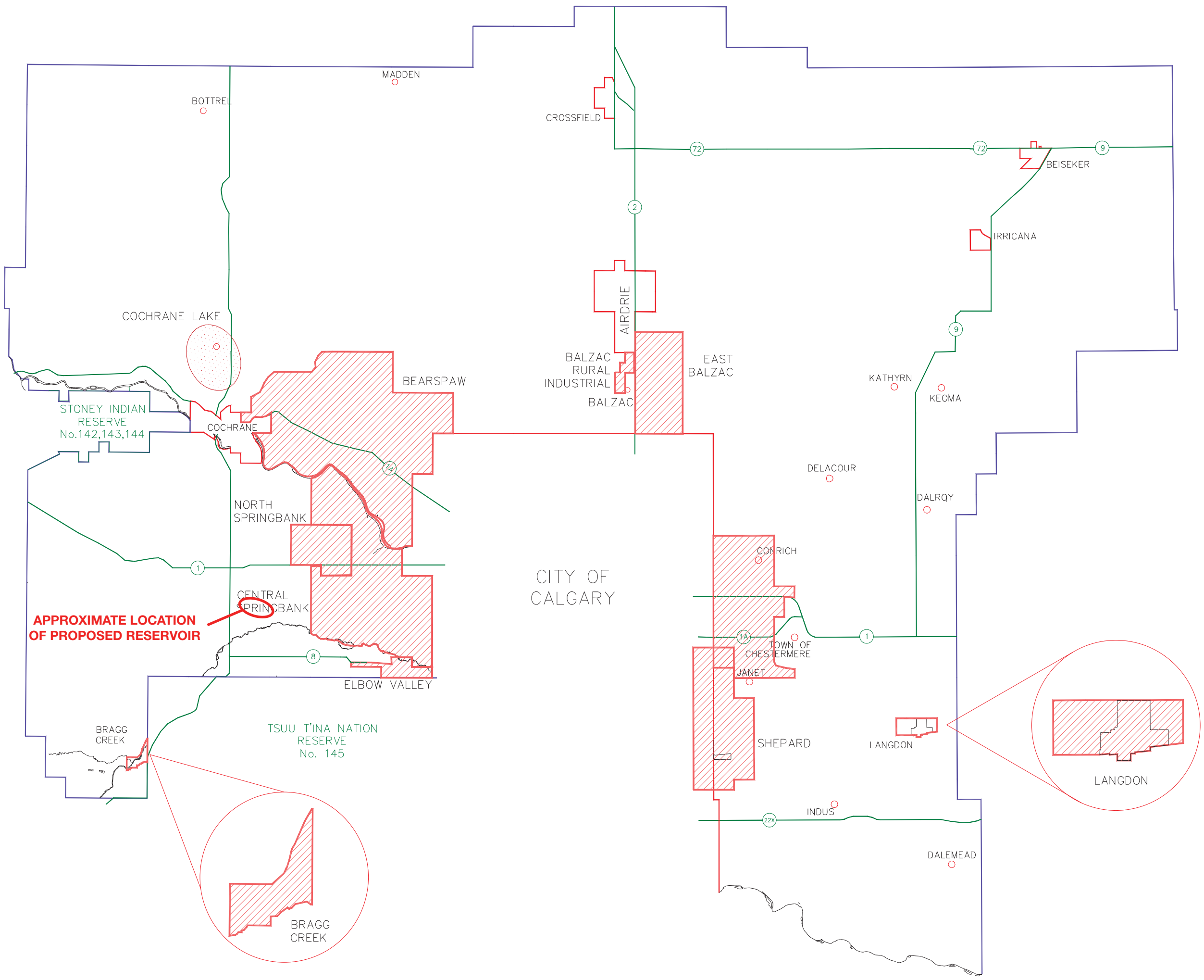
Sources: Base Data - Natural Earth, Government of Canada, Department of Natural Resources. Thematic Data - Alberta Transportation; GeoBase; GeoLogic
Land ownership based on titles received from Land Titles on March 10, 2015

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Stantec

(For Information Purposes Only)

Rocky View Area Structure Plans (adapted from Rocky View Municipal Development Plan, 2010)



MUNICIPAL DISTRICT OF ROCKY VIEW No.44

SUGGESTED AND APPROVED AREA STRUCTURE PLANS

N

AREA STRUCTURE PLANS
(EXISTING OR BEING PREPARED)

AREAS UNDER DEVELOPMENT PRESSURE

4.1.2.5 Highest and Best Use

A report prepared in 2015 by Brown and Associates Planning Group (see **Appendix B**) evaluated the highest and best use for land surrounding the proposed Springbank Reservoir. The report first sought to identify the critical factors in determining the highest and best use, which can be summarized as follows:

- The land use must be legal and comply with land-use classification, zoning, and building regulations.
- The land use must not only be possible, but also probable, within a reasonable amount of time.
- The evaluated use must be in demand, and economic conditions must make it probably that use of that land will take place.
- The land use must be profitable and provide the highest net return to the land owner.

The study also took into account the goals and growth strategy of Rocky View County, which did not identify any areas of residential or business development in the reservoir project area.

Based on current and potential land uses in the project area, the majority of which is presently designated Ranch and Farm district, most of the land in the project area is considered to be best used for agricultural purposes, including consideration for agricultural innovation and diversification on smaller parcels.

Brown and Associates (2015) also considered recreational land use as a possible appropriate use for some land in the project area, due to the presence of the Elbow River and other natural features. In evaluating the project land, most recreational land was found to lie directly adjacent to the Elbow River, and was given a higher corresponding base value land assessment.

Based on available data, the report concluded that the highest and best land use for the majority of the parcels in the study area is for continued agricultural development. To undertake a suitable cost assessment, IBI Group subdivided the agricultural parcels down further into three agricultural categories, described in more detail in Section 4.1.2.8.4.

4.1.2.6 Municipal Assessment Data

The Province of Alberta has created provincial guidelines that must be adhered to in the preparation of a property assessment.

Assessors submit the information they gather on behalf of the municipality by April 1st of every year. The municipality maintains a record of all the information that it is required to report according to Alberta Municipal Affairs. The information that must be recorded by the assessor includes:

- Property characteristics and condition attributes
- Legal description and use information
- Assessment related information
- Market value variables and parameters
- Information related to indicators of value

This information is compiled and the assessed land value for various parcels is available through the Rocky View County website. The most basic land value is based solely on the 2017 assessment values for the impacted parcels in the project area. If parcels inside the project area were connected to parcels outside the impacted area, those outside the impacted area were also included to maintain the connectivity and integrity of the land.

Farm properties containing a residence are assessed at market value, and include an assessment for the first 1.2 ha (3.00 ac) of land at market value, as if it were a 1.2 ha (3 ac) subdivided parcel. They are classified as residential on the assessment notice. Farmland is assessed based on regulated agricultural values, with farm buildings being exempt from assessment and taxation, as long as they are used for farming purposes.

Rocky View County has publicly available assessment roll data, searchable by multiple criteria, including LINC number,[2] Legal Parcel Description, or address, among others. Depending on the land use designation, non-government owned parcels will have an assessed value for at least one of the following: residence or farm residence; farmland (AUV)[3] or vacant farmland; non-residential (industrial or commercial); and exemptions.

For the purposes of calculating a total land assessment, parcels were separated into three categories:

1. Those that had only a residential and farm residence assessment, due to the similarity in assessed value with market sale price (see Section 4.1.2.8.1).
2. Those that had farmland (AUV) or vacant farmland, in addition to residential or non-residential improvements.
3. Those parcels with only an assessed land value.

This division helped to compare the assessed impacted parcels to the comparable MLS sales, and gain a more accurate value for bare land in the impacted area and Project Perimeter.

4.1.2.7 Subdivision of Parcels

A ‘First Parcel Out’ or ‘Farmstead’ can be subdivided out of a quarter section that has not previously been subdivided. The subdivision is one parcel, and is restricted to between 1.6 ha (3.95 acre) and 20.23 ha (50.00 acre), depending on the type of land use of the desired subdivision. If the owner wishes to subdivide into more parcels, rezoning is required. Rezoning to Country Residential One (CR-1) would allow for a maximum of four lots per quarter section, and Country Residential Two (CR-2) would allow for a maximum of 26 lots per quarter section. Commercial and industrial uses would be dealt with on an individual basis.

Because the highest and best land use has been determined to be Agricultural, the assumption is that the owner would choose to keep their land as agricultural land, or retain as large a portion as agricultural land as possible, thus subdividing out the smallest allowable portion.

Furthermore, based on a combination of the findings contained in the Brown and Associates Planning Group report and the Rocky View County Planning Documentation, as well as the requirements set out in the Highest and Best Use analysis (Section 4.1.2.5) as it pertains to legality of a proposed use, there is a very low likelihood that the appropriate redesignation of any of the subject properties could be obtained in order to value them as anything other than agricultural or recreational lands as they currently exist.

4.1.2.7.1 First Parcel Out

A ‘First Parcel Out’ may occur once on a quarter section that has not previously been subdivided, allowing owners to subdivide out a single parcel as either a farmstead, an agricultural parcel, or a residential parcel.

[2] A LINC (Land Identification Numeric Code) number is a unique ten-digit number assigned to all land parcels in Alberta.
[3] AUV denotes the Agricultural Use Value of the land. On property assessments, the AUV is often appraised according to its current agricultural use and not according to its actual market value, which is often significantly higher, in order to give the landowner a property tax benefit.

Farmsteads

For farmsteads, redesignation and subdivision requires subdivision of a minimum parcel of 1.6 ha (3.95 acre) and a maximum of 7.99 ha (19.7 acre), with the remainder of the land being retained as agricultural. Additionally, there must be no physical constraints to the subdivision, and there must be suitable access to the newly subdivided farmstead.

Agricultural

Where an agricultural first parcel out subdivision is desired, a minimum of 20.23 ha (50.00 acre) of land must be designated for agricultural use and the land must have appropriate access.

If the agricultural first parcel out is isolated, the parcel must be greater than or equal to 8.10 ha (20.01 acre), have access provided to the site, and leave at least 0.8 ha (2 acre) of developable land. These size restrictions are generally placed on agricultural subdivisions to maintain plot sizes that will continue to be agriculturally productive.

Residential

A residential first parcel out redesignation is also an option, and should be between 1.60 ha (3.95 acre) and 2.50 ha (6.18 acre). Other criteria for residential first parcel out redesignation include:

- The redesignated minimum parcel size will allow only one lot to be created when subdivided.
- The new parcel must be located at least 300 meters from a highway right-of-way.
- There must be direct access from the new parcel to a developed public roadway.
- The new subdivision must minimize the need for new public infrastructure and minimizes impacts on agricultural operations.
- The remaining unsubdivided land is retained as agricultural.

Additional costs associated with subdividing a first parcel out are included in **Exhibit 4.5**.

4.1.2.8 Comparable Sales

An extensive search of property sales and listings primarily involving full quarter section transactions and offerings was conducted. The primary emphasis was placed on agriculturally designated properties, though land sales located slightly closer to Calgary that had subdivision potential as a result of being included in some form of longer term planning documentation, were also reviewed.

Sales involving parcels smaller than full quarter sections were also considered, although it must be recognized that once a property falls below 40 ha (100 acre), the realizable price per acre begins to increase rather dramatically. This is due primarily to affordability, and for those properties that are within a reasonable commuting distance from Calgary, they become viable alternatives to living in the City. Agricultural use ceases to become the primary objective for these properties, and they can become hobby farms or simply rural estates. Therefore, sales of under 40 ha (100 acre) were given less emphasis than those which were clearly used for agricultural operations.

Apart from recent purchases by Alberta Transportation for the works, there was limited recent sales activity west of the developed portions of Springbank between Highway 1 and Highway 8. The sales which did take place had smaller acreage subdivision potential, as indicated in the Rocky View Municipal Development Plan (1998). These transactions had values above pure agricultural lands, and could be misleading if utilized for valuing the subject holdings. It is difficult to make an adjustment for development potential when the existing Planning Documentation is clear that the balance of the lands to the west of existing Springbank development will be used agriculturally for the foreseeable future.

Description of work	Unit	Quantity	Unit Price	Total Costs
Standard Country Residential Road - Rockyview County 7.0m road in 20m R/W Assume 400 meters				
Strip and Grade R/W	m^3	2500	$10.00	**$25,000.00**
Subgrade Preparation	m^2	3600	$5.00	**$18,000.00**
250mm Granular Sub-base Course	m^2	3600	$15.00	**$54,000.00**
100mm Granular Base Course	m^2	2800	$7.50	**$21,000.00**
Ditch Grading and Landscaping	m^2	4400	$5.00	**$22,000.00**
Total Road Construction				**$140,000.00**
Shallow Utility Servicing				
Power	lm	400	$190.00	**$76,000.00**
Gas	lm	400	$175.00	**$70,000.00**
Total Shallow Utility Servicing				**$146,000.00**
Onsite Services - Water and Sanitary				
Water Well	each	1	$20,000.00	**$20,000.00**
Septic Field	each	1	$20,000.00	**$20,000.00**
Onsite Services				**$40,000.00**
Professional Fees - Engineering, Geotechnical and Administration				
Total Cost of Work				
Engineering Fees- Add 15%				
Professional Fees Total				**$0.00**
Grand Total				**$326,000.00**

Accordingly, other agricultural pockets in close proximity to Calgary, such as those in the vicinity of Cochrane and Cochrane Lakes, were also considered. Land even further afield, in Water Valley and nearing Bottrel, were also considered, but these were used primarily to establish the lower end of the subject's value range, with aggressive adjustments for location.

The data was narrowed down to approximately 10 sales including the three purchases by Alberta Transportation. The location of these sales in comparison to the Project Perimeter is illustrated in **Exhibit 4.6**. It should be noted that overall, many more transactions were reviewed in establishing a generalized value range for the various categories of property contained within the subject works area.

4.1.2.8.1 Residential Price Adjustment Factor

When examining comparable properties with only a residential assessment value[4] it was found that they consistently sold for close to the assessed value, on average selling for 2.9504% higher than the assessed value of the property. As such, a value of 1.029504 was used to adjust the 2017 residential assessment values to 2017 market values. Parcels with assessed land or commercial improvements required further adjustments.

4.1.2.8.2 Date of Sale Adjustments

Agricultural properties do not experience the same price sensitivity to the passage of time as urban properties. Their pricing structure has much longer and gradual fluctuations than the more reactive residential or commercial property market found in an urban environment. As some of the comparable sales took place in 2017, with others dating back to 2015, it was not considered necessary to make any meaningful adjustments for time in this instance.

4.1.2.8.3 Location Adjustments

The locational adjustments can be broken into two categories for this assignment – those being a macro adjustment for overall location based on proximity to the City of Calgary, and a micro locational adjustment based on factors such as road access, highway exposure and proximity to desirable features such as the Elbow River. Properties with a unique positioning relative to view potential, such as the high laying portions of the Jones parcel acquired by Alberta Transportation, are examples where there needs to be some negative adjustment to recognize these special features.

There must be an ongoing focus on the fact that these are predominately Agricultural Lands. Therefore, the micro-locational aspects have less of an impact on the value of Agricultural Lands than they would on Development Lands. There is certainly a linear trend of falling values per acre as one progresses away from the City of Calgary, but these are in relatively small increments for pure agricultural properties.

4.1.2.8.4 Land Classification

In addition to the higher value range Recreational Land, found adjacent to the Elbow River, IBI Group divided the study area into three basic agricultural categories under which to assess the land: A, B, and C, in order of decreasing base value.

- Agricultural-A: high-value, productive land that is also in a good location. Some parcels may already be productive or have river access.
- Agricultural-B: this land has agricultural potential, but currently lacks development, access, or some other desirable feature, or may be low-lying. Alternatively, this land is more suitable for grazing as opposed to being arable land.

[4] On their property assessment, properties may also have an assessed land value, commercial value, and/or tax exemption.

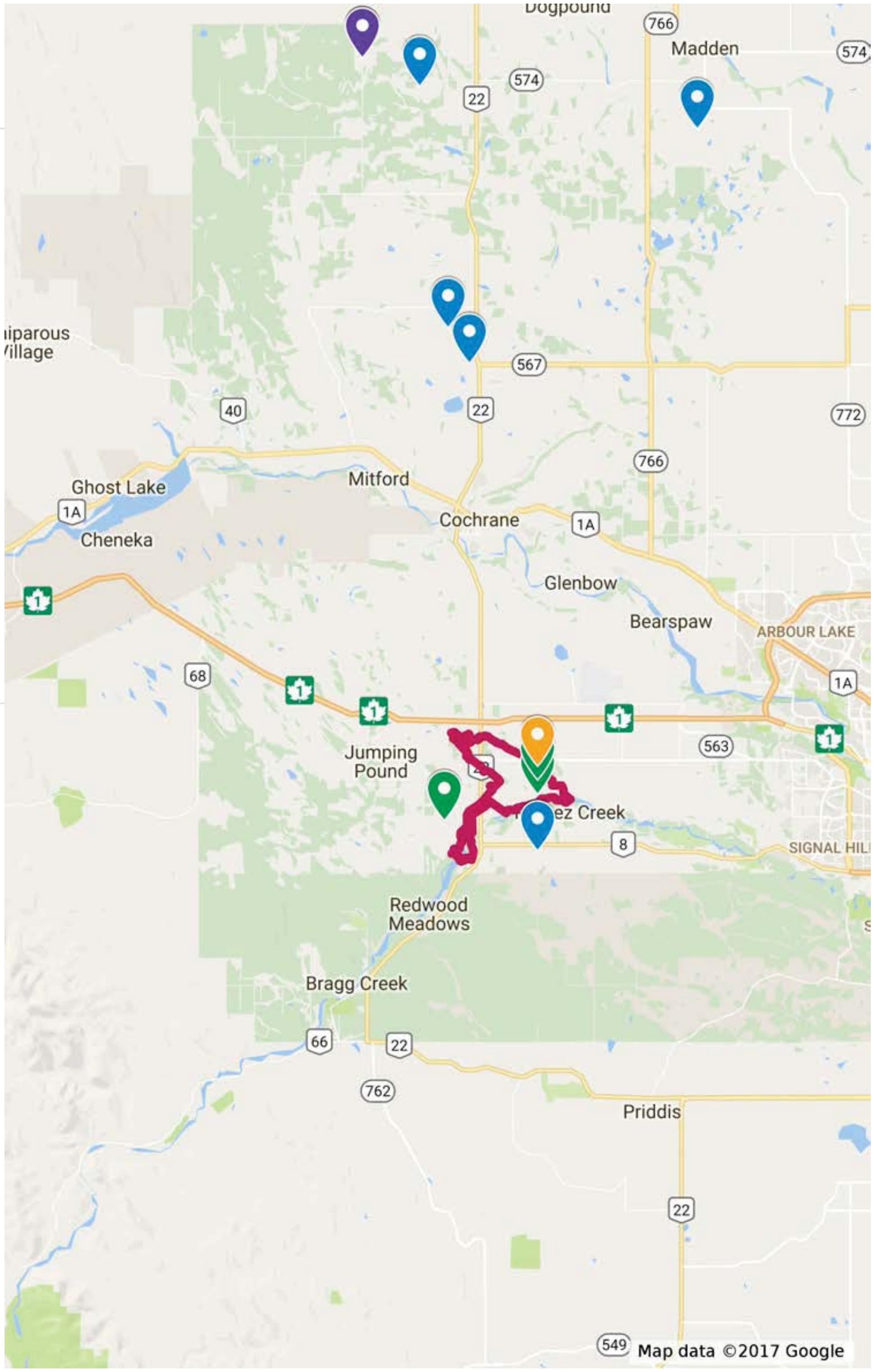
Springbank Dam Comparable Sales

Project perimeter

- Project Perimeter

Land Sales Greater than 100 Acres

- Paired Sale
- Paired Sale
- No. S13
- No. S23
- No. S36
- No. S55
- No. S72
- Provincial Land Transfer
- Provincial Land Transfer
- Provincial Land Transfer
- Inside Project Perimeter



- Agricultural-C: this land was valued as the least productive, and was given the lowest base value. It would require substantial input to yield significant agricultural output, or the output crop is of lower value. Grazing value is minimized due to scrub overgrowth, and year round bog conditions such as those found near the centre of the proposed reservoir area.

Base prices per acre for each land type can be found in **Exhibit 4.7**.[5]

Exhibit 4.7: Base Price per Acre for Land Classification Valuations

Land Classification	Base Price per Acre
Agricultural-A	$12,000
Agricultural-B	$8,000
Agricultural-C	$5,000
Recreational	$20,000

4.1.2.9 Other Adjustments

Beyond the base land classification, further adjustments were made to the base price per acre for each parcel to recognize the presence or absence of:

- Public road access
- Power to the parcel
- Views (mountain, river, or ravine)
- Agricultural fencing
- Exemptions included in the municipal assessment
- Residential and commercial improvements (not valued on a per-acre basis)

Pricing quantum for most enhancements was made by adjusting the price per acre from the amount representative to install the equivalent item on a quarter section of land.

After making the above adjustments to the base values, land values for the impacted area ranged from $6,625 to $51,375 per acre – the higher end of the range reflective of much smaller parcels than full quarter sections or even the 100 acre threshold utilized for detailed comparison of pure agricultural holdings. This range of values does not include residentially-zoned parcels because residential-only parcels were treated on a per-unit basis, not a per-acre basis. The rationale for this being that whether a residentially developed parcel is three acres, six acres or even nine acres in size, there is not a material difference in the land value. This is because the land value is derived primarily from the legal ability to build a house and outbuildings on the land, not the actual size of the land parcel.

4.1.2.9.1 Business Losses

Business losses were taken into account in the land valuation classification, with more productive land being valued more highly than less productive land, and the highest value being placed on recreational land. Base values per acre can be found in Exhibit 4.7.

Furthermore, only two commercial properties were located within the impacted area. These parcels were considered separately, and were given a base value per acre between the Agricultural-A and Recreational base values, in addition to their residential, commercial, and

5 Calculations were performed using acres as a base unit because it remains the standard unit of measurement for land parcels in Alberta.

land value assessments, any applicable exemptions, improvements, and other parcel adjustments.

Due to a lack of full access to parcels and information, IBI Group was unable to take into account potential losses in income from cell phone towers, oil and gas wells, or other parcel-specific sources of income.

4.1.2.9.2 Relocation Premiums

When considering costs for the Project Perimeter only, and not the total area of impacted parcels, the notion that certain parcels would have to be divided up was taken into consideration, and expropriation principals were utilized in calculating the associated land costs (see Section 4.1.2.10 below). All the parcels in the project area were examined to determine which parcels had improvements laying inside the Project Perimeter. These parcels had an additional 5% added to the value of their 2017 assessment to account for damages for relocation; the same 3% to account for fair market value; plus another 27% to account for home-for-a-home provisions.[6]

The collective land inside the Project Perimeter area was valued at 98% of the per-acre price of the total value of the impacted area after performing a weighted average calculation, and was then adjusted by 20% for damages similar to those that may be experienced in the expropriation process (such as damages for injurious affection).

4.1.2.10 Expropriation

In the event that no mutually agreeable land negotiation can be reached, the government has the ability to expropriate land for certain uses if it is in the public's best interest. The Expropriation Act of Alberta (2014) specifically defines how an expropriating authority, in this case the Province of Alberta, must compensate the landowner if their land is expropriated. The Province of Alberta must consider:

- The market value of the land
- Damages attributable to disturbance (if the owner is required to move), and compensation necessary to enable the owner to relocate the owner's residence in an equivalent or better accommodation[7]
- The value of any element of special economic advantage arising out of, or incidental to, the owner's occupation of the land
- Damages for injurious affection (in the event of a partial taking)

To make adjustments for injurious affection, IBI Group noted parcels within the Project Perimeter and impacted area that had adjoining properties with the same owner outside the project area. Such properties were given additional damages for injurious affection in the event that they be subdivided. A property ownership map is available from Rocky View County, a portion of which is shown in **Exhibit 4.8**.

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6 Home-for-a-home provisions are there to ensure that the family will be put back into a home similar to the one that they left. Given the scarcity of comparable residential properties in rural Alberta, this is likely to be a fairly difficult task, and as such, this number is relatively high. Recent expropriation cases have seen the reproduction cost new of the existing improvements utilized to quantify the home-for-a-home provision.

7 The owner means the registered owner, and does not include a tenant.

Ownership Map

Benefit/Cost Analysis of Flood Mitigation Projects for The City of Calgary and Environs on the Elbow River with Emphasis on MC1 and SR1
August 2017

Exhibit 4.8

When determining the value of the land for expropriation, the Province of Alberta is not required to take into account:

- Any anticipated future use of the land after the expropriation
- Any transactions or agreements involving the sale or lease of the land made after expropriation proceedings have commenced
- Any increase or decrease in land value resulting from development or anticipated development of expropriated land, change in land use bylaws, land use classification, or any other change resulting from the expropriation of the parcel of land or surrounding expropriated land

4.1.2.11 Total Costs

The total value of the impacted parcels, excluding the land already owned by Alberta Transportation, is estimated to be $108,780,000 ($16,689/acre). A summary of these costs by category can be found in **Exhibit 4.9,** while a breakdown with the cost for each parcel may be found in **Appendix C**. Including only the 3,610 acre inside the Project Perimeter, the total cost becomes $65,981,000 ($18,277/acre), as displayed in **Exhibit 4.10**.

Exhibit 4.10: Land and Improvement Costs, including Damages, for Project Perimeter Only

Project Perimeter (3,610 Acres)	Cost
Land Value[8] (@ 98% per-acre value)	$44,793,845
Improvements Inside Perimeter	$12,228,851
Damages (+20% on land portion)	$8,958,769
Total	**$65,981,465**
Price Per Acre	**$18,277**

Google Earth was used to determine the location of all of the improvements on each parcel of land, enabling IBI Group to separate those located within the Project Perimeter from those outside. Only those located within the Project Perimeter were included in the costs in Exhibit 4.10. The location of all of the improvements can be seen in **Exhibit 4.11**.

Despite buying up a smaller amount a land, the price estimate per acre for the Project Perimeter is 10% higher than the price paid per acre for all of the impacted parcels ($18,277 vs $16,689 per acre). This is due to all of the potential damages inherent in the cost of purchasing land in this manner, as well as the elevated price expectations of those who wish to negotiate an agreed-upon sale price, knowing beforehand that the buyer will otherwise experience the potential damages.

Notwithstanding the fact that significant adjustments have already been applied to the appraised market values, a further premium of 21% (±$14 million) was added to account for the anticipated contracted negotiating timeframe given the desired construction schedule. This results in a total land acquisition cost for the project perimeter (3,610 acre) of $80 million.

8 The land within the Project Perimeter was adjusted to 98% of the value of the bare land price for all of the impacted parcels by comparing the respective percentages and values of each land type in both areas. This was done to account for the unknown irregularly shaped areas in the Project Perimeter, as well as those that did not constitute a full parcel. This indicates that the total impacted area outside the Project Perimeter was, on average, of slightly higher value than the land inside the Project Perimeter.

Costs for Land and Improvements for All Impacted Parcels (6,518 Acres)

	All Impacted Parcels		Total	Price Per Acre	
Residentially Zoned	Land	Improvements		Total	Bare Land
Acres of Land			405.46		
Value	$1,724,210	$10,062,147	$11,786,357	$29,069	
Land with Improvements	Land	Improvements			
Acres of Land	2,173.44	48.00	2,221.44		
Value	$29,518,767	$20,204,376	$49,723,144	$22,383	$13,582
Vacant Land	Land	Improvements			
Acres of Land	3,891.31		3,891.31		
Value	$47,270,074		$47,270,074		$12,148
Total	Bare Land	Land with Improvements			
Acres of Land	6,064.75	2,626.90	6,518.21		
Value	$76,788,841	$30,266,524	$108,779,575	$16,689	$12,661

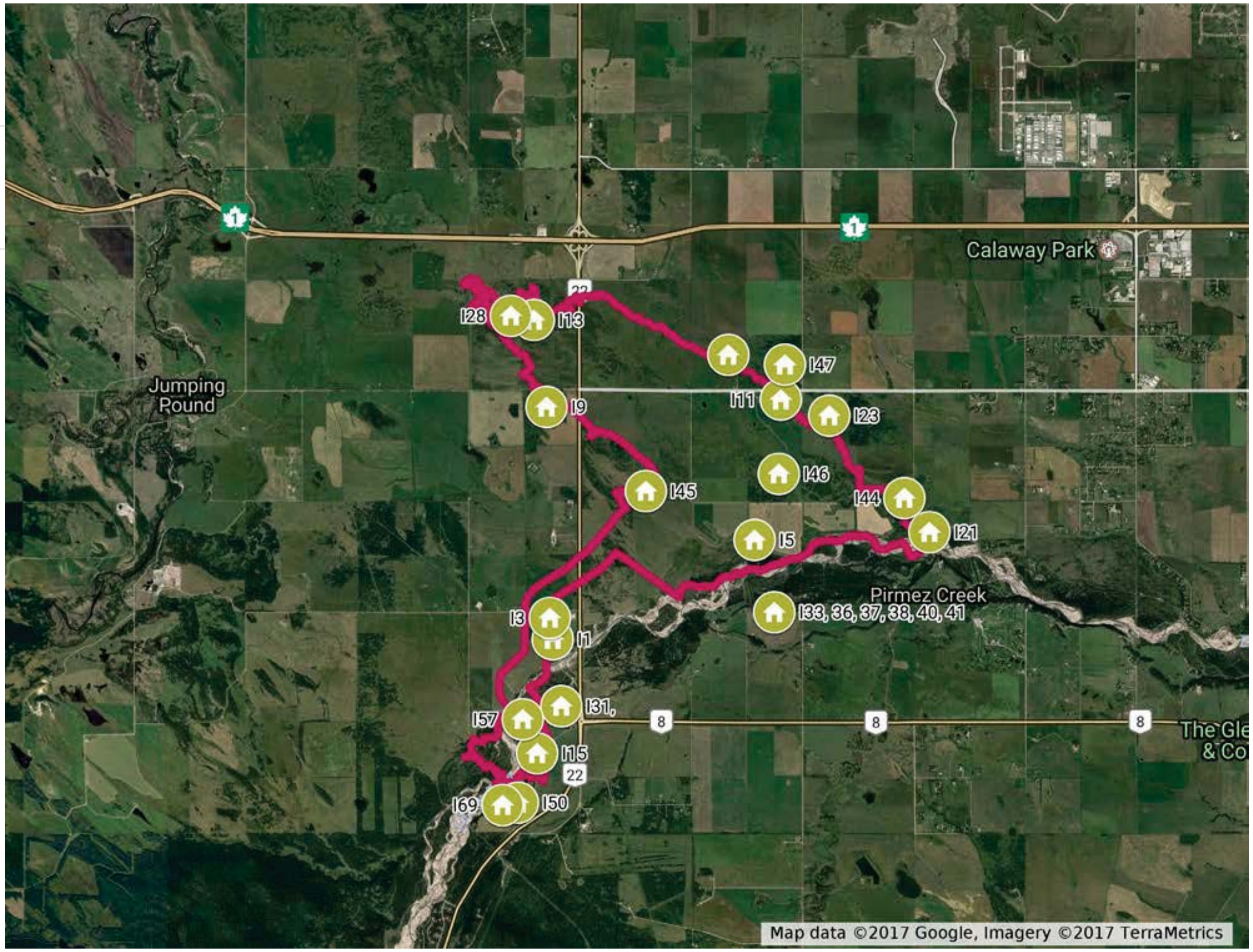
Improvements on Impacted Parcels in Relation to the Project Perimeter

Project Perimeter

Project Perimeter

Parcels with Improvements

All items



4.1.2.12 Agricultural Leaseback Potential

It is not untoward to suggest that a good portion of the lands acquired for the works, whether they were expropriated or voluntarily acquired, have the potential to be leased back to the original owners or other parties who wish to use them for agricultural or recreational pursuits. It is common to lease agricultural lands to unrelated third parties, but much more difficult to ascertain the actual terms of such leases, as they are not publicly documented, and many are quite dated and have not been brought to current economic levels. Therefore, it is necessary to project the potential lease rates for the lands in question.

Typically, there is a relationship between the value of land and the lease rate which can be derived from it. As there is no recapture requirement in a land lease, the yield rates or Capitalization Rates would tend to fall at the low end of the investment spectrum. The Capitalization Rate (Cap Rate) represents the annual return that a property or piece of land can expect to realize before mortgage payments and income taxes on the total investment in that land. In the case of the Government, there would likely be no corresponding debt related to the lands themselves, nor would there be any tax considerations. The base price per acre for each land valuation category can then be utilized with the appropriate yield rate to generate what would be viewed as a realistic lease rate for the various properties. It would be difficult to realize a return on the extra-ordinary costs associated with the acquisition of the lands through expropriation, leaving the base per acre values as a more reliable indicator of market lease rates.

When calculating the agricultural Cap Rate, a number of factors are commonly considered, including:

- The quality of the lessee
- The rent compared to market rates
- The term of the lease
- Any return on capital
- Any depreciation of capital
- The potential reversionary value of the land

Agricultural land investments generally see a lower than typical return on investment, or a Cap Rate, of 4%. However, there has been some divergence of agricultural lease rates from the market value of land in some locations. Land prices have risen faster than the income, and thus rents, that can be achieved on the land. A 4% Cap Rate yields rents that are much higher than has been reported in the region.

Ordinarily, if the land were unable to be leased back, this would be an indication that the land was overvalued in the initial purchasing process. However, there are several unknown and altered variables relating to the lease potential. Cash rent is paid only on cultivated acres, and is influenced by the return a lessee could achieve on the crops as well as the introduced uncertainty of flooding. For these reasons, a much more conservative agricultural Cap Rate of 1% has been applied.

This rate was applied to both the low- to medium-value agricultural land in the Reservoir Area, as well as the high-value agricultural land in the Dam and Outlet Area. Not all of the land in the Project Perimeter has been deemed useable land, and as such, IBI Group has excluded the Project Footprint and Elbow River from leaseback calculations. The Project Footprint excludes a total of approximately eight percent of the land in the Project Perimeter. Because the Cap Rate utilizes averages, and because all the land is currently occupied, the calculations assume that all of the remaining useable land has the potential to be leased out year-round, either back to its current owner, or to an equally interested party.

4.1.2.12.1 Recreational Leaseback Potential

Cap Rates for comparable recreational properties are more difficult to come by than residential or agricultural land, however, some regional information is available. Estimated returns on a typical campground range from nine to ten percent, primarily because of their low ongoing expenses (Western Investor, 2016). The more improvements there are on a property, the higher the Cap Rate needs to be, as there will be increased levels of depreciation which would otherwise eat into the overall yield. As land does not depreciate, yield rates on pure land, while lower, are not further diluted by depreciation.

A lower value has been chosen here because the parcels are located in a flood plain, prohibiting development in the area, and limiting options for the installation of more upscale recreational activities, such as pools and clubhouses (Western Investor, 2016). Furthermore, there are two existing campsites in the area, both of which have their improvements lying outside of the Project Perimeter. In order to run a campsite or recreational area, some development would have to be undertaken on the currently undeveloped land.

The Cap Rate is higher compared to that of the agricultural land due in part to a lack of competition in the area, as seen by a decrease in camping sites in Alberta and BC in recent years, as many sites have been sold and redeveloped into condo projects or apartment complexes. Additionally, there has been an increase in RV usage across Canada, indicating an increased demand for RV recreational camp sites.

As seen in **Exhibit 4.12**, the total potential leaseback income for the Project Perimeter is $1,392,000 per year.

Exhibit 4.12: Lease-back Income Potential Calculation

Project Perimeter Land Category Type	Base Price	Useable Acres in Project Perimeter	Overall Yield	Leaseback Income per Year
Reservoir (A-B and A-C)	$6,500	2,079.62	1%	$135,176
Dam and Outlet (A-A)	$12,000	754.62	1%	$90,555
In-stream and Diversion (REC)	$20,000	407.40	6%	$488,880
			Potential Income Per Year	**$714,610**

4.2 MC1

4.2.1 Design Considerations

The MC1 primary function was independently compared to SR1, and it was concluded that both are temporary storage facilities. Therefore, MC1 Dam should be designed as a 'Dry Dam' above elevation 1399.0 m.

Moreover, the June 2013 flood would be stored by the MC1 Dam with the assumption that some shore erosion is acceptable and maintenance by the GOA would be undertaken. The flood water would be drawn down in 7 days, which would mitigate the need for holding permanent water above elevation 1399.0 m

The design elements have been evaluated to provide reasonable and acceptable Dry Dam elements, as follows:

- Cut Off Wall - Left Abutment - has been reduced to 370 m in length and is envisioned to provide sufficient length to reduce the potential of hydraulic piping in the gravel zone of the till.

- Cut Off Wall - Right Abutment - has been reduced to 930 m in length for the same reasons noted above. Additional description and discussion will be presented in the final report.
- Rip Rap - has been removed from the Dam face above elevation 1399.0 m. Above this elevation, rip- rap bedding is being utilized to mitigate surficial erosions of the slope (i.e., erosion rills) from rain, snow, and waves due to wind.
- Tunnel Outlet Concrete Stilling Basin - through review of the borehole logs it is expected that bedrock will be encountered beyond the end of the tunnels and based on the core logs, the bedrock is sufficient to withstand the eroding forces of the water and a reinforced concrete still basin is therefore not required.
- Sheet Pile Wall for Service Spillway - reduced to just function as a foundation system of the head works of the spillway.
- Auxiliary Spillway - the hard surface treatment presented in the April 19, 2017 configuration was selected to mitigate potential erosion risk for the PMF (1:10,000 to 1:20,000 years) has been removed as current Dam design practice and the GOA are not providing provision for such.
- Materials and Unit Rates - specification adjustments and clarity have developed a more optimized use of the local pit run aggregate with less processing requirements, which reduce the unit costs.

4.2.2 Cost Estimate Opinion

Exhibit 4.13 displays a summary of the current MC1 Cost Estimate Opinion.

Exhibit 4.13: McLean Creek Option Cost Summary

Component	Cost
Mobilization	$12,000,000
Care of Water	$3,000,000
Dam Construction	$188,000,000
Highway 66 Relocation	$34,341,000
Facility Relocation	$22,853,000
Wetland Compensation	$708,000
Aquatic Habitat Management Plan	$10,000,000
Engineering/Environment/Engagement	$54,180,400
Contingencies	$81,270,600
Project Total	**$406,353,000**

Notes:

1. This Construction Estimate is based on the level of project information developed in the study.
2. Unit prices are based on calculated information, historic bid data, past project experience, and engineering judgement.
3. The summary information is rounded to nearest $1000s.

The above Cost Estimate Opinion, has been reviewed by a team of knowledgeable engineers. The following provides a summary of information and processes undertaken by the team to develop the cost estimate:

- The quantities have been calculated using Microstation, with the major earthworks quantities confirmed independently using Civil 3D.
- Unit Rates for Tunnel, Cut-Off wall, grouting, and all concrete as well as all soils (gravel and mineral) for the Dam have been determined through a bottom up approach similar to the process a contractor would develop a bid. Quotes for cement, concrete plants, equipment, and labour, from various suppliers and sub-contractors were utilized to develop these costs and rates.
- The unit rates for the Roadway and Bridge have been rationalized through existing Alberta Transportation information and construction experience.
- The cost of the Infrastructure relocation (including reclamation of the existing site) has been based on a combination of direct pricing for building relocation, utilizing engineered buildings for the new building, engineering knowledge, and experience.
- Information on contamination clean-up costs has been provided by Hemmera, and is included under the Infrastructure relocation.

4.2.3 Land Value

The MC1 in-stream project would be located on public land. Therefore, no formal purchase of lands would occur. However, the land is very valuable to Albertans and in limited supply. Therefore, the value of replacement land should be considered even if it is not a cost included in the benefit/cost analysis.

The McLean Creek Public Land Use Zone under consideration for MC1 is located on the eastern edge of Kananaskis Country. Kananaskis Country is a vast, 4200 km^2 swath of land primarily located in Alberta’s Eastern Slopes foothills and mountains, extending to include a small amount of parkland near the City of Calgary. The region contains a wide variety of vegetation, wildlife, geology, and scenery. This, combined with its proximity to Calgary and easy access make it the most heavily used recreation area in the province (Alberta Tourism, Parks and Recreation, 2012). Alberta Environment and Parks manages this land and is currently leading the restoration and reconstruction of a number of priority backcountry trails in this area that were impacted by the 2013 Southern Alberta Floods.

As part of their mandate, the Kananaskis Country Provincial Recreational Area (PRA) provides a wide range of safe and enjoyable outdoor public recreation use to Albertans, Canadians, and international users alike, while aiming to limit the impacts of that use on natural and cultural features (Alberta Tourism, Parks and Recreation, 2012). The development of recreational facilities in the park was governed by policy developed in the late 1970s and has evolved ever since, incorporating government decisions, parks legislation, and public input.

Past surveys and statistics have found that the most popular activities within the park include camping, picnicking, trail recreation, and fishing. Approximately 80 percent of total park use is day use, and 20 percent is overnight camping (Alberta Tourism, Parks and Recreation, 2012). Of the recreational campgrounds in Kananaskis Country, McLean Creek Campground is the only one that accepts reservations, and provides electrical hookups and showers. It is also the largest of the campgrounds, offering 170 sites, and is the only area to allow off-highway vehicles.

Recreation areas such as Kananaskis Country are generally used because they are better able to accommodate a higher level of use and development, and are therefore typically considered to be less ecologically sensitive. Nevertheless, appropriate measures need to be in place to prevent degradation of natural land and water systems while still promoting healthy living.

The MC1 flood storage reservoir will remove some 935 ha (2,310 acres) of land from the existing recreational land base of the park, 1 km^2 (247 acres) associated with the permanent pond and an additional 835 ha (2,063 acres) associated with the dam structure and footprint of the design flood storage area (June 2013 flood). This land is essentially sterilized for the purposes of recreation, particularly in terms of trails, washrooms, picnic areas and any other fixed facilities. In order to maintain the original recreational land base, additional land outside the park boundary will need to be acquired.

The land proposed for the use of the MC1 flood storage reservoir will be removing specialized recreational land enjoyed by a high number of users. McLean Creek in particular is accessible via paved road and is close to both Calgary and smaller municipalities such as Bragg Creek and High River. It is one of the few areas in the Province of Alberta that allows off-highway vehicles, and the only campground in Kananaskis Country that takes reservations, provides electrical hookups, and has showers. Furthermore, the land itself is adjacent to the Elbow River, providing unparalleled recreational opportunities, and finding equivalent land elsewhere would be a difficult task.

4.2.4 MC1 Land Costs

A search was performed to find transactions for land-only sales in the Bragg Creek area in order to discover comparable land sales that could be used to calculate compensation for the potential loss of recreational land arising from the construction of the McLean Creek Dam (MC1). Seven suitable transactions were found going back three years, listed in **Exhibit 4.14**. The location of the transactions in relation to MC1 can be found in **Exhibit 4.15**. Much like the in the case of the Springbank Dam, many more land sales were inspected, but were deemed unsuitable for comparison based on their land type, location, or other characteristics.

Only one transaction found in the proximity was a full quarter section (160 acre), while the majority of the transactions were acreages or smaller residential properties. It should be noted that while the 2017 residential assessment for sale No. 7 is quite high, the sale occurred in 2014, before the second residence was completed. As such, the transaction in 2014 can be compared more closely to bare land sales containing a cabin or house.

The three Country Residential (CRES) properties included in this list tend to artificially increase the value of the land per acre, primarily because of their small size, and also because of their zoning and potential for development. If these three parcels are removed, the median sale price becomes $25,060/acre, which is more indicative of the size of parcels that would need to be purchased, and also the nature of the required land without improvements.

Assuming an average sale price of $61,925/ha ($25,060/acre) acquisition of replacement land will cost **$57,750,000**.

If one were to consider the total land area impacted, including land required for the relocation of Highway 66, the land replacement value would increase to $**88.6 million**.

For the purposes of the benefit/cost analysis in this report, no public land replacement costs have been included.

Comparable Transactions for Recreational Land in Bragg Creek Area

									2017 Assessment Values			
ID No.	LINC	Size of Parcel (acres)	List Price	Sale Price	Sale Price per Acre	Sale Date	Land Use	Total AG Living Space (m^2)	Residence	Farmland (AUV)	Total Assessment	Comments
1	0026993759	16.34	$799,000	$700,000	$42,840	10/27/2014	CRES	-	$605,900		$605,900	Outside flood zone, one block from school, trees, open meadow, small cabin on property, natural gas and telephone service, no water.
2	0034366773	24.04	$799,000	$710,000	$29,534	11/13/2014	R-3	-	nd	nd	$0	Backs onto lake and municipal reserve, mixed forest, has drilled water well, electricity, plus other utilities at property line.
3	0031051824	99.58	$2,250,000	$2,050,000	$20,586	07/13/2015	RF	-		$7,520	$7,520	Rolling hills, treed lot, 1,200 meters of river frontage on the Little Elbow River to the north and Elbow River to the south.
4	0033727694	4.00	$275,000	$250,000	$62,500	08/07/2015	CRES	-	nd	nd	$0	Year-round lake access, walking paths, cross-fenced, flat site.
5	0032370934	14.51	$575,000	$525,000	$36,182	03/30/2016	R-3	-	$569,500		$569,500	Drilled water well, woodlands, rolling meadows, river frontage on Bragg Creek, fenced, small cabin on property.
6	0032423873	4.18	$298,000	$288,500	$69,019	07/01/2016	CRES	-	nd	nd	$0	442 ft of river frontage, across from municipal reserve, drilled water well, flat lot, mostly treed, with space to build residence.
7	0021401534	160	$1,900,000	$1,750,000	$10,938	05/13/2014	RF	182.80	$3,169,900		$3,169,900	2 Residences: Log bungalow that has walkout suite in basement; second residence is three storey mansion with swimming pool, elevator, and indoor/outdoor fireplaces.
	Median	**16.34**	**$799,000**	**$700,000**	**$36,182**							
	Mean	**46.09**	**$985,143**	**$896,214**	**$38,800**							

MC1 MLS Comparable Sale Locations

MLS Land Sales

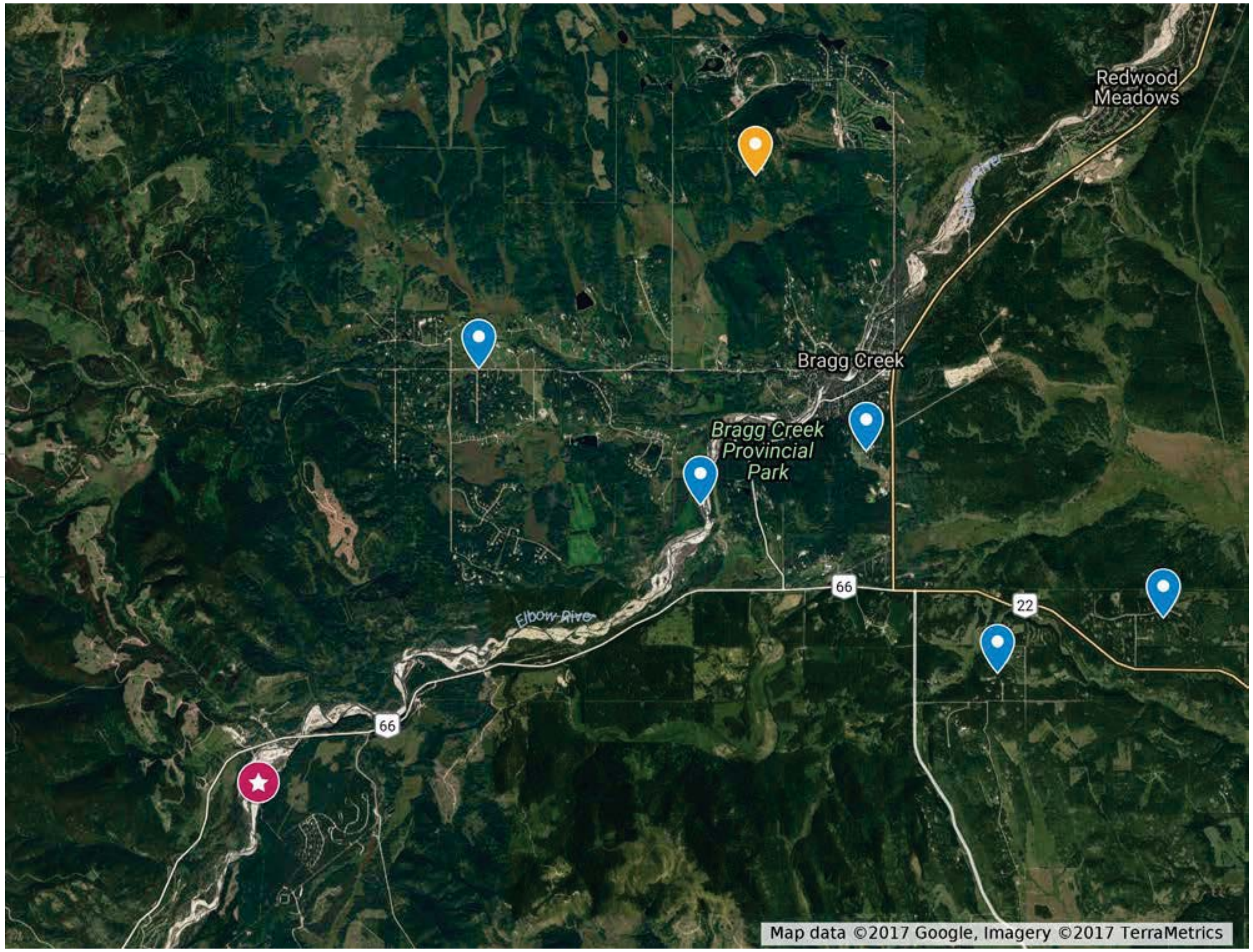
- 1
- 2
- 3
- 4
- 5
- 6

Full Quarter Sections

- 7

Project Location

- Project Location



4.3 Cost Comparison Summary

A summary of costs for each project is presented in **Exhibits 4.16** and **4.17.**

Exhibit 4.16: SR1 Cost Opinion

Component	Cost
General*	$38,486,000
Diversion Structure	$51,147,000
Diversion Channel	$78,686,000
Off-stream Storage Dam	$38,643,000
Contingencies	$31,045,000
Utility Relocation	$15,705,000
Engineering, Permitting, Admin	$38,000,000
Project Total	**$291,712,000**

*includes mobilization, care of water, utility and road work, etc.

Exhibit 4.17: MC1 Cost Opinion

Component	Cost
Mobilization	$12,000,000
Care of Water	$3,000,000
Dam Construction	$188,000,000
Highway 66 Relocation	$34,341,000
Facility Relocation	$22,853,000
Wetland Compensation	$708,000
Aquatic Habitat Management Plan	$10,000,000
Engineering/Environment/Engagement	$54,180,400
Contingencies	$81,270,600
Project Total	**$406,353,000**

5 Flood Damages

5.1 Without Mitigation Alternative

5.1.1 City of Calgary Base Line Flood Risk [9]

5.1.1.1 Introduction

The following section details damage estimates for the flood study area, including direct and indirect damages, along with the monetization of intangibles. Damages have been calculated separately for the Bow and Elbow in accordance with the flow distribution assumptions as presented in the Calgary Flood Mitigation Option Assessment study. **Exhibit 5.1** presents the estimated boundary lines separating the flood inundation areas attributed to the Bow River or Elbow River for those areas where mixing of the river flood waters may occur. A comparison with previous damage estimates is also provided along with an explanation of the differences. And finally, damage estimates are presented for the existing conditions with consideration for mitigation measures that are in place or being constructed as well as for specific social impacts in various communities.

5.1.1.2 City-Wide Unmitigated Baseline

The unmitigated estimates reflect total potential damages. These values reflect a "worst case" scenario as they do not consider any existing mitigations. This is equivalent to failure of existing structures and lack of any non-structural measures. The unmitigated baseline allows for the evaluation, including benefit/cost analyses, of both current and proposed mitigation options.

5.1.1.2.1 Adjustment of Damage Model Results

For the Calgary Flood Mitigation Option Assessment study, considerable effort was devoted to groundwater flood damage modelling, resulting in a predicted flood groundwater elevation by return period which was subsequently employed to calculate basement damage in the flood hazard zone as well as the "adjacent-to" areas. A review of the unadjusted values employing this relationship resulted in unrealistically high damage values for the higher frequency events (1:10-year flood and below) when very little overbank flooding actually occurs.

The unadjusted values have a significant effect on the average annual damage, adding over $20 million on an annual basis and thereby overstating damage for benefit/cost purposes (see **Exhibit 5.2**). The high estimated direct damages have a hyperbolic effect on the myriad other calculations tied to these values.

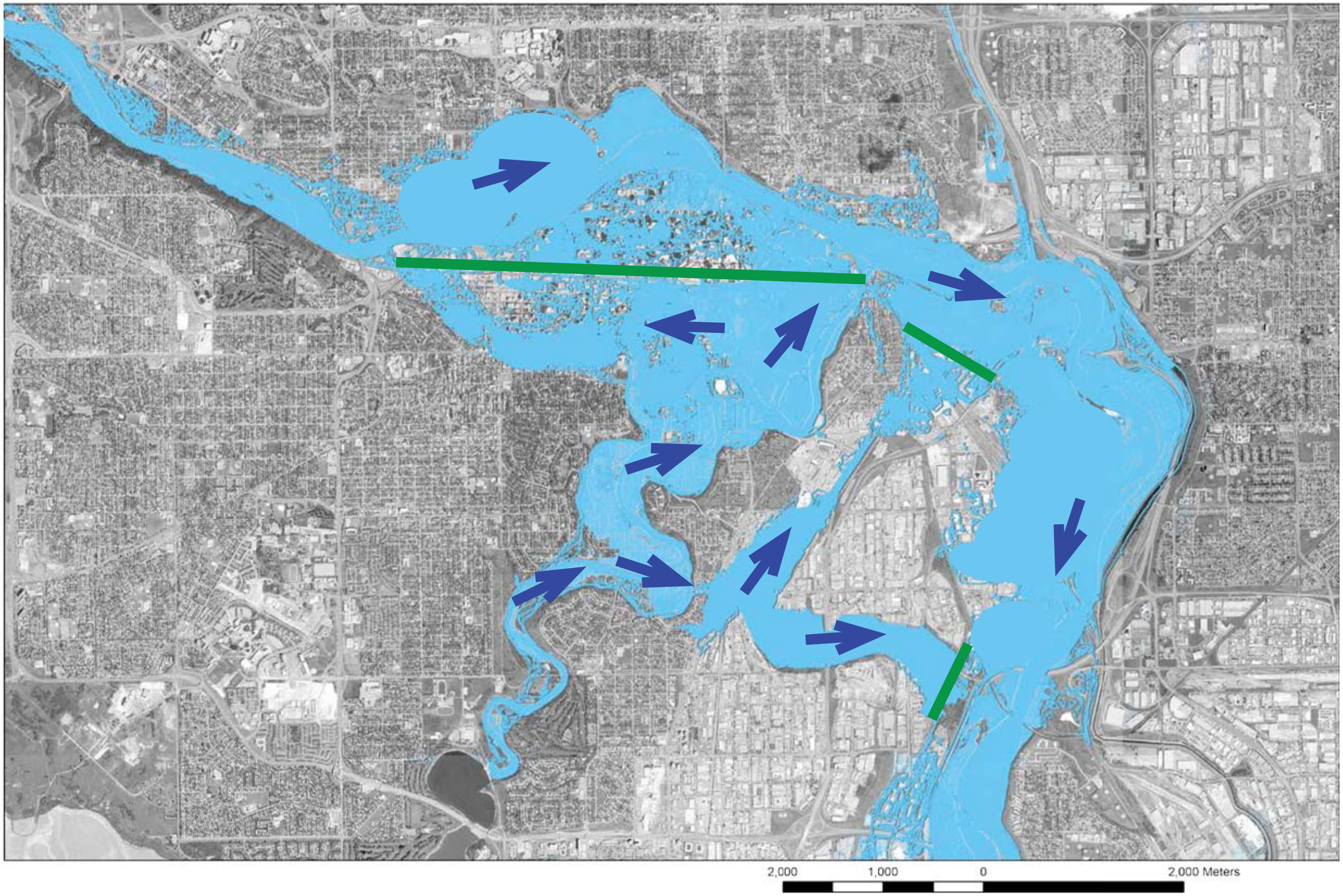
Properties affected by the more frequent floods are likely to have implemented protective or adaptive measures. A recent survey (April, 2016) commissioned by the City found that 50% of flood prone households had sump pumps, 27% had a backup generator, and 29% had some form of private flood mitigation measure. The frequent flood events are not associated with issues such as widespread power loss that exacerbate groundwater damages due to pump failures, particularly in the commercial core.

In reviewing basement seepage complaints and damage data from the June 2005 flood (a 1:8-year event) it should be noted that a large percentage of basement flooding was related to soil saturation due to successive and intensive rainfall events, along with storm sewer backup, rather than riverine or overland flooding. In addition, research undertaken by the University of Calgary in the neighbourhoods of Rideau and Roxboro indicated a significant decrease in average basement damages as one moved away from the area of inundation (see **Exhibit 5.3**).

Accordingly, it was considered prudent to adjust the damages for the 5, 8, and 10-year return floods to reflect more reasonable anticipated damage values.

[9] IBI Group/Golder Associates Ltd. "Flood Mitigation Options Assessment", City of Calgary, Nov. 2016

Estimate of Flooding Attributed to Bow & Elbow River

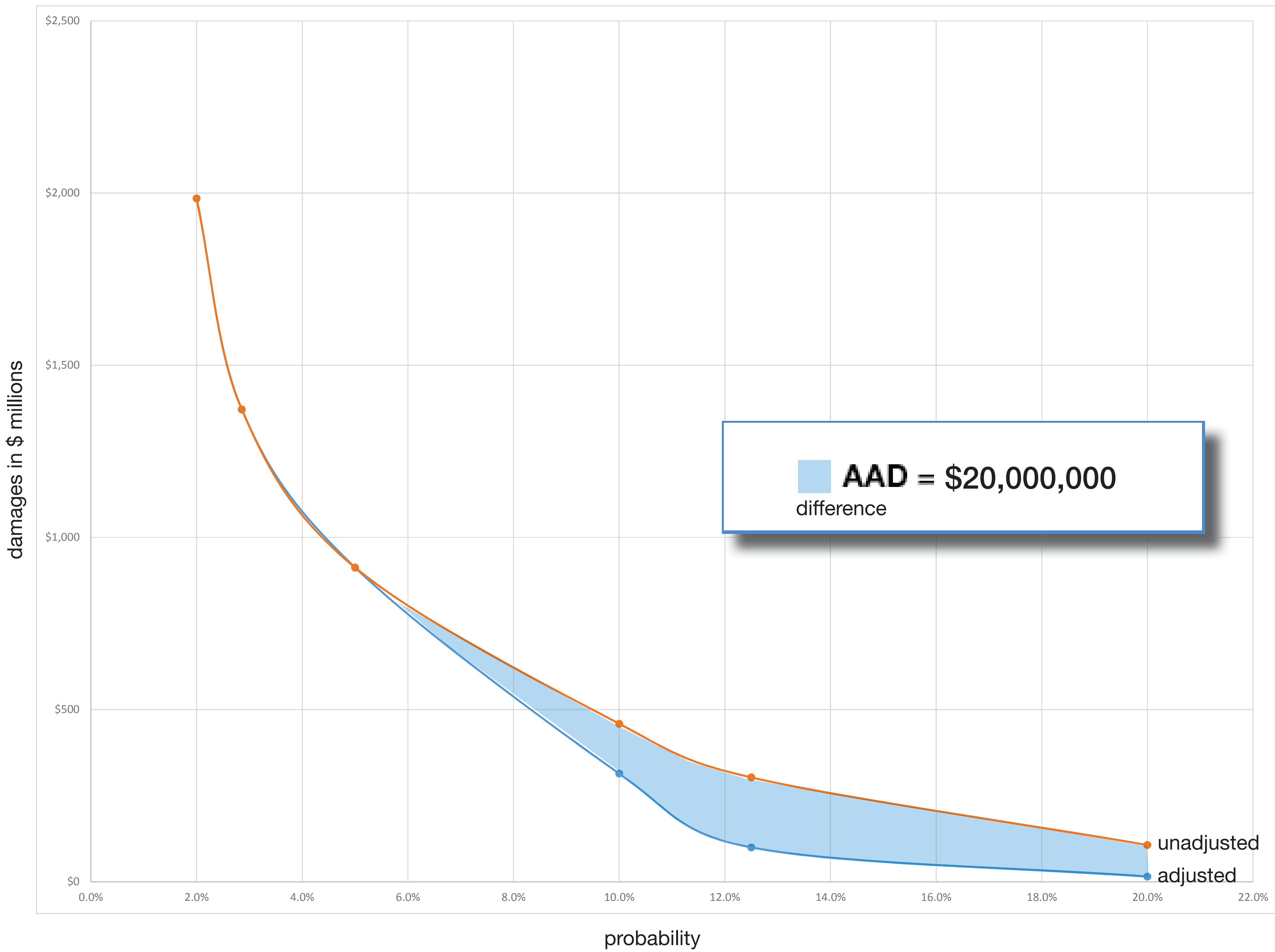


allocation of boundary for damage estimation purposes

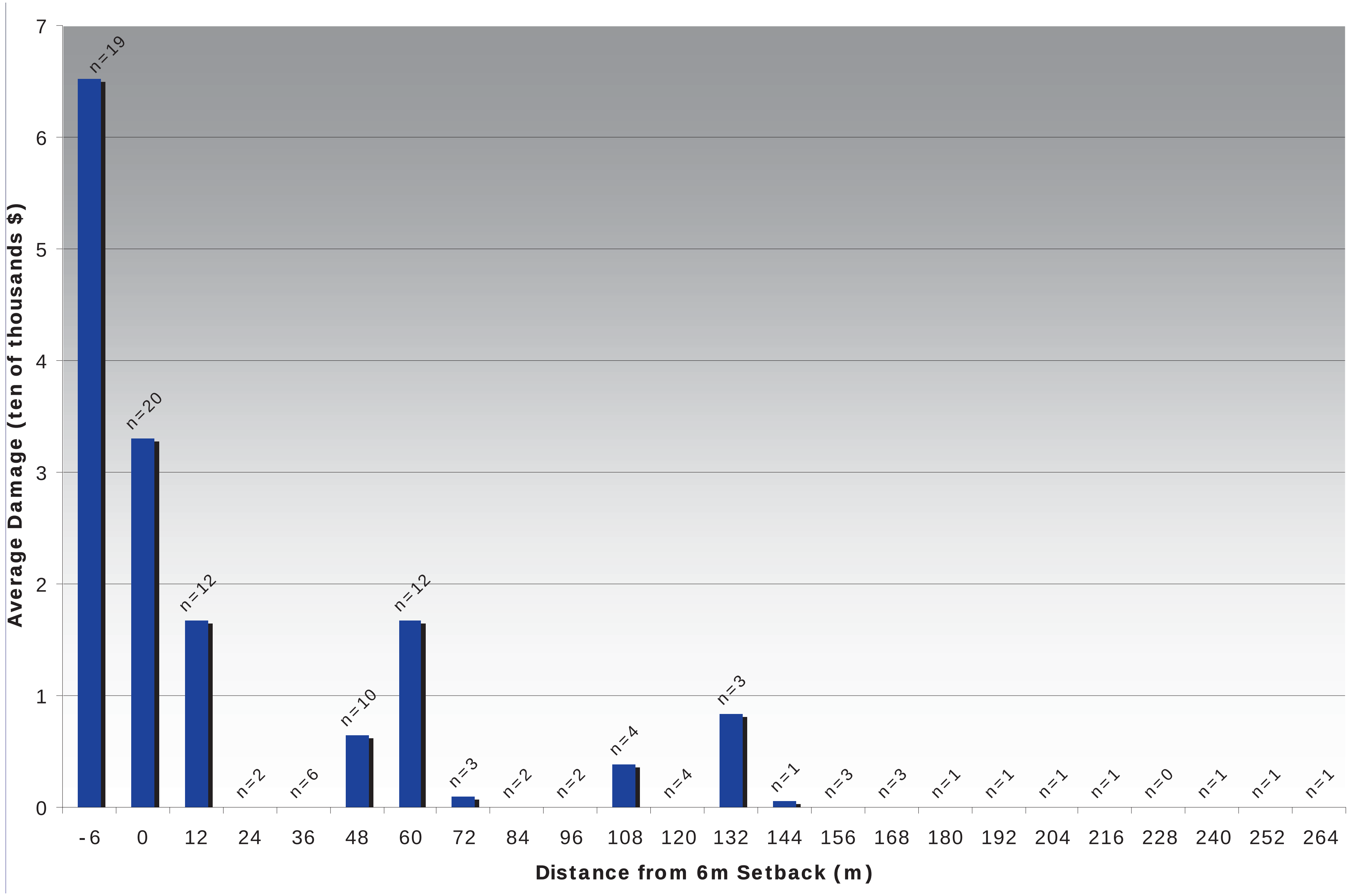
extent of 1:1000 year flood event

direction of flow

Effect of Groundwater Damage Adjustment on AAD



Average Damage vs. Distance from 6m Setback, Rideau and Roxboro June 2005



Source: University of Calgary Environmental Science 2006

5.1.1.2.2 Direct Damage Estimates

As outlined in the Calgary Flood Mitigation Option Assessment study, direct damages are limited to damage to physical property as a result of floodwaters.

Residential Damages

Residential damages for the entire study area by return period are detailed in **Exhibit 5.4**. As evidenced, these damages equate to approximately $1.1 billion for the 1:100-year flood, increasing to $1.6 billion for the 1:200-year flood, $2.1 billion for the 1:500-year flood, and $2.5 billion for the 1:1000-year flood event.

Non-Residential Damages

Non-residential property is comprised of commercial uses, such as retail, office, and industrial, as well as institutional uses, such as schools, government, or recreational facilities. Stampede Park, and in particular the associated annual Calgary Exhibition and Stampede, represents a unique circumstance as it relates to flood damage estimates. The reported 2013 damages were employed to adjust the combined Stampede Park stage-damage curves and indirect damages to current values.

Total direct non-residential damages for the entire study area for the 1:100-year flood are estimated at $399 million, increasing to $1.7 billion for the 1:500-year event.

Infrastructure Damages

Flood damages to City infrastructure were estimated by various City Departments based on the 2013 flood and have been extrapolated across return periods to reflect the revised flow regime and areal extent of flooding with no adjustments for structural or non-structural measures currently in place.

For the 1:100-year event, infrastructure damages equate to some $549 million.

5.1.1.2.3 Indirect Damage Estimates

Indirect damages include other costs incurred due to flood damaged property and infrastructure such as residential displacement, business disruption, traffic delays, habitat restoration, emergency response, and waste disposal. These damages were developed from first principles as outlined in the Calgary Flood Mitigation Option Assessment study. Environmental damages are largely considered intangible. However, the monetization of environmental damages has been achieved by utilizing the tangible costs of habitat enhancement or compensation required for erosion control projects. Therefore, the amount is considered an indirect tangible cost and included in this total. The values are expressed in Exhibit 5.4**.** As with infrastructure, the amounts for traffic disruption, habitat restoration and emergency response were extrapolated across return periods based on inundation areas relative to events with available data.

Total indirect damages for the 1:100-year return are estimated at approximately $1 billion, or some 48% of the direct damage estimate.

5.1.1.2.4 Intangibles

The methodology for assigning a monetary value to intangible damages such as public health is detailed in the Calgary Flood Mitigation Option Assessment study. For the city-wide worst-case baseline, standard values per household were utilized as follows:

- $24,505 per affected single-family or townhouse household ($1,000 per year);
- $17,153 per affected main-floor apartment household ($700 per year); and
- $6,126 per affected upper-level apartment in a building with main-floor flooding ($250 per year).

Flood Study Area Total Damages

Damage Category / Return Period

Damage Category		5	8	10	20	35	50
Residential	Direct	$7,126,000	$42,535,000	$121,203,000	$359,928,000	$523,486,000	$704,926,000
	Displacement	$294,000	$2,631,000	$6,781,000	$21,113,000	$31,308,000	$41,075,000
	Subtotal	$7,420,000	$45,166,000	$127,984,000	$381,041,000	$554,794,000	$746,001,000
Commercial	Direct	$2,869,000	$10,803,000	$29,968,000	$71,417,000	$122,418,000	$218,168,000
	Disruption	$2,216,000	$8,407,000	$38,198,000	$91,097,000	$167,741,000	$361,219,000
	Subtotal	$5,085,000	$19,210,000	$36,415,000	$116,002,000	$232,484,000	$386,955,000
Infrastructure		$0	$13,800,000	$63,870,000	$213,580,000	$314,696,000	$391,614,000
Traffic Disruption		$0	$652,000	$1,029,000	$3,259,000	$7,468,000	$13,691,000
Habitat Restoration		$0	$4,047,000	$4,514,000	$5,837,000	$7,237,000	$8,366,000
Emergency Response		$0	$3,400,000	$10,887,000	$36,406,000	$53,641,000	$66,752,000
Waste Disposal		$168,000	$894,000	$2,347,000	$6,957,000	$10,488,000	$14,341,000
Tangibles	Direct	$9,995,000	$67,139,000	$215,041,000	$644,925,000	$960,600,000	$1,314,707,000
	Indirect	$2,677,000	$20,030,000	$63,756,000	$164,668,000	$277,884,000	$505,444,000
	Subtotal	$12,672,000	$87,169,000	$278,797,000	$809,593,000	$1,238,483,000	$1,820,152,000
Intangibles		$2,345,000	$12,613,000	$35,361,000	$102,881,000	$133,214,000	$164,206,000
Grand Total		**$15,017,000**	**$99,782,000**	**$314,158,000**	**$912,474,000**	**$1,371,698,000**	**$1,984,357,000**

		75	100	200	350	500	1000
Residential	Direct	$934,557,000	$1,109,205,000	$1,615,144,000	$1,929,321,000	$2,153,960,000	$2,554,062,000
	Displacement	$54,703,000	$68,387,000	$113,922,000	$153,039,000	$181,498,000	$225,110,000
	Subtotal	$989,261,000	$1,177,591,000	$1,729,066,000	$2,082,360,000	$2,335,458,000	$2,779,172,000
Commercial	Direct	$295,762,000	$398,755,000	$732,732,000	$1,320,176,000	$1,676,316,000	$2,127,897,000
	Disruption	$517,934,000	$739,583,000	$1,535,202,000	$2,985,234,000	$3,987,784,000	$5,879,685,000
	Subtotal	$583,672,000	$824,154,000	$1,848,870,000	$3,810,152,000	$4,903,251,000	$7,125,350,000
Infrastructure		$486,377,000	$548,842,000	$705,730,000	$866,399,000	$934,836,000	$1,074,926,000
Traffic Disruption		$26,228,000	$53,284,000	$71,195,000	$88,993,000	$131,919,000	$153,906,000
Habitat Restoration		$10,000,000	$10,973,000	$13,696,000	$16,187,000	$17,938,000	$21,829,000
Emergency Response		$82,905,000	$93,553,000	$120,295,000	$147,682,000	$159,347,000	$183,226,000
Waste Disposal		$19,270,000	$23,429,000	$36,891,000	$51,556,000	$59,729,000	$73,291,000
Tangibles	Direct	$1,716,697,000	$2,056,801,000	$3,053,605,000	$4,115,896,000	$4,765,112,000	$5,756,885,000
	Indirect	$711,041,000	$989,208,000	$1,891,201,000	$3,442,690,000	$4,538,215,000	$6,537,047,000
	Subtotal	$2,427,737,000	$3,046,009,000	$4,944,806,000	$7,558,586,000	$9,303,327,000	$12,293,932,000
Intangibles		$187,123,000	$211,108,000	$310,334,000	$382,559,000	$436,802,000	$508,616,000
Grand Total		**$2,614,861,000**	**$3,257,117,000**	**$5,255,140,000**	**$7,941,145,000**	**$9,740,129,000**	**$12,802,548,000**

Average Annual Damages (AAD)	**$168,000,000**

These amounts represent the present value of annual payments for 100 years derived from secondary research on household willingness-to-pay to avoid the intangible effects of flooding. Further adjustments to these amounts based on community amenities and demographics is included in the community-specific risk profiles.

The total intangible value for each return period is included in Exhibit 5.4. As indicated, intangibles amount to $211 million at the 1:100-year event.

5.1.1.2.5 Groundwater Damage Estimates

Groundwater accounts for a large portion of flood damages in Calgary, particularly for higher frequency events where there is limited overland inundation. The amount of damage caused by groundwater alone decreases as larger floods inundate more of the floodplain surface. At the more frequent events, groundwater is responsible for nearly all the residential damage. Total direct groundwater damage peaks at $334 million for the 1:50-year flood and ranges from 72% of direct damages at the 1:10-year flood down to 4% at the 1:1000-year flood. The groundwater damage amounts for each category and return period are detailed in **Exhibit 5.5**.

5.1.1.2.6 Bow and Elbow Rivers

Exhibit 5.6 details damages by the Bow and Elbow Rivers respectively for the specified return periods. The Bow constitutes a majority of the direct damages, ranging from 74% to 51% of the total and generally decreasing with probability. As well, the Bow River experiences much greater non-residential damages. This is most evident at the higher frequencies but diminishes at the lower frequency events as water spills from the Elbow River through the Beltline district, in addition to covering several hundred acres in the Manchester, Alyth, Bonnybrook, Highfield and Inglewood industrial areas at the 1:500-year return period. The Bow River accounts for approximately 68% of Annual Average Damages (AAD).

5.1.1.2.7 Total Damage Estimates

Total damage estimates by return period are illustrated in Exhibit 5.4.

As detailed for the 1:100-year flood event, damages are estimated at $3.26 billion, increasing to $9.74 billion for the 1:500-year and $12.8 billion for the 1:1000-year event.

5.1.1.2.8 Average Annual Damages

Average annual damages are the cumulative damages occurring from various flood events over an extended period of time, averaged for the same timeframe. The average annual damages are obtained by integrating the area under the damage-probability curve, which depicts total damage versus probability of occurrence and is illustrated for the entire study area in **Exhibit 5.7**. The average annual damage for the flood study area is estimated at $168 million.

5.1.1.2.9 Comparison with Previous Damage Estimates

A variety of factors have contributed to an increase in the estimated damages for the City of Calgary. These are briefly summarized hereinafter.

Increase in Peak Discharge and Flood Level

As discussed in the Phase 1 report, the previous City of Calgary damage estimates undertaken in 2014 were based on the 2011 hydrology study and 2012 hydraulic model undertaken by Golder Associates. The most recent damage estimates are based on revised updated hydrology and hydraulics by Golder Associates in 2015. Hydraulic modelling has resulted in simulated water levels that are on average 0.27 m higher for the Bow River and 0.38 m higher for the Elbow River than those using the 2012 model.

Damages Attributed to Groundwater

Return Period

Damage Category	5	8	10	20	35	50	75	100	200	350	500	1000
GW Direct Damages	$6,872,092	$33,003,140	$100,237,624	$265,863,764	$296,120,819	$334,204,898	$223,624,020	$202,856,096	$271,765,967	$242,990,021	$226,081,449	$182,349,320
GW % of Total	69%	62%	72%	64%	47%	39%	19%	15%	12%	8%	6%	4%
GW Residential Direct Damages	$6,139,719	$30,704,113	$92,682,600	$239,094,795	$241,022,845	$255,485,872	$155,033,844	$139,772,301	$198,660,918	$198,110,438	$186,785,246	$158,902,597
GW % of Total	86%	72%	76%	66%	46%	36%	17%	13%	12%	10%	9%	6%
GW Non-residential Direct Damages	$732,373	$2,299,028	$7,555,024	$26,768,969	$55,097,974	$78,719,027	$68,590,176	$63,083,795	$73,105,049	$44,879,583	$39,296,202	$23,446,723
GW % of Total	26%	21%	40%	49%	54%	52%	32%	22%	12%	4%	3%	1%
Waste Disposal	$115,191	$553,206	$1,680,205	$4,456,466	$4,963,641	$5,602,015	$3,748,434	$3,400,318	$4,555,400	$4,073,051	$3,789,626	$3,056,579
GW % of Total	69%	62%	72%	64%	47%	39%	19%	15%	12%	8%	6%	4%
GW Residentail Displacement	$248,667	$1,780,831	$5,041,779	$13,970,926	$13,233,304	$13,629,616	$9,340,764	$8,623,733	$13,896,043	$14,072,179	$12,900,413	$10,088,076
GW % of Total	85%	68%	74%	66%	42%	33%	17%	13%	12%	9%	7%	4%
GW Residential Intangible	$2,075,203	$9,187,103	$27,959,435	$75,107,463	$73,333,498	$75,164,046	$46,259,200	$41,381,505	$61,029,358	$63,312,048	$61,285,546	$59,422,051
GW % of Total	89%	73%	79%	73%	55%	46%	25%	20%	20%	17%	14%	12%
GW Non-residential Disruption	$895,026	$2,849,681	$9,974,205	$35,613,974	$89,263,850	$154,226,893	$160,262,156	$156,006,218	$191,856,819	$133,795,596	$101,328,758	$60,959,897
GW % of Total	40%	34%	57%	58%	69%	65%	43%	29%	15%	5%	3%	1%
Number of GW Affected Households	2,479	5,235	6,556	8,709	11,943	13,515	10,458	9,475	13,082	10,475	8,577	6,251
GW % of Total	100%	96%	93%	82%	73%	66%	48%	39%	36%	26%	20%	13%
Groundwater Subtotal	$10,090,988	$46,820,755	$143,213,042	$390,556,126	$471,951,472	$577,225,453	$439,486,140	$408,867,552	$538,548,187	$454,169,844	$401,596,166	$312,819,344
GW % of Total	68%	61%	72%	65%	51%	44%	25%	18%	14%	7%	5%	3%
AAD due to GW	$40,700,000											
GW % of Total	24%											

* Damages due to flooding of buildings (does not include infrastructure, traffic, habitat, or emergency response)

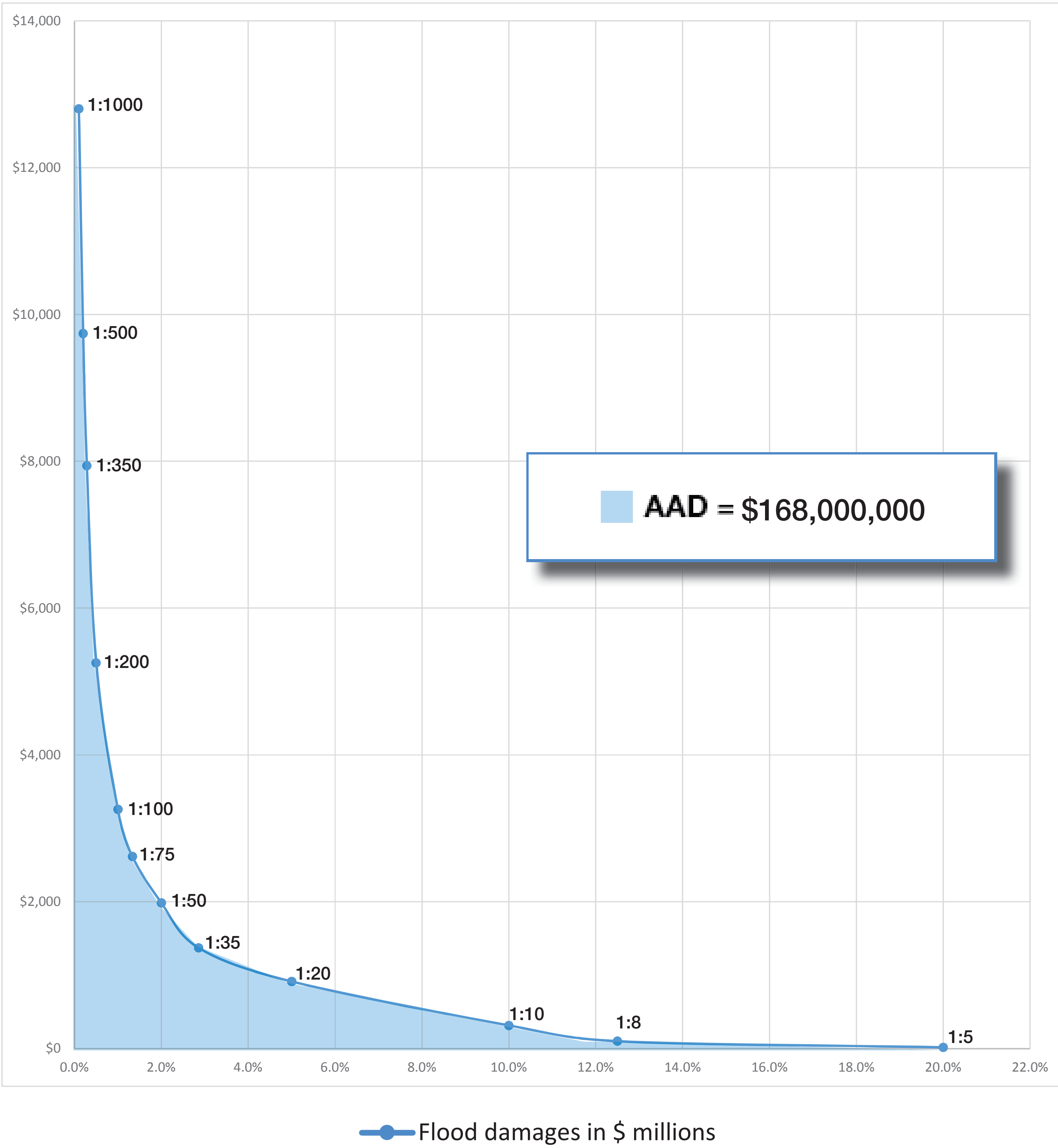
Damages Attributed to Bow and Elbow Rivers

Return Period

Damage Category		5	8	10	20	35	50	75	100	200	350	500	1000
Direct Damages	Elbow	$2,664,514	$16,034,588	$43,700,407	$108,047,275	$163,134,601	$289,005,175	$435,606,040	$565,259,546	$959,693,806	$1,494,483,672	$1,704,046,268	$2,005,647,880
	%	27%	30%	31%	26%	26%	34%	38%	40%	44%	49%	48%	46%
	Bow	$7,330,798	$37,304,016	$96,329,957	$306,978,203	$462,532,317	$566,568,307	$714,003,335	$832,459,884	$1,241,141,763	$1,581,238,702	$1,859,264,874	$2,366,756,162
	%	73%	70%	69%	74%	74%	66%	62%	60%	56%	51%	52%	54%
Residential Direct Damages	Elbow	$1,912,704	$15,016,316	$41,518,165	$101,823,198	$147,363,963	$254,765,153	$384,280,931	$477,062,529	$763,328,417	$898,764,799	$990,756,153	$1,108,284,177
	%	27%	35%	34%	28%	28%	36%	41%	43%	47%	47%	46%	43%
	Bow	$5,213,707	$27,519,078	$79,685,298	$258,104,888	$376,121,891	$450,160,784	$550,276,507	$632,142,142	$851,815,437	$1,030,556,352	$1,163,203,800	$1,445,778,087
	%	73%	65%	66%	72%	72%	64%	59%	57%	53%	53%	54%	57%
Non-residential Direct Damages	Elbow	$751,810	$1,018,272	$2,182,242	$6,224,078	$15,770,639	$34,240,023	$51,325,109	$88,197,016	$196,365,389	$595,718,873	$713,290,115	$897,363,704
	%	26%	9%	12%	11%	15%	23%	24%	31%	34%	52%	51%	49%
	Bow	$2,117,091	$9,784,937	$16,644,659	$48,873,315	$86,410,426	$116,407,523	$163,726,828	$200,317,742	$389,326,326	$550,682,350	$696,061,074	$920,978,074
	%	74%	91%	88%	89%	85%	77%	76%	69%	66%	48%	49%	51%
Residentail Displacement	Elbow	$72,404	$856,677	$2,061,360	$4,713,657	$6,567,981	$12,400,633	$20,393,620	$28,245,392	$57,589,142	$78,485,005	$93,389,936	$112,370,663
	%	25%	33%	30%	22%	21%	30%	37%	41%	51%	51%	51%	50%
	Bow	$221,415	$1,773,928	$4,719,519	$16,399,576	$24,740,093	$28,674,340	$34,309,738	$40,141,433	$56,333,115	$74,553,705	$88,107,629	$112,739,293
	%	75%	67%	70%	78%	79%	70%	63%	59%	49%	49%	49%	50%
Residential Intangible	Elbow	$293,079	$2,972,904	$8,063,302	$20,635,519	$28,394,987	$47,187,694	$62,322,743	$74,611,593	$133,267,671	$164,320,628	$186,692,952	$209,746,528
	%	12%	24%	23%	20%	21%	29%	33%	35%	43%	43%	43%	41%
	Bow	$2,051,679	$9,639,975	$27,297,830	$82,245,629	$104,819,472	$117,017,981	$124,800,661	$136,496,726	$177,066,657	$218,237,938	$250,108,585	$298,869,214
	%	88%	76%	77%	80%	79%	71%	67%	65%	57%	57%	57%	59%
Non-residential Disruption	Elbow	$585,387	$788,737	$1,769,950	$9,071,940	$22,218,001	$47,607,102	$80,712,836	$160,975,415	$354,208,912	$1,071,851,452	$1,333,616,441	$1,797,486,350
	%	26%	9%	10%	15%	17%	20%	22%	30%	28%	40%	38%	34%
	Bow	$1,630,338	$7,618,348	$15,817,799	$51,832,859	$108,085,007	$188,699,881	$287,907,317	$374,663,596	$908,969,004	$1,591,899,613	$2,160,282,963	$3,509,521,454
	%	74%	91%	90%	85%	83%	80%	78%	70%	72%	60%	62%	66%
Number of Affected Households	Elbow	658	2,032	2,882	3,578	5,794	9,456	10,173	11,398	18,788	20,700	21,879	23,512
	%	26%	37%	41%	34%	35%	46%	46%	47%	52%	51%	50%	50%
	Bow	1,832	3,438	4,154	7,084	10,599	11,133	11,728	12,976	17,229	20,152	21,922	23,878
	%	74%	63%	59%	66%	65%	54%	54%	53%	48%	49%	50%	50%
Totals	Elbow	$3,615,384	$20,652,906	$55,595,018	$142,468,391	$220,315,570	$396,200,604	$599,035,238	$829,091,945	$1,504,759,530	$2,809,140,757	$3,317,745,597	$4,125,251,422
	%	24%	27%	28%	24%	24%	31%	34%	37%	39%	45%	43%	40%
	Bow	$11,234,231	$56,336,267	$144,165,105	$457,456,267	$700,176,889	$900,960,509	$1,161,021,051	$1,383,761,639	$2,383,510,540	$3,465,929,957	$4,357,764,051	$6,287,886,122
	%	76%	73%	72%	76%	76%	69%	66%	63%	61%	55%	57%	60%
AAD	Elbow	$62,400,000											
	%	37%											
	Bow	$105,600,000											
	%	63%											

* Damages due to flooding of buildings (does not include infrastructure, traffic, habitat, or emergency response)

Flood Damages Probability Distribution Bow and Elbow Rivers



Expanded Flood Hazard Area

The areal extent of inundation has increased substantially and particularly within the downtown area for the lower frequency events, greater than 1:200-year. For the 1:100-year event, the largest increases occur in Hillhurst and the Beltline, with lesser increases evident in the area just north of the Deerfoot Meadows commercial development in southeast Calgary. The other area of note is related to a large area of spill at the 1:500-year return period, which covers several hundred acres in the Manchester, Alyth, Bonnybrook, Highfield and Inglewood industrial areas.

The expanded flood hazard area includes more than double the amount of buildings as the 2014 inventory. The estimated total number of residential units in the hazard area is 52,883 along with 1,970 non-residential buildings.

Reallocation of Flood Inundation Areas for Damage Estimation

Along some of the river reaches the source of overland floodwater can be a mixture of Bow and Elbow River water, particularly during extreme flood events (e.g., 1,000-year flood). Consequently, judgement and approximation was employed to define the boundary lines separating the flood inundation areas attributed to the Bow River or Elbow River for those areas where mixing of the river floodwaters may occur. These boundary lines were used to attribute the flood inundation areas to either one of the rivers for the purpose of flood damage modelling.

Residential Displacement and Commercial Disruption

Indirect damages include other costs incurred due to flood damaged property and infrastructure such as residential displacement, business disruption, traffic delays, habitat restoration, emergency response and waste disposal. These damages were developed from first principles as outlined in the Calgary Flood Mitigation Option Assessment study.

Monetization of Intangibles

A methodology was developed for assigning a monetary value to intangible damages such as public health. These amounts represent the net present value of annual payments for 100 years derived from secondary research on household willingness to pay to avoid the intangible effects of flooding.

Groundwater Damage Estimates

Groundwater accounts for a large portion of flood damages in Calgary, particularly for higher frequency events where there is limited overland inundation. In consideration of the overall characteristics of the alluvial aquifer a simplified relation of maximum groundwater level versus distance from the edge of surface inundation relationship was developed for application throughout the study domain. This relationship was used to estimate or approximate the maximum groundwater table rise within the alluvial aquifer for the various flood return periods.

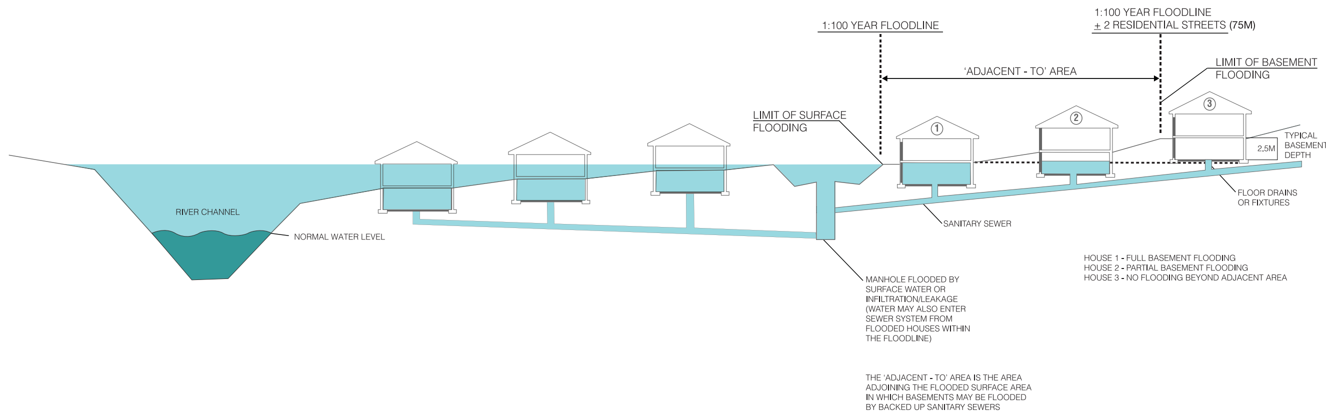
As it relates to the “adjacent-to” area, the area adjoining the flooded surface area in which basements may be flooded by backed up sanitary sewers, the modelled groundwater profiles were employed to determine basement damages from groundwater beyond the area of surface inundation. A further groundwater profile was modelled for areas with flood barriers in place to account for damages to basements due to groundwater flooding. These relationships are depicted in **Exhibit 5.8**. Additional relationships were developed to model the effects on maximum groundwater levels by the Springbank and potential Bow River reservoir(s).

Discussion of Results

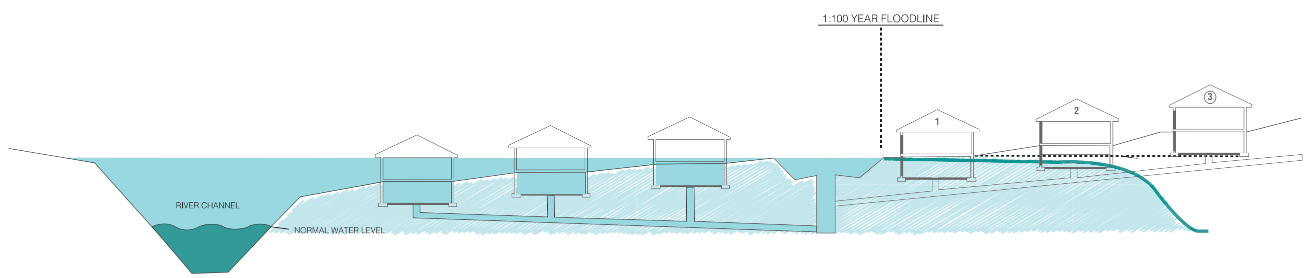
The impact of these factors resulted in an essential doubling of the average annual damage from $84 million to $168 million with the largest impact (62%) attributable to the increase in peak discharge.

Groundwater Flooding Assumptions

1) CONVENTIONAL 'ADJACENT-TO AREA' ASSUMPTIONS
- ALL BASEMENTS BELOW HYDRAULIC GRADELINE FLOODED WITHIN DEFINED AREA (75m)

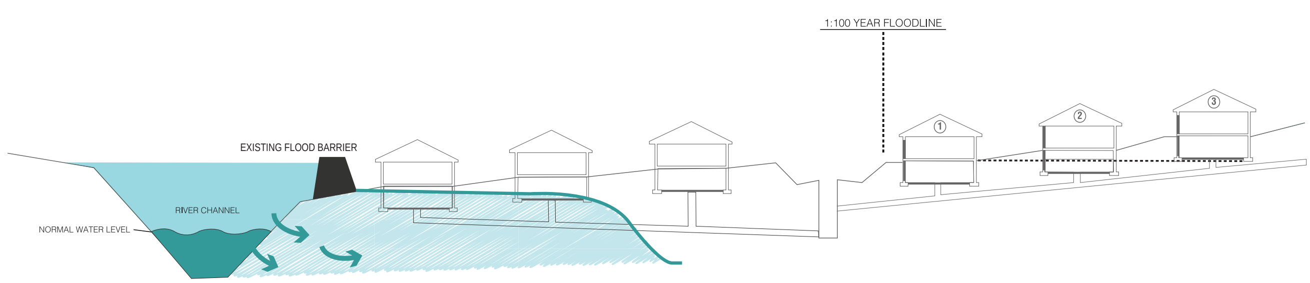


2) GROUNDWATER/LIMIT OF SURFACE FLOODING FUNCTION
- ALL BASEMENTS FLOODED BELOW MODELLED GROUNDWATER PROFILE



3) EXISTING BARRIER IN PLACE - NO SURFACE FLOODING

BASEMENT FLOODING BASED ON GROUNDWATER FLOODING FUNCTION



5.1.2 Existing Mitigation

Many parts of the city are currently protected to various levels by existing barriers. The City is also currently constructing several new barriers and drainage improvements. To conduct benefit/cost analyses on the proposed scenarios, only the additional benefit they provide should be considered. Therefore, a second damages baseline, or 'Scenario 0', was calculated.

Existing baseline mitigation measures include:

- TransAlta's hydro facilities and reservoirs in the Bow River basin - historical operations
- Glenmore reservoir on the Elbow River, including gates improvements
- Existing barriers (existing conditions without raising dykes)
- Discovery Ridge barrier (not in study area)
- Stampede barrier
- Zoo barrier (100-year flood level)
- Eau Claire West barrier (200-year flood level)
- Heritage Dr./Glendeer Circle barrier (100-year flood level)
- Centre Street bridge lower deck - gates (50-year flood level)
- Bonnybrook improvements (100-year flood level)
- Deane House barrier (100-year flood level)
- Stormwater outfall gates (downtown, Mission, Eau Claire, Bowness)
- Gates and Pump Stations at planned permanent barriers
- Temporary flood barriers at various locations per the City's flood emergency response plan

This scenario represents damages that would be incurred at the current level of protection. The difference in the AAD of the unmitigated and current scenarios is the benefit of existing measures. The benefit of proposed mitigation scenarios is the amount of damages they reduce from the current scenario.

5.1.2.1 Adjustment of Damage Model Results

For the reasons outlined in Section 5.1.1.2.1, and to provide consistent comparison of scenarios the modeled damages at the 5, 8, and 10-year return floods were adjusted in the same manner for all scenarios.

5.1.2.2 Isolated Flooding

The flood modelling for each scenario identified overland flooding areas as either being inundated or isolated. An inundated area is flooded by water from the river channel. An isolated area has surface water that is disconnected from the water in the river channel. Isolated flooding occurs due to elevation lower than the river level and poor drainage of stormwater, groundwater, or sewer backup. A separate flood surface was created for the isolated areas.

The isolated areas are further identified as having no mitigation, stormwater outfall gates, or gates and pumps. For the purposes of assigning damages, the following assumptions were used:

- Isolated without protection: a 100% probability of overland accumulation was assumed. The isolated area flood surface was applied to all structures.

- Isolated with gates: a 50% probability of overland accumulation was assumed. The isolated area flood surface was applied to 50% of structures, and the river plus groundwater surface applied to the remaining 50%.
- Isolated with gates and pumps: a 0% probability of overland accumulation was assumed. The river plus groundwater surface was applied to all structures.

5.1.2.3 Application of Intangible Damage Values

The Calgary Flood Mitigation Option Assessment study details the research conducted to assess and monetize the intangible impacts of flooding on households. Based on the methodology and results of studies that determined a household's willingness-to-pay to avoid the effects of flooding, a standard value per affected household was adopted and utilized for the city-wide damages as indicated in Section 5.1.1.2.4. This value represents the impact on a household's quality of life including but not limited to illness, worry, loss of services, community relations, loss of enjoyment of the environment or historical assets, etc.

Calgary Flood Mitigation Option Assessment research also sought to identify variables that contribute to this impact. Many of the key variables such as personality, previous experience, pre-existing conditions, trust in authorities, and preparedness cannot be measured. Others, such as age, gender, income, and household type can be assessed with census data. It was found that household type and income would be the most reliable indicators. The impact of flooding is generally greater for families with children and for households with lower incomes.

The intangible damage amount per household was adjusted according to the tract level data from the 2011 federal census and national household survey. Flooding affects a total of 15 tracts within the city. The percentile rank for each census tract was calculated based on a combination of median household income and percentage of households with children. This determined the top, middle, and bottom thirds in terms of relative impact, or high, medium, and lower groups.

The high impact was associated with an increase of 30% annually per household, no change for the medium impact, and a decrease of 30% for the lower impact. These values were then assigned to each affected household according to the census tract it is located in.

5.1.2.4 Infrastructure, Traffic Disruption, Habitat Restoration, and Emergency Operations

Several of the categories included in this study are not object-based and therefore not determined by a depth of flooding in a specific location. This includes infrastructure, traffic disruption, habitat restoration, and emergency operations. For the unmitigated scenario, damages associated with these categories were estimated for select return periods, primarily using data from past events (2005 and 2013 floods). These costs were then extrapolated to other return periods based on the relative extent of inundation. In order to apply these categories of damages to the existing and all other scenarios to be analysed, a relationship between the unmitigated estimate and the overland direct damage amount across all return periods was determined for each category. These equations were subsequently applied to the overland direct damage of all remaining scenarios.

5.1.2.5 Total Damage Estimates

Total damage estimates by category and return period are illustrated in **Exhibit 5.9**.

As detailed for the 1:100-year flood event, damages are estimated at \$2.68 billion, increasing to \$9.08 billion for the 1:500-year and \$12 billion for the 1:1000-year event.

5.1.2.6 Average Annual Damages

The average annual damage for the flood study area is estimated at \$116.6 million. The Bow River accounts for approximately \$75 million, or 64%, of the total AAD.

Scenario 0 - Existing Baseline

		Return Period (yrs)											
		5	8	10	20	35	50	75	100	200	350	500	1000
Residential	Direct	$3,868,000	$22,484,000	$47,726,000	$241,227,000	$383,460,000	$586,502,000	$852,257,000	$1,042,714,000	$1,557,819,000	$1,928,469,000	$2,152,833,000	$2,552,599,000
	Displacement	$122,000	$1,071,000	$2,557,000	$11,542,000	$20,427,000	$32,127,000	$49,141,000	$64,922,000	$108,839,000	$152,646,000	$181,067,000	$224,804,000
	Total	$3,991,000	$23,554,000	$50,283,000	$252,768,000	$403,887,000	$618,629,000	$901,398,000	$1,107,635,000	$1,666,658,000	$2,081,115,000	$2,333,900,000	$2,777,403,000
Commercial	Direct	$296,000	$8,688,000	$11,439,000	$34,570,000	$58,718,000	$90,605,000	$150,218,000	$223,210,000	$555,751,000	$1,146,401,000	$1,409,351,000	$1,818,342,000
	Disruption	$202,000	$6,510,000	$8,703,000	$28,812,000	$49,645,000	$107,577,000	$224,685,000	$450,315,000	$1,219,213,000	$2,694,879,000	$3,541,697,000	$5,381,885,000
	Total	$497,000	$15,199,000	$20,142,000	$63,382,000	$108,364,000	$198,182,000	$374,903,000	$673,524,000	$1,774,964,000	$3,841,280,000	$4,951,048,000	$7,200,227,000
Infrastructure		$0	$8,807,000	$37,523,000	$144,695,000	$222,186,000	$325,388,000	$441,362,000	$511,923,000	$700,893,000	$866,399,000	$934,836,000	$1,074,926,000
Traffic		$0	$416,000	$573,000	$2,208,000	$5,273,000	$11,376,000	$23,801,000	$49,700,000	$70,707,000	$88,993,000	$131,919,000	$153,906,000
Habitat Restoration		$0	$2,582,000	$1,025,000	$3,954,000	$5,110,000	$6,951,000	$9,074,000	$10,235,000	$13,603,000	$16,187,000	$17,938,000	$21,829,000
Emergency Operations		$0	$2,170,000	$6,396,000	$24,664,000	$37,873,000	$55,464,000	$75,232,000	$87,260,000	$119,470,000	$147,682,000	$159,347,000	$183,226,000
Waste Disp.		$71,000	$530,000	$1,006,000	$4,689,000	$7,517,000	$11,511,000	$17,042,000	$21,521,000	$35,931,000	$52,287,000	$60,576,000	$74,331,000
Subtotals	Direct	$4,164,000	$39,979,000	$96,688,000	$420,492,000	$664,365,000	$1,002,496,000	$1,443,837,000	$1,777,847,000	$2,814,463,000	$3,941,269,000	$4,497,020,000	$5,445,866,000
	Indirect	$394,000	$13,279,000	$20,260,000	$75,868,000	$125,845,000	$225,005,000	$398,976,000	$683,951,000	$1,567,762,000	$3,152,674,000	$4,092,544,000	$6,039,981,000
	Subtotal	$4,559,000	$53,258,000	$116,948,000	$496,360,000	$790,209,000	$1,227,501,000	$1,842,813,000	$2,461,797,000	$4,382,225,000	$7,093,943,000	$8,589,564,000	$11,485,847,000
Intangibles		$1,526,000	$7,109,000	$14,429,000	$74,619,000	$111,605,000	$159,389,000	$187,038,000	$219,771,000	$328,969,000	$455,326,000	$491,979,000	$542,804,000
Total		$6,085,000	$60,367,000	$131,377,000	$570,979,000	$901,815,000	$1,386,890,000	$2,029,851,000	$2,681,569,000	$4,711,194,000	$7,549,268,000	$9,081,543,000	$12,028,651,000
AAD		$116,578,000											

	Existing Mitigation - Average Annual Damages	
Total	$116,579,000	
Bow River	$57,128,000	64.4%
Elbow River	$41,451,000	35.6%

5.1.2.7 Comparison with Unmitigated Damage Estimates and Community Groups

A comparison of the unmitigated and existing scenario (0) is provided in **Exhibit 5.10**. The exhibit indicates damages associated with the flooding of buildings (direct damages, business interruption, residential displacement, and household intangibles). Damages are further broken down by community group. The community groups reflect areas that would likely be protected together by mitigation along a common reach of the river.

When comparing the AAD from the unmitigated direct damages to buildings to the existing mitigations in place, the largest change can be seen along the Bow River in the City Centre for communities such Sunnyside and Hillhurst, on the north side as well as Downtown on the south. Bowness and communities along the Elbow River benefit less from existing mitigation.

5.1.3 Summary and Conclusions

The updated hydrology and hydraulics have greatly increased the baseline damage amounts. In addition, application of the groundwater modeling over the expanded hazard area results in large estimated damages due to groundwater flooding.

Existing mitigation measures are providing considerable benefit. The difference in AAD between the unmitigated and existing scenarios amounts to an annual benefit of over $50 million.

The majority of existing mitigations are effective for floods of higher frequency (below 100-year return period). Therefore, the damage estimates differ greater for these events and are essentially equal above the 1:200-year event. However, the benefits at the frequent events are substantial. For instance, at the 1:20-year event the mitigated total is estimated at $571 million which is roughly 60% of the unmitigated total of $912 million.

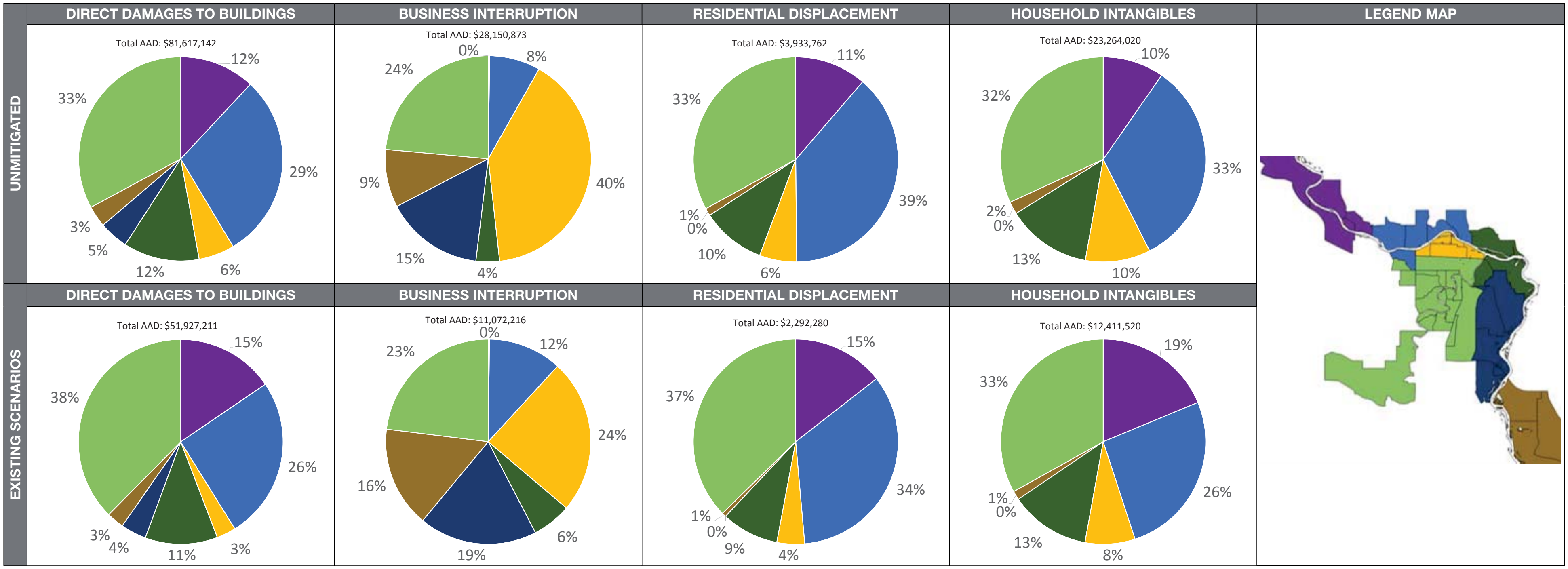
For the purposes of the City of Calgary Flood Mitigation Options Assessment, the benefits provided by all scenarios were derived from the existing scenario, referred to as Scenario 0 or simply “the baseline”. The benefits were calculated as the reduction in AAD from the $116.6 million baseline.

5.1.4 Other Damages

Flood damage studies, akin to the detailed assessment undertaken for the City of Calgary have not been generated for areas downstream of the McLean Creek storage project, including Bragg Creek, Redwood Meadows and infrastructure within Rocky View County, which could be afforded partial, if not full protection, by the proposed McLean Creek project. These potential damages averted constitute costs over and above those accruing to the City of Calgary and would logically be taken into consideration as part of the benefit/cost analysis. What is unknown at this juncture is what portion of downstream damage can be attributed to contributing drainage areas below McLean Creek along with other factors such as pluvial flooding, inadequate stormwater management and groundwater damage. In addition, available damage information is limited to a single event, the 2013 event.

In terms of the 2013 Southern Alberta Disaster Recovery Program, the total estimated amount for flood recovery projects between the McLean Creek dam site and the City of Calgary is approximately $5.6 million. This amount is made up of $1.084 million for recovery projects in Rocky View County (including Bragg Creek), $2.657 million for recovery projects in the Townsite of Redwood Meadows, and $1.901 million for recovery projects in the Tsuu T’ina First Nation. Details are contained in **Appendix D**.

Comparison of Unmitigated and Existing Scenarios by Community Group



GROUP	1	2	3	4	5	6	7
COMMUNITY	BOWNESS PARKDALE MONTGOMERY	HILLHURST SUNNYSIDE WEST HILLHURST CRESENT HEIGHTS SUNALTA	DOWNTOWN COMMERCIAL CORE CHINATOWN EAU CLAIRE DOWNTOWN EAST VILLAGE DOWNTOWN WEST END	INGLEWOOD BRIDGELAND/RIVERSIDE RAMSAY	BURNS INDUSTRIAL EAST FAIRVIEW INDUSTRIAL ALYTH/BONNYBROOK GLENDEER BUSINESS PARK HIGHFIELD	RIVERBEND DOUGLASDALE/GLEN SHEPARD INDUSTRIAL	BELTLINE ELBOW PARK ELBOYA RIDEAU PARK MISSION ROXBORO ERLTON CLIFF BUNGALO LOWER MOUNT ROYAL MANCHESTER INDUSTRIAL PARKHILL GLENMORE PARK

5.1.4.1 1987 Bragg Creek Floodplain Management Study

The 1987 Bragg Creek Floodplain Management Study[10] identified 37 residential units and 21 commercial units within the flood hazard area. This has increased to 51 residential units and 29 commercial units, representing an increase of 27% for residential and 28% for commercial. A very cursory assessment of potential damages employing values from the updated stage-damage curves suggests total damages in the order of $12.7 million for the Bragg Creek flood study area for the 1:100-year event.

5.1.4.2 Flood Defences at Bragg Creek

The AMEC flood mitigation measures study for the Bow, Elbow and Old Man River basins recommended flood defences at Bragg Creek if flood protection infrastructure for the City of Calgary was located down stream of Bragg Creek. Protection of the hamlet via dykes was proposed with a further recommendation that if a decision was made to proceed with a project located downstream of Bragg Creek, then the detailed design and planning of the dykes at Bragg Creek should be initiated as soon as possible.[11] Detailed design of the dyke system has been estimated at $32.8 million.[12]

The Province is initiating this solution independent of considerations relating to benefits accruing to MC1 versus SR1. Accordingly, these are considered “sunk costs” and no additional benefits to MC1 or costs to SR1 associated with this standalone alternative have been factored into the benefit/cost analysis.

As well, given the lack of average annual damage estimates based on detailed damage assessments by return period, along with the required flood modelling, no additional benefits to MC1 or costs to SR1 have been factored into the benefit/cost analysis. Given the total value of flood recovery projects associated with the 2013 flood ($5.6 million) it is suggested that the additional benefits would be nominal in any event and would not impact the benefit/cost ratio significantly.

5.2 With Mitigation Alternative

5.2.1 Current Benefit/Cost Analysis: Benefits from Upstream Mitigation on the Elbow River

The benefit of each project is the reduction in damages within the City of Calgary. Additional upstream implications have been considered in the costs as described in Section 5.1.4. Upstream protection to the 1:200-year level on the Elbow River results in a reduction of $27.7 million in AAD from the existing mitigation amount.

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10 *Bragg Creek Floodplain Management Study – Final Report*, J.N. MacKenzie Engineering Ltd. in association with W-E-R Engineering Ltd., IBI Group and Ecos Engineering Services Ltd., January 1987.

11 AMEC

12 This figure seems inordinately high given the previous estimate of $6 million. It should also be noted that the cost includes payments to the benefiting landowners for easements for construction of the dyke that is protecting their properties.

6 Benefit/Cost Analysis

6.1 Benefit/Cost Analysis for Flood Mitigation Projects

For flood mitigation projects, economic evaluation requires a comparison between the events predicted to occur if the project is built and those predicted to occur if the project is not built. This is called the "with and without principle". For flood control one cannot directly equate an exchange in the market, however flood control benefits can be estimated by assuming they are equivalent to the flood damage prevented.

For flood mitigation projects the probabilistic approach to benefit/cost estimates is used. To reiterate, within the defined flood risk area, flood damages were estimated with the application of depth-damage curves applied to the various return flood events (probability). The flood damage probability distribution was then plotted and the average annual damage (AAD) estimated for project evaluation purposes.

With the updated average annual damages and cost estimates of the mitigation alternatives, an economic efficiency evaluation was performed. This evaluation is based upon the net present value (NPV) of respective benefits and costs. The net present value of any project is governed by three variables: the average annual cost or benefit, discount rate, and discount period. To provide a consistent economic evaluation of flood mitigation projects across the Province, a common discount rate of 4% was agreed upon and applied. The discount period is the estimate of the alternative's project life.

The benefit/cost (B/C) ratio of a project is the ratio of net present value of the benefits (average annual damages) over the net present value of the costs. This value is the indicator of economic efficiency. Where the benefits exceed costs, the ratio would be greater than 1.0, and where benefits are less than costs then the ratio would be less than 1.0. An economically-efficient project would have a B/C ratio greater than 1.0. At a B/C ratio of 1.0, the project is at a breakeven point.

6.2 Assumptions/Methodology

6.2.1 Benefits

Both projects are assumed to achieve the same benefits once completed. The annual benefit is the average annual damages (AAD) averted, which is estimated at $27,736,265. This amount is the reduction in AAD from the existing mitigation condition on the Elbow River below the Glenmore Reservoir.

6.2.2 Total Costs

The total costs are comprised of the project estimates, land estimates, additional upstream mitigation requirements for SR1, annual operation and maintenance, and annual lease-back potential for SR1, as illustrated in **Exhibit 6.1.**

Exhibit 6.1: Total Costs for Benefit/Cost Analysis

Cost	SR1	MC1
Construction Total	$291,712,000	$406,353,000
Land	$80,000,000	n/a
Total	**$371,712,000**	**$406,353,000**
Annual Operation/Maintenance (1% of Dam Construction Cost)	$1,685,000	$1,880,000
Annual Lease-Back Potential	-$714,610	n/a

- The benefit/cost analysis has been carried out using a net present value analysis.
- 100-year economic analysis based on the life expectancy of the structures.

6.2.3 Timing

The analysis was performed using the net present value of benefits and costs over a 100-year period at a discount rate of 4%.

The SR1 project is currently well along the way in terms of design and approval processes. In addition, it is understood that the construction process, because it is off-stream, is subject to much less onerous environmental constraints which limit the construction window of MC1, and therefore can be completed within a much shorter timeframe. Accordingly, it can deliver the design flood benefits much faster than MC1 by somewhere between three and five years.

To fairly include this difference in the benefit/cost analysis, the annual benefits (average annual damages averted) begin in 2020 for the SR1 project and in 2023 for the MC1 project. Over the same 100-year period (2018-2118), with the 4% discount rate, the four-year advantage gives SR1 $74 million in additional present value of benefits compared to MC1.

Assumptions regarding timing are as follows:

SR1:

- land costs are incurred in year 1
- costs are split 50/50 between years 1 and 2
- annual benefit, operation and maintenance, and lease back amounts begin in year 3

MC1:

- costs are spread between years 1-5 as follows: 5%, 10%, 15%, 35%, 35%
- annual benefit and operation and maintenance amounts begin in year 6

6.3 Results

The results of the benefit/cost calculation are detailed in **Exhibit 6.2**.

Exhibit 6.2: Benefit/Cost Results

Indicator	SR1	MC1
PV Benefits	$653,008,000	$578,997,000
PV Costs	$388,943,000	$402,999,000
Net Present Value	$264,065,000	$175,998,000
Benefit/Cost Ratio	1.68	1.44

As evidenced, both projects yield a positive benefit/cost ratio with SR1 scoring higher than MC1 by a margin of 0.24 (1.68 vs 1.44). *If a land value was included in the MC1 costs, the BC ratio would decrease to 1.26.*

6.4 Benefits Beyond the Study Area

An analysis any potential benefits downstream of the City was outside the scope of this analysis. Needless to say, it is anticipated that benefits downstream of the City of Calgary would be marginal in any event.

6.5 Triple Bottom Line Considerations

Traditional economic analyses of flood mitigation alternatives have generally assumed a straightforward objective of maximizing the net benefits (total benefits minus total costs) that accrue to a project. Society however, has other goals besides economic efficiency. These goals or objectives are the results of outcomes that society desires and have more recently been described as triple bottom line objectives which include, in addition to economic objectives, considerations of environmental and social impacts. In relation to flood mitigation projects, the following criteria are often considered in the evaluation process:

- Disaster prevention:
  - reduces current losses
  - reduces future losses
  - potential residential loss of life
  - potential non-residential loss of life
- Environmental impact:
  - biophysical impacts
  - social impacts
  - aesthetic impacts
- Implementation:
  - complexity
  - flexibility of integration with other measures
- Incidental benefits:
  - recreation
  - drought mitigation
  - other

This study was concerned solely with economic efficiency and consequently does not include a full analysis of the aforementioned non-commensurable criteria. The intangible impact on households, however, was included as an adapted willingness-to-pay amount per affected household.

7 References

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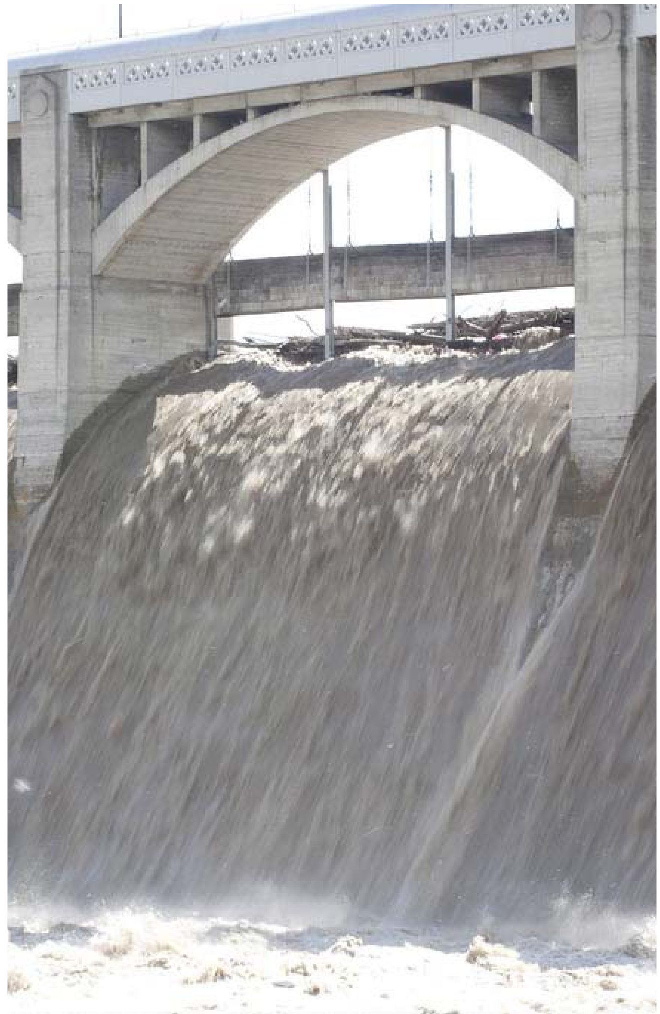
Appendix A – City of Calgary Flood Mitigation Scenarios (2017)

4.6.1 EVALUATION OF FLOOD MITIGATION SCENARIO 0 - BASELINE

Description & Discussion

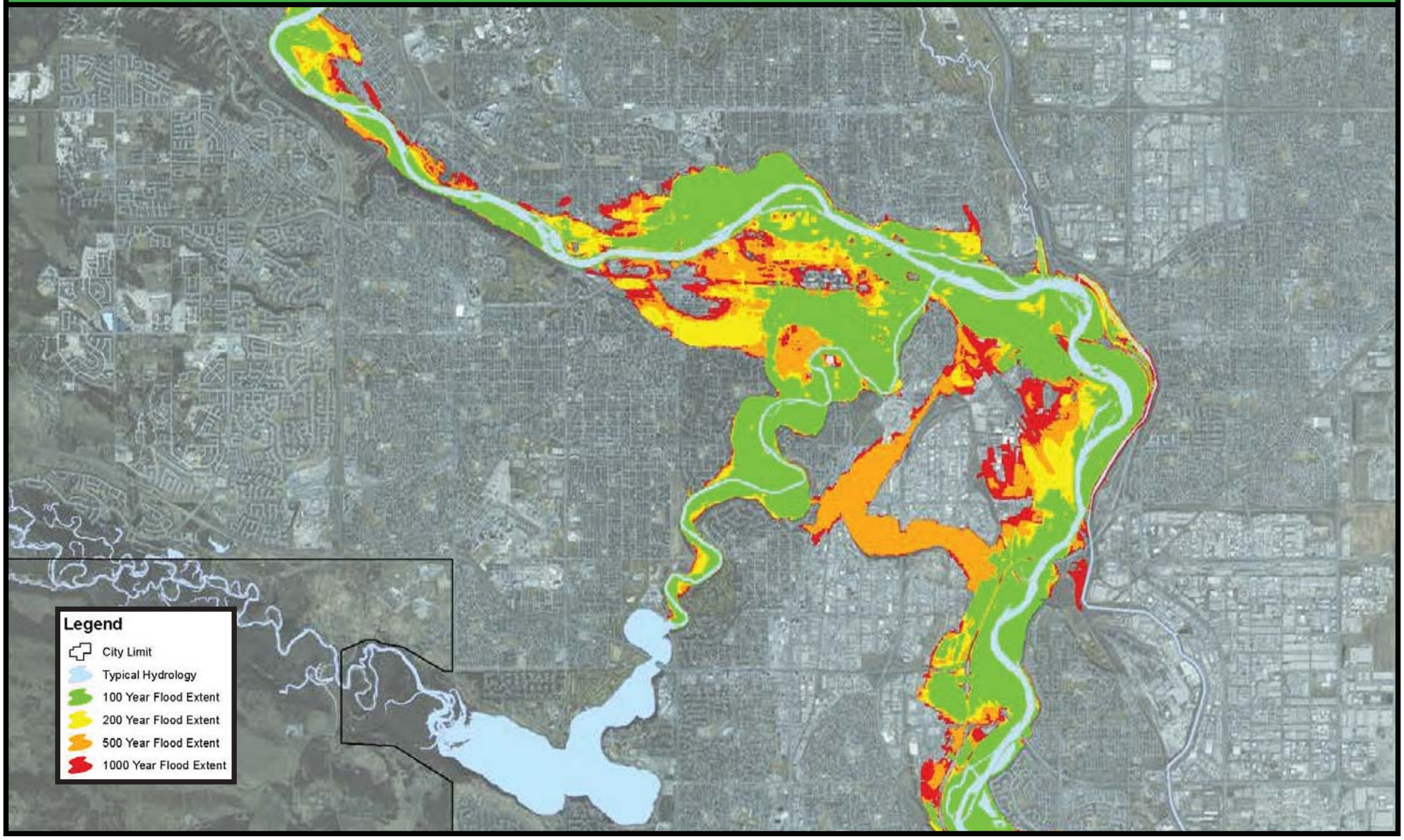
The baseline case involves existing improvements and modifications that were initiated after the 2013 flood. This includes historic dykes, new barriers and stormwater improvements.

No costs have been attached to this scenario. However, benefits have been calculated in relation to flood events without mitigation. As indicated, total unmitigated average annual damages are $168 million versus $117 million with the aforementioned mitigation measures in place, a reduction of $51 million. However, significant damages remain city-wide. Changes to the operating agreement for the TransAlta hydro facilities are not included in Scenario 0 or 0a.

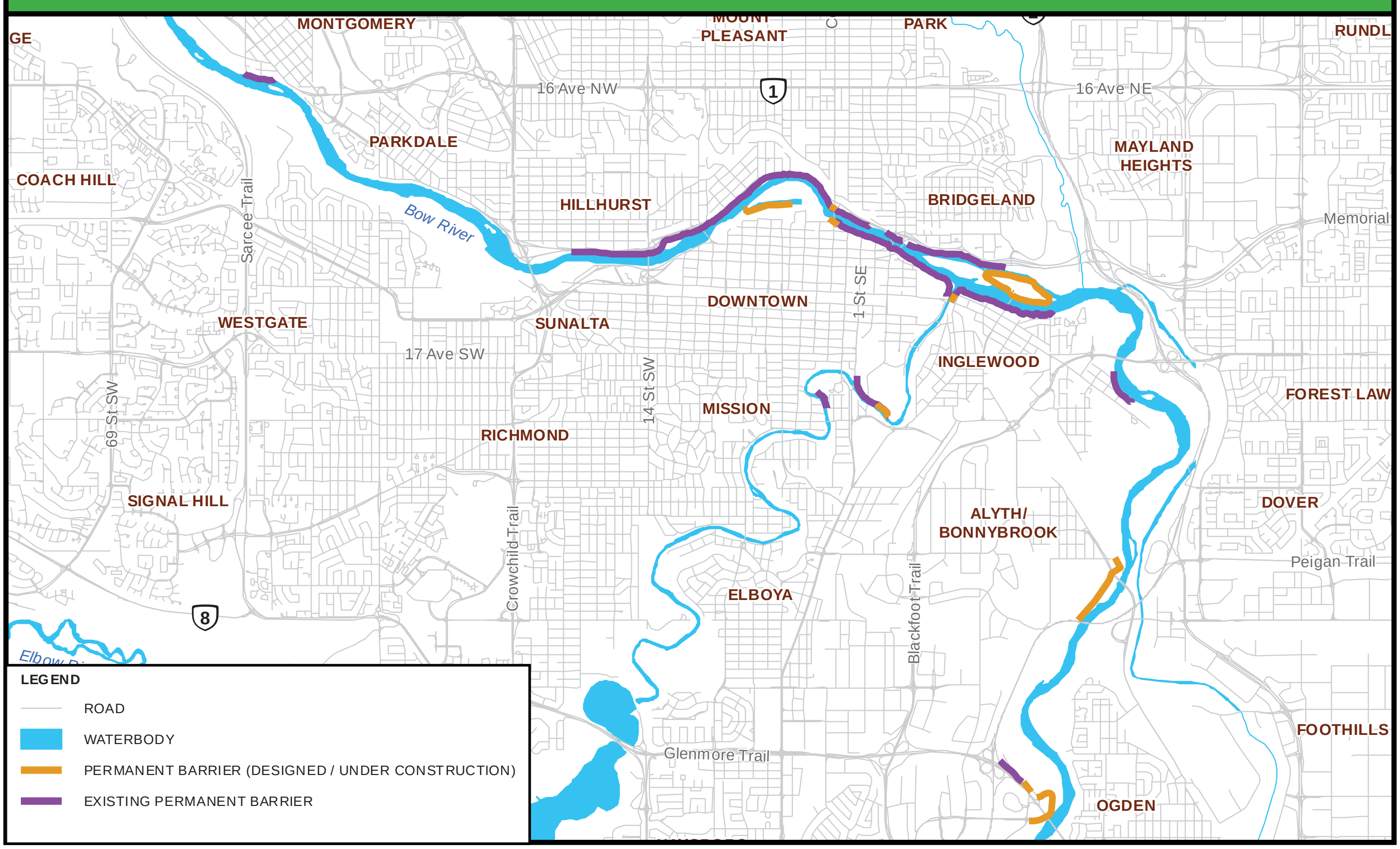


Category of Damages		Scenario 0			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$51,421,567		$116,578,433	
Building-related (Direct, Displacement, Intangible)	Overland	$18,274,067	35.5%	$50,319,967	43.2%
	Groundwater	$21,444,885	41.7%	$25,966,261	22.3%
Infrastructure, Traffic, Habitat, Emergency Response		$12,814,984	24.9%	$19,757,271	16.9%
Isolated (all categories)		-$996,982	-1.9%	$19,974,968	17.1%
Evacuation (no direct damage)		-$115,387	-0.2%	$559,966	0.5%
Bow River		$41,997,960	81.7%	$75,127,711	64.4%
Elbow River		$9,423,607	18.3%	$41,450,721	35.6%

Unmitigated Inundation Extents



Location of Existing Barriers



4.6.2 EVALUATION OF FLOOD MITIGATION SCENARIO 0a

Description & Discussion

This scenario entails the implementation of non-structural measures along with the existing improvements. Further details on non-structural options is presented in Section 3.7.

Non-structural measures selected for implementation include improved flood warning and homeowner response protocols; emergency measures focused on key damage areas with the implementation of temporary flood barriers and cut-offs to spill areas; land use regulations aimed at reducing potential future damages; and, programs to facilitate the installation of backflow preventers and sump pumps to reduce basement damages from higher frequency events.

Contingency measures including flood warning, forecasting, and emergency measures can reduce residential contents damage by some 30%, with commercial damages reduced by an equivalent amount. This equates to a reduction of $8 million in average annual damages.

Average annual damages are estimated to be reduced by between $8 million and $12 million with the installation of temporary barriers.

Residential damages up to and including the 1:200 return period represent over $48 million. The annual redevelopment of 1% of at-risk residential properties to a new design standard will reduce average annual damages by nearly $500,000 each year over a 100 year period. The present value would be $441 million. Despite the nominal annual accumulation, the annual benefit only increases for the first 35 years due to discounting. For redevelopment of non-residential properties, the annual reduction would be $182,000 with a present value of $166 million. These measures would essentially eliminate all residential and commercial damages up to the 1:200 year event.

Groundwater flooding amounts to $26 million in average annual damages, or some 22% of the total. Installation of backflow preventers, sump pumps and foundation waterproofing could mitigate damage by this amount. If this is aggressively completed within 20 years it would have a present value of $607 million. Over 100 years, it would be $232 million.

While the benefits of these measures are calculated to be high in relation to anticipated cost, there is still significant residual damage. In addition, the timeframe for implementation, and therefore achievement of full benefits, is long-term.

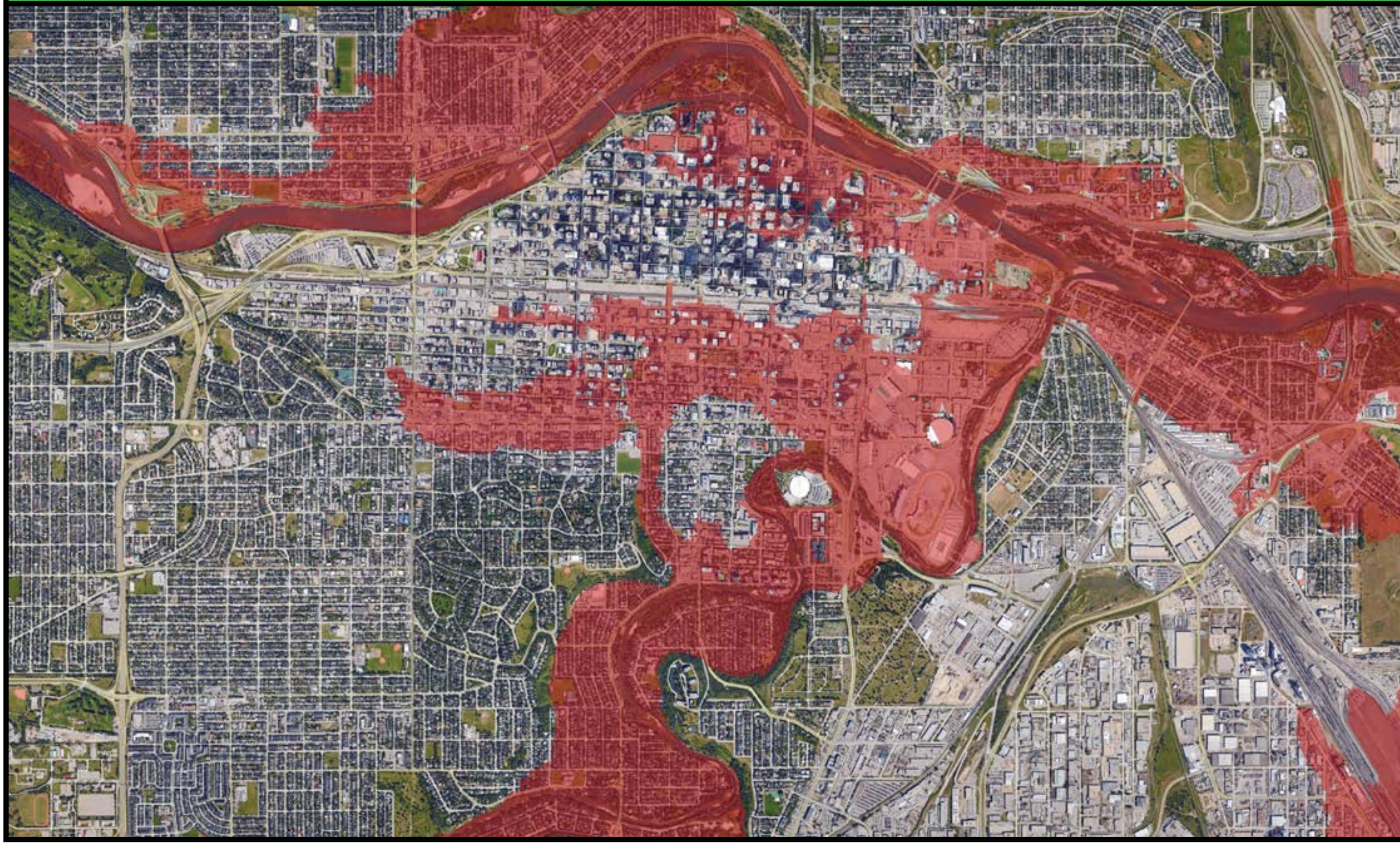
Notwithstanding, given the impact of groundwater flooding, implementation of a mandatory/voluntary sump pump/backflow preventer program is prudent and extremely beneficial in terms of reducing damages.

Recommended improvements to the contingency measures program, along with more restrictive development/redevelopment standards for properties within the flood hazard area, will also render cost beneficial flood damage reductions.

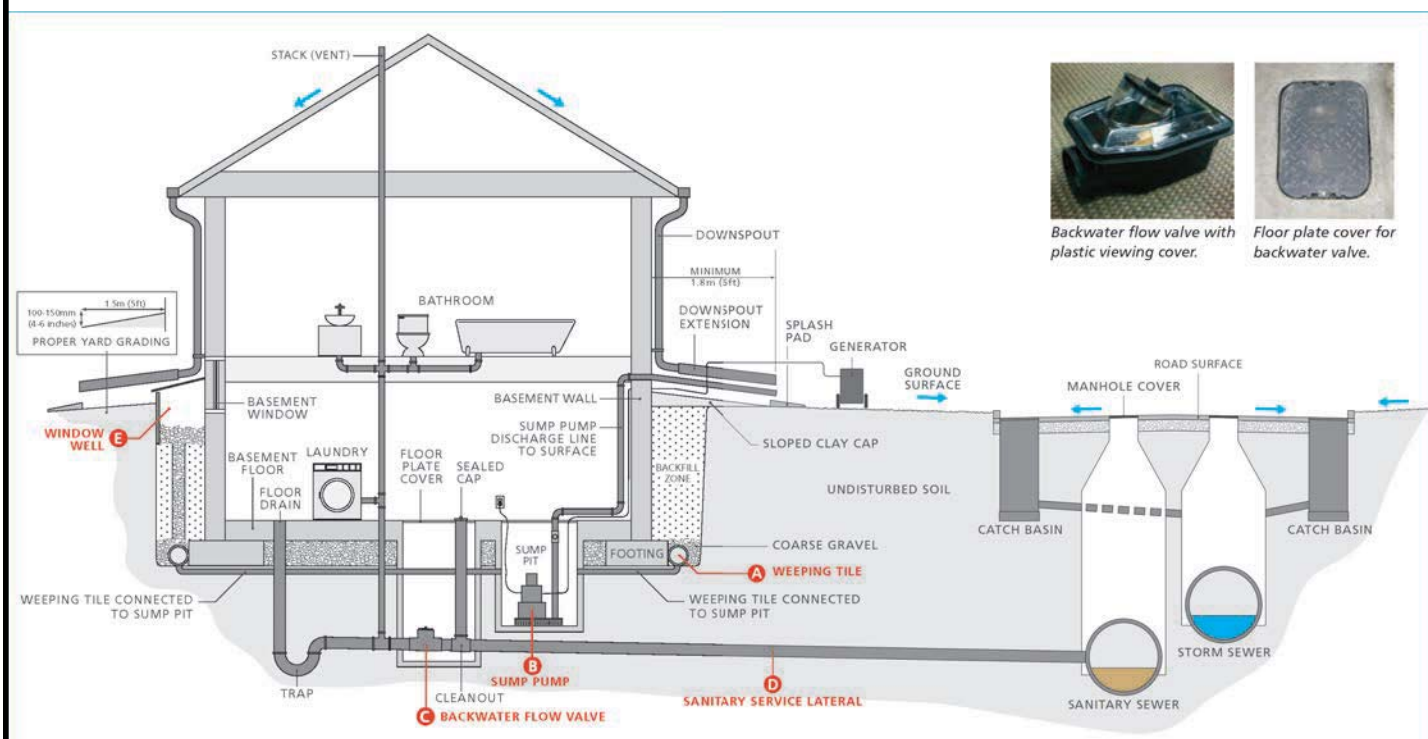
Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-2	5
	Equitable protection	3	7
	Vulnerable populations	0	11
	River aesthetics	-2	6
	Recreation access	2	5
	Emergency access	2	4
	Risk transparency	2	8
ENVIRONMENTAL	Water security	0	9
	Riparian health and ecosystem functions	4	1
	Water quality and contamination prevention	-2	8
IMPLEMENTATION	Timeliness of Implementation	-8	6
	Adaptability/Flexibility	3	10
	Jurisdictional control	12	1
	Regulatory complexity	-6	8
ECONOMIC	Economic Environment	-3	11
	Economic Efficiency	18	1
	Damages Averted	-18	12
	Total Cost	18	1
	TOTAL SCORE	23	5

1:200 Flood Hazard Area



Backflow Preventer and Sump Pump



Source: ICLR

4.6.3 EVALUATION OF FLOOD MITIGATION SCENARIO 1

Description & Discussion

This scenario entails a new operating agreement between TransAlta Utilities and the Government of Alberta aimed at managing flows for improvement of flood protection. It also includes stormwater and drainage improvements at Sunnyside and Quarry Park. The major piece of infrastructure is the SR1 storage reservoir.

The project consists of three basic components:

1. a river diversion structure;
2. a diversion channel and reservoir inlet structure; and
3. an off-stream storage dam and reservoir.

The diversion structure system would consist of a concrete overflow weir section crossing the Elbow River, a gated concrete sluiceway/fishway located adjacent to the left side valley abutment with its invert at the river thalweg level, and a gated diversion outlet structure located in the left valley abutment immediately upstream of the sluiceway.

The diversion channel is designed to convey a peak diversion flow of 300 m^3/s from the Elbow River into the off-stream storage reservoir. The channel is designed with a 24 m bottom width, three horizontal to one vertical side slopes and a 3.6 m water depth.

The development cost estimate was provided by the City and operating expenses assumed to be 1% of development cost annually, with a 10% repairs or upgrade expense every 30 years.

This scenario renders the highest benefit/cost ratio under the assumptions employed. It should be noted that significant benefits accrue to the Bow River flood hazard area due to the revised operating regime upstream as well as the assumption of temporary barrier protection for which no costs have been assigned. There are still significant damages on the Bow River, particularly for the lower frequency events (> 50 year).

Essentially this scenario provides good protection for the Elbow, with some level of benefits for the Bow, particularly for the higher frequency events.

Triple Bottom Line Analysis

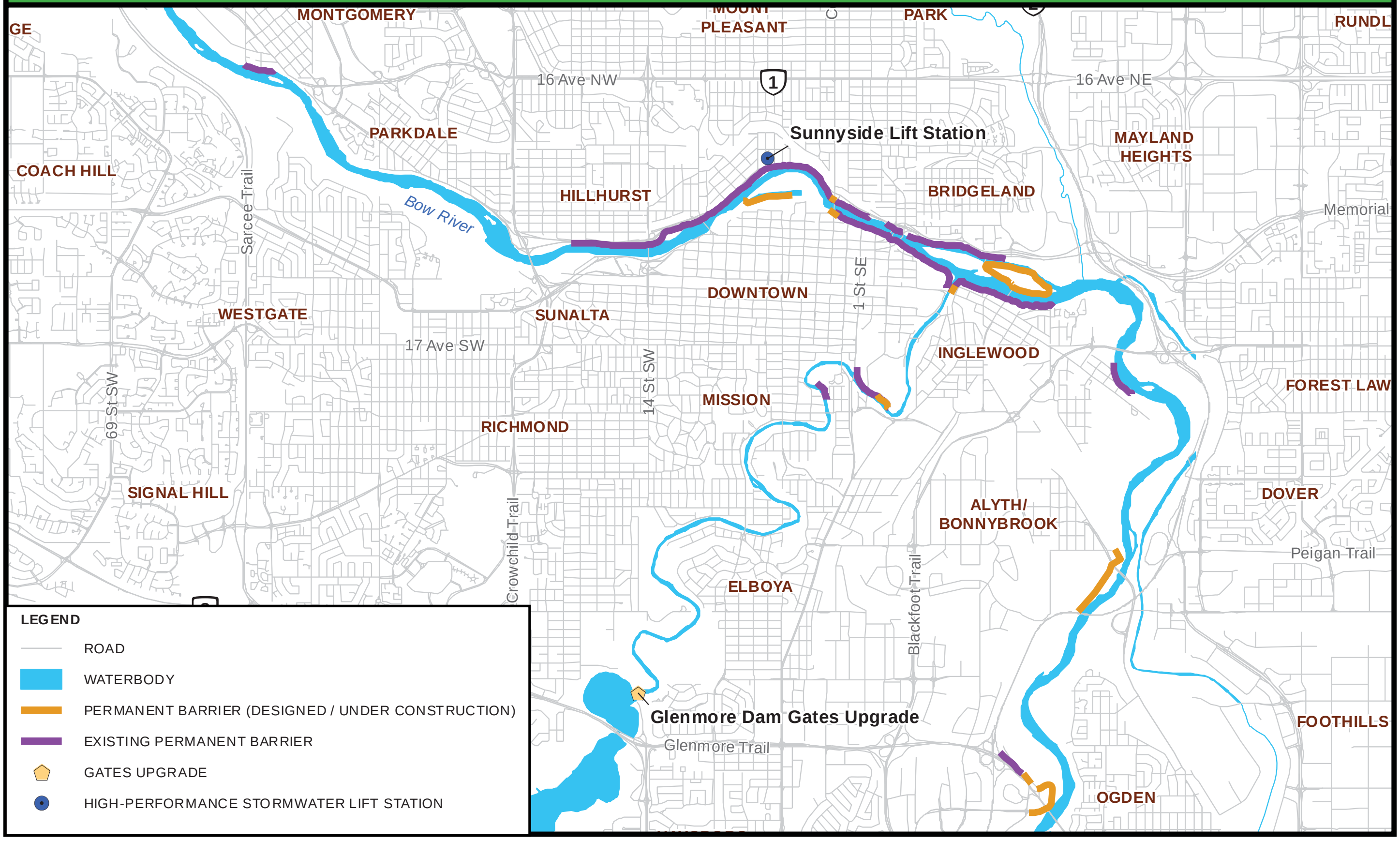
GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	6	4
	Equitable protection	-12	11
	Vulnerable populations	3	4
	River aesthetics	10	2
	Recreation access	10	1
	Emergency access	3	1
	Risk transparency	1	10
ENVIRONMENTAL	Water security	6	5
	Riparian health and ecosystem functions	-4	3
	Water quality and contamination prevention	-4	9
IMPLEMENTATION	Timeliness of Implementation	20	1
	Adaptability/Flexibility	6	6
	Jurisdictional control	0	8
	Regulatory complexity	-4	6
ECONOMIC	Economic Environment	9	4
	Economic Efficiency	15	2
	Damages Averted	10	9
	Total Cost	15	2
	TOTAL SCORE	90	3

Benefit/Cost Analysis

Development Cost	$510,000,000
O&M	$5,100,000
PV Benefits (average annual damages)	$2,255,422,000
PV Costs (development & operating total cost)	$701,065,000
Benefit / Cost Ratio	3.22
Net Present Value	$1,554,357,000

Category of Damages		Scenario 1			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$71,376,591		$45,201,842	
Building-related (Direct, Displacement, Intangible)	Overland	$28,713,460	40.2%	$21,606,507	47.8%
	Groundwater	$13,175,420	18.5%	$12,790,841	28.3%
Infrastructure, Traffic, Habitat, Emergency Response		$12,739,140	17.8%	$7,018,131	15.5%
Isolated (all categories)		$17,032,942	23.9%	$2,942,026	6.5%
Evacuation (no direct damage)		-$284,372	-0.4%	$844,338	1.9%
Bow River		$43,640,325	61.1%	$31,487,386	69.7%
Elbow River		$27,736,265	38.9%	$13,714,456	30.3%

Location



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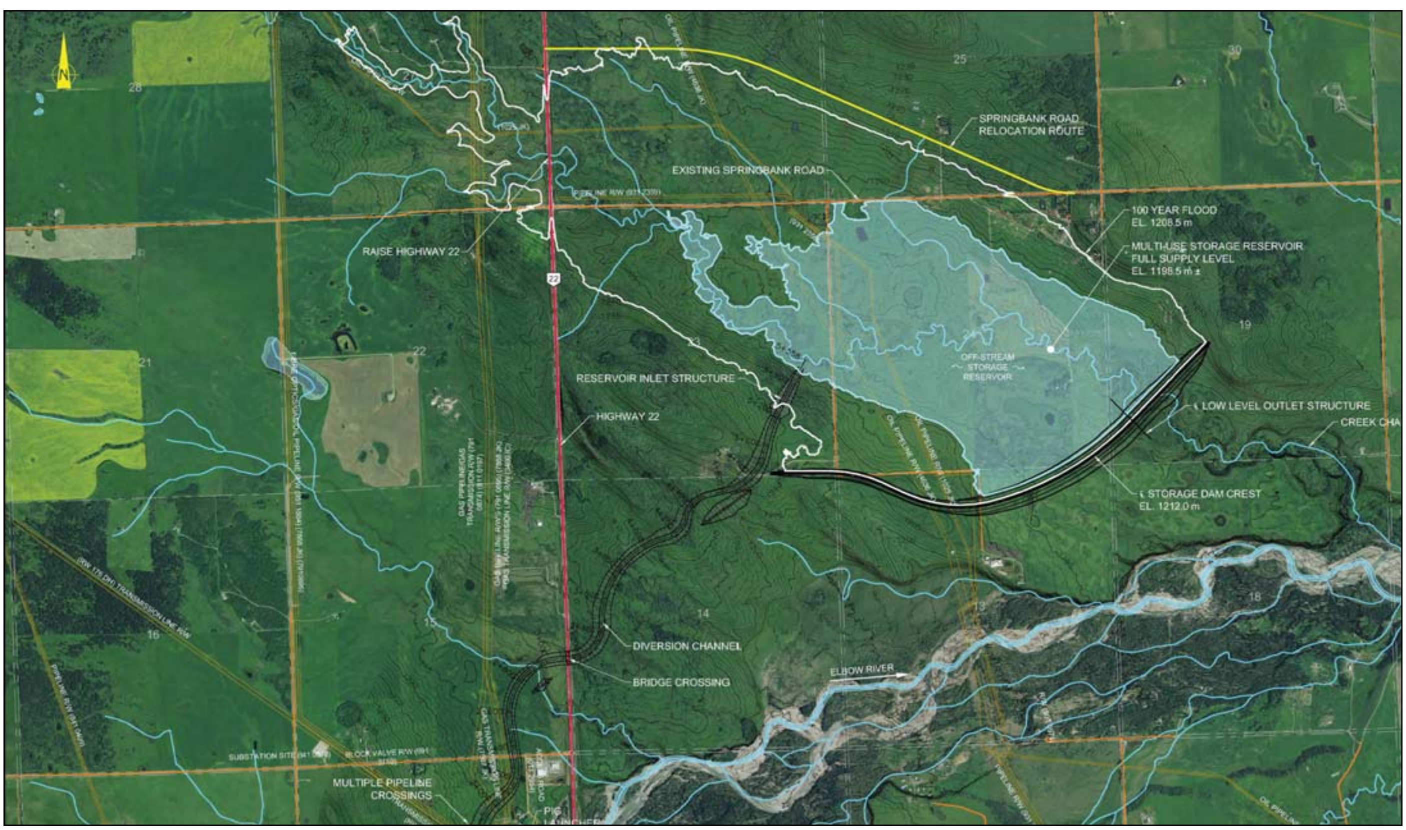


4.6.4 EVALUATION OF FLOOD MITIGATION SCENARIO 1a

Description & Discussion

This scenario includes SR1, stormwater drainage improvements at Sunnyside and Quarry Park and a new operating regime for TransAlta's hydro facilities and reservoirs in the Bow River basin. The additional component is the installation of barriers to the 1:350 year level of protection for the downtown area. The barriers would total approximately 14 km in length and average between 0.6 and 3.0 m in height.

This scenario provides an additional measure of benefits in the order of $4 million in average annual damages averted; however, at a much higher cost (± $800 million over Scenario 1). The high downtown barriers would have a detrimental impact in terms of aesthetics, access and resident psychology (walled city effect).

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	8	3
	Equitable protection	-15	12
	Vulnerable populations	4	3
	River aesthetics	2	5
	Recreation access	-2	6
	Emergency access	2	4
	Risk transparency	2	8
ENVIRONMENTAL	Water security	6	5
	Riparian health and ecosystem functions	-4	3
	Water quality and contamination prevention	-4	9
IMPLEMENTATION	Timeliness of Implementation	16	2
	Adaptability/Flexibility	6	6
	Jurisdictional control	3	5
	Regulatory complexity	-4	6
ECONOMIC	Economic Environment	15	1
	Economic Efficiency	1	5
	Damages Averted	13	7
	Total Cost	5	4
	TOTAL SCORE	53	4

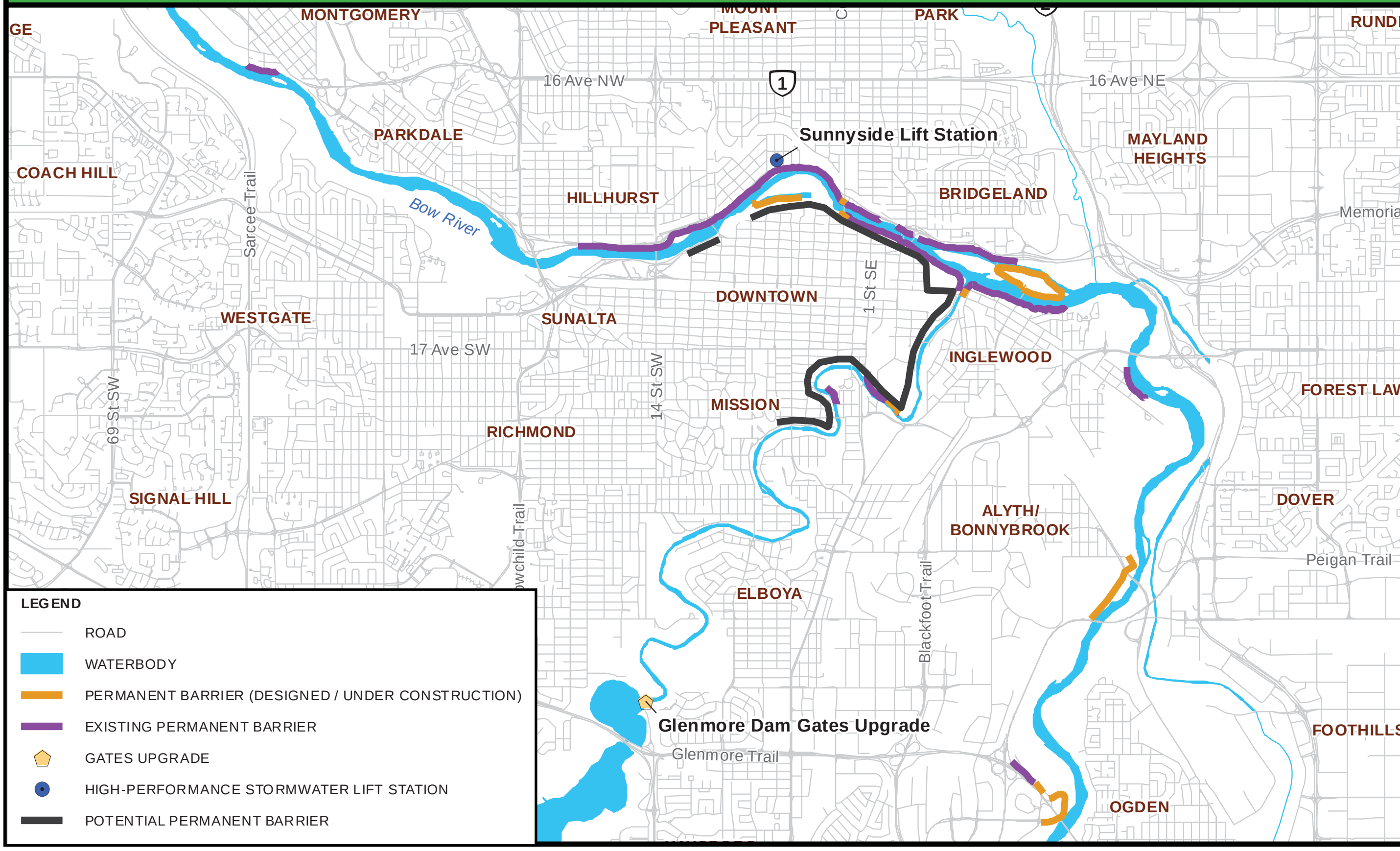
Benefit/Cost Analysis

Development Cost	$992,645,885
O&M*	$5,100,000
PV Benefits (average annual damages)	$2,394,764,000
PV Costs (development & operating total cost)	$1,183,711,000
Benefit / Cost Ratio	2.02
Net Present Value	$1,211,053,000

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 1a			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$75,786,288		$40,792,145	
Building-related (Direct, Displacement, Intangible)	Overland	$31,476,345	41.5%	$18,843,622	46.2%
	Groundwater	$13,362,214	17.6%	$12,604,047	30.9%
Infrastructure, Traffic, Habitat, Emergency Response		$13,032,971	17.2%	$6,724,300	16.5%
Isolated (all categories)		$18,328,021	24.2%	$1,646,947	4.0%
Evacuation (no direct damage)		-$413,263	-0.5%	$973,229	2.4%
Bow River		$46,728,017	61.7%	$28,399,694	69.6%
Elbow River		$29,058,269	38.3%	$12,392,452	30.4%

Location



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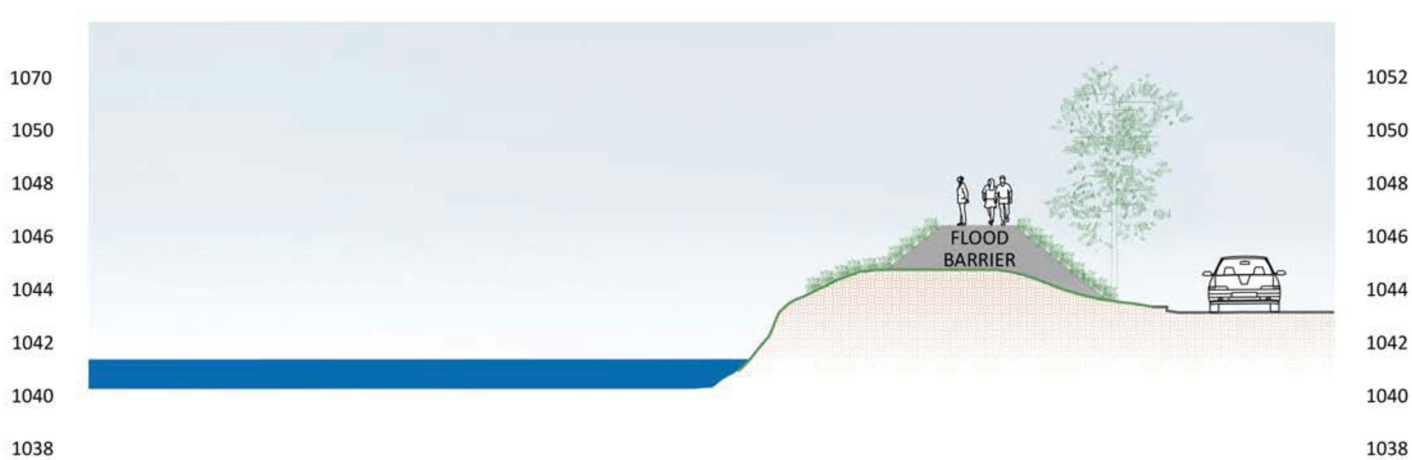


4.6.5 EVALUATION OF FLOOD MITIGATION SCENARIO 2

Description & Discussion

This scenario includes SR1 plus a new reservoir upstream on the Bow in addition to TransAlta's modified operating regime and stormwater and drainage improvements. The development cost and estimated attenuation provided by a single reservoir on the Bow River was provided by The City.

This scenario provides the third highest benefits/level of protection, with average annual damages averted estimated at $85 million. It has a benefit/cost ratio of 1.35, with the fourth highest capital cost. It has the least impact at the community level – being the least intrusive. It also has the potential for very high incidental benefits related to water supply, irrigation and recreation.

Benefit/Cost Analysis

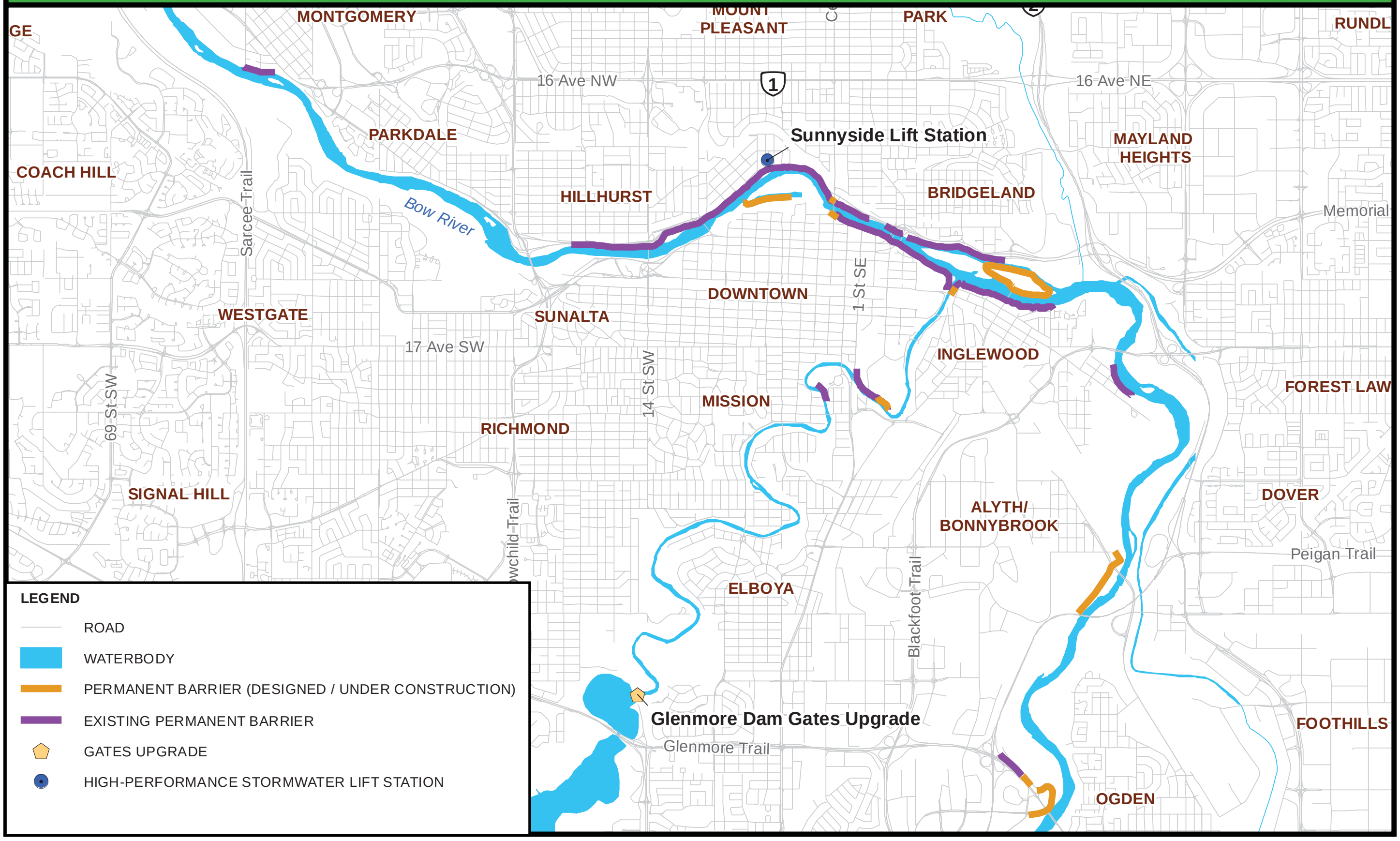
Development Cost	$1,410,000,000
O&M	$14,100,000
PV Benefits (average annual damages)	$2,676,498,000
PV Costs (development & operating total cost)	$1,988,997,000
Benefit / Cost Ratio	1.35
Net Present Value	$687,501,000

Triple Bottom Line Analysis

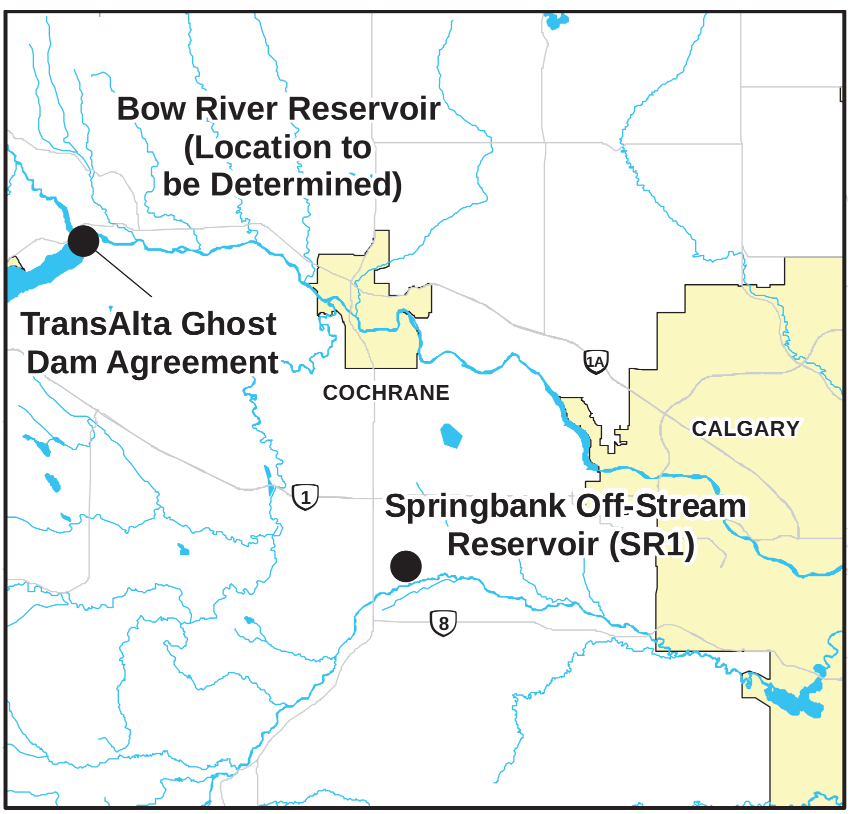
GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	12	1
	Equitable protection	9	4
	Vulnerable populations	5	1
	River aesthetics	10	2
	Recreation access	10	1
	Emergency access	3	1
	Risk transparency	1	10
ENVIRONMENTAL	Water security	36	1
	Riparian health and ecosystem functions	-4	3
	Water quality and contamination prevention	0	3
IMPLEMENTATION	Timeliness of Implementation	-12	8
	Adaptability/Flexibility	12	2
	Jurisdictional control	-9	12
	Regulatory complexity	6	2
ECONOMIC	Economic Environment	15	1
	Economic Efficiency	-7	8
	Damages Averted	18	3
	Total Cost	-12	9
	TOTAL SCORE	93	2

Category of Damages		Scenario 2			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$84,702,228		$31,876,205	
Building-related (Direct, Displacement, Intangible)	Overland	$43,628,028	51.5%	$6,691,939	21.0%
	Groundwater	$6,262,418	7.4%	$19,703,843	61.8%
Infrastructure, Traffic, Habitat, Emergency Response		$17,087,199	20.2%	$2,670,072	8.4%
Isolated (all categories)		$18,073,212	21.3%	$1,901,756	6.0%
Evacuation (no direct damage)		-$348,630	-0.4%	$908,596	2.9%
Bow River		$56,180,864	66.3%	$18,946,847	59.4%
Elbow River		$28,521,363	33.7%	$12,929,358	40.6%

Location



Reservoir Location Map



4.6.6 EVALUATION OF FLOOD MITIGATION SCENARIO 3

Description & Discussion

This scenario entails a new reservoir upstream on the Bow River along with barriers on the Elbow River. The barriers total 14.6 km and average between 1.6 and 3.0 m in height with a max height of 6.3 m. The barriers are a combination of walls and berms. Buyouts would be required in many location where they would be located on what is currently private property.

This scenario provides one of the lower levels of overall protection with benefits estimated at $72 million in average annual damages averted. The Elbow barriers are costly and difficult to integrate into the community, in addition to impacting aesthetics and access to the river. Flood damages related to groundwater remain high because of groundwater propagation beneath the barriers and the increased duration of high flows released from the upstream storage facility on the Bow River. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-8	6
	Equitable protection	-6	8
	Vulnerable populations	2	5
	River aesthetics	-10	9
	Recreation access	-8	7
	Emergency access	-1	6
	Risk transparency	3	3
ENVIRONMENTAL	Water security	36	1
	Riparian health and ecosystem functions	-16	7
	Water quality and contamination prevention	4	1
IMPLEMENTATION	Timeliness of Implementation	-20	11
	Adaptability/Flexibility	9	3
	Jurisdictional control	-6	9
	Regulatory complexity	-6	8
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	-11	11
	Damages Averted	10	8
	Total Cost	-15	11
	TOTAL SCORE	-36	12

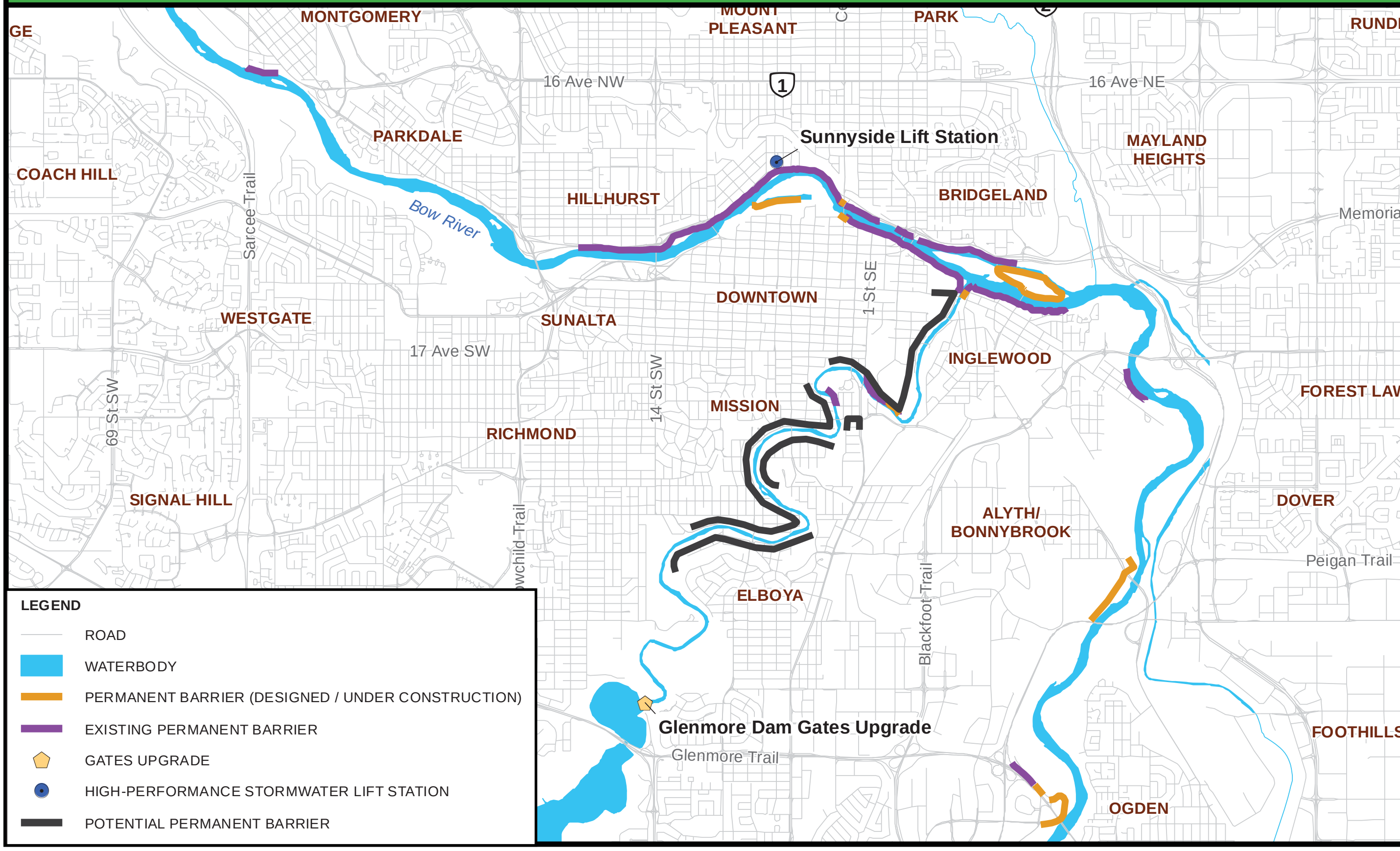
Benefit/Cost Analysis

Development Cost	$1,802,850,000
O&M*	$9,100,000
PV Benefits (average annual damages)	$2,270,535,000
PV Costs (development & operating total cost)	$2,143,770,000
Benefit / Cost Ratio	1.06
Net Present Value	$126,765,000

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 3 Benefits		Scenario 3 Residual AAD	
Total Average Annual Damages (AAD)		$71,854,851		$44,723,582	
Building-related (Direct, Displacement, Intangible)	Overland	$39,641,494	55.2%	$10,678,473	23.9%
	Groundwater	-$1,640,083	-2.3%	$27,606,344	61.7%
Infrastructure, Traffic, Habitat, Emergency Response		$16,100,183	22.4%	$3,657,088	8.2%
Isolated (all categories)		$17,966,624	25.0%	$2,008,344	4.5%
Evacuation (no direct damage)		-$213,367	-0.3%	$773,333	1.7%
Bow River		$49,935,679	69.5%	$25,192,032	56.3%
Elbow River		$21,919,171	30.5%	$19,531,550	43.7%

Location



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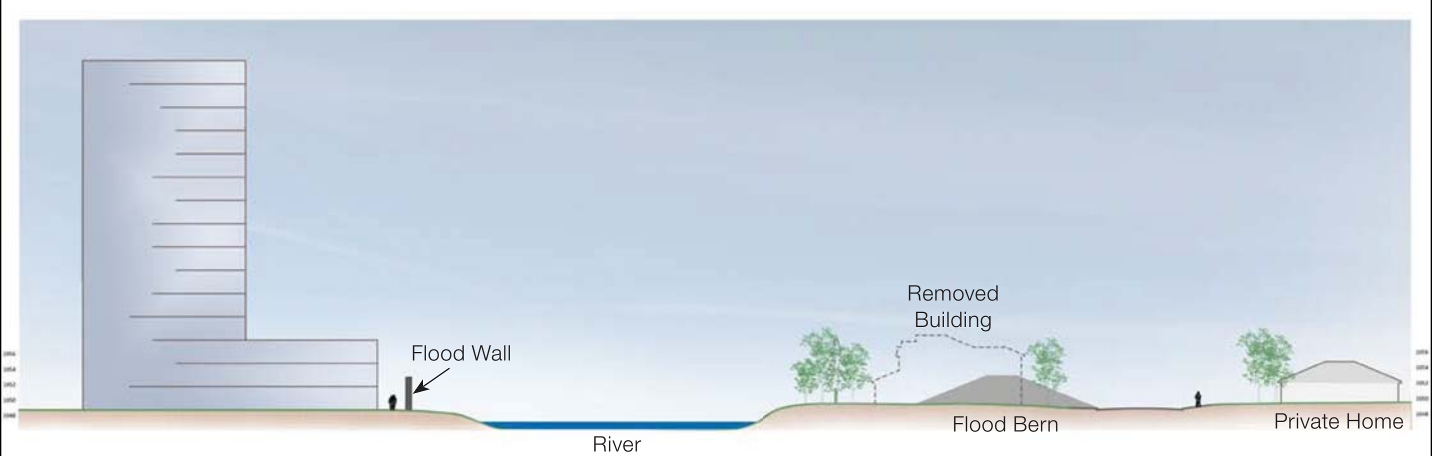


4.6.7 EVALUATION OF FLOOD MITIGATION SCENARIO 3a

Description & Discussion

This scenario includes one new reservoir upstream on the Bow River and barriers along the Elbow River (Scenario 3) with the added benefit of groundwater protection in the construction of the barriers. The barriers total 14.6 km and average between 1.6 and 3.0 m in height with a max height of 6.3 m. The barriers are a combination of walls and berms. Buyouts would be required in many location where they would be located on what is currently private property.

This scenario provides the same benefit/cost ratio as 3 as increased benefits are offset by increased costs, although the AAD averted is substantially higher by ±$6.5 million. Groundwater flooding remains an issue along the Bow River. The Elbow barriers are costly and difficult to integrate into the community, in addition to impacting aesthetics and access to the river. Flood damages related to groundwater remain high because of groundwater propagation beneath the barriers and the increased duration of high flows released from the upstream storage facility on the Bow River. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

Benefit/Cost Analysis

Development Cost	$1,959,100,000
O&M*	$9,100,000
PV Benefits (average annual damages)	$2,476,359,000
PV Costs (development & operating total cost)	$2,300,020,000
Benefit / Cost Ratio	1.08
Net Present Value	$176,339,000

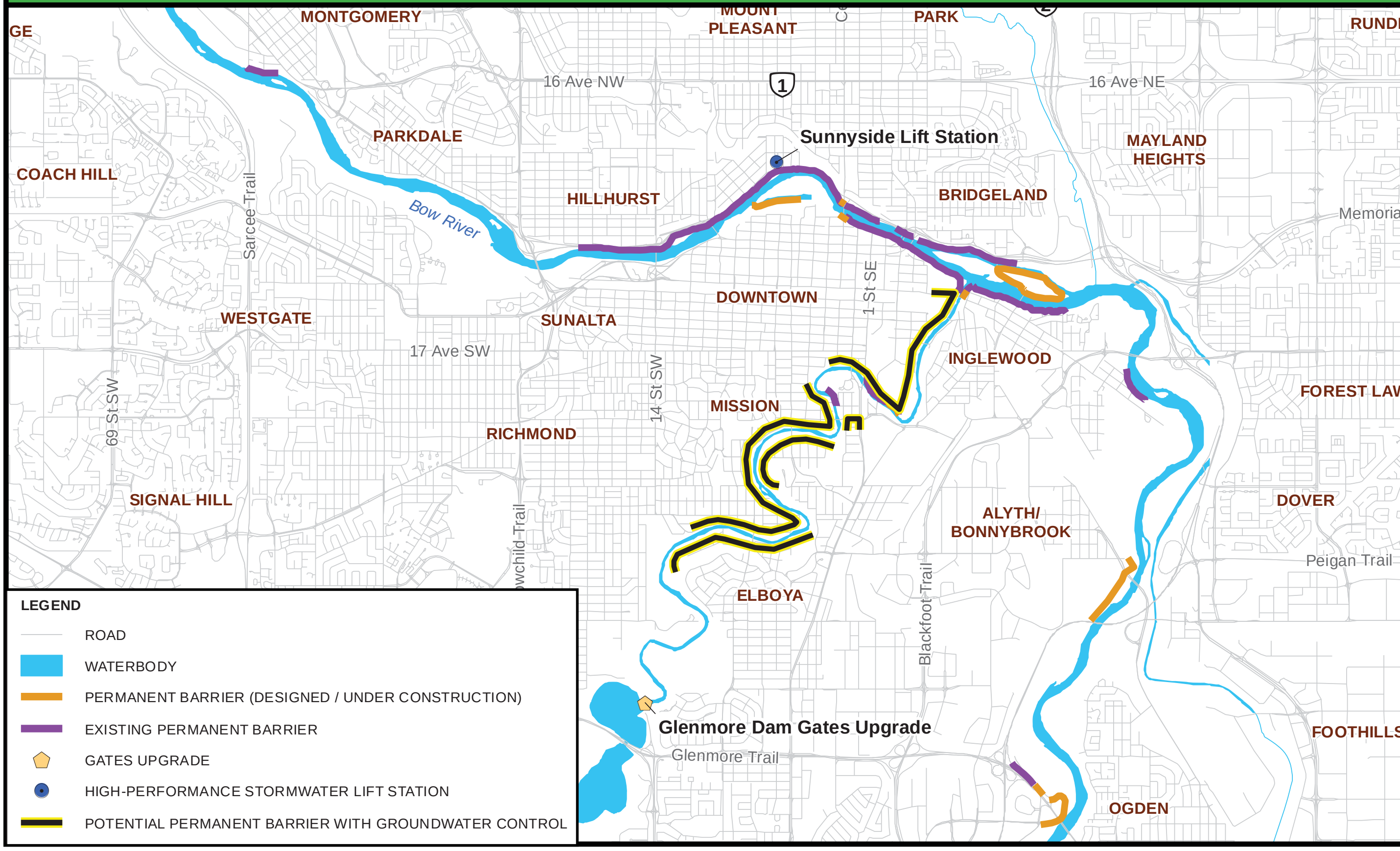
Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-8	6
	Equitable protection	-6	8
	Vulnerable populations	2	5
	River aesthetics	-10	9
	Recreation access	-8	7
	Emergency access	-1	6
	Risk transparency	3	3
ENVIRONMENTAL	Water security	36	1
	Riparian health and ecosystem functions	-16	7
	Water quality and contamination prevention	4	1
IMPLEMENTATION	Timeliness of Implementation	-20	11
	Adaptability/Flexibility	9	3
	Jurisdictional control	-6	9
	Regulatory complexity	-6	8
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	-11	10
	Damages Averted	14	6
	Total Cost	-18	12
	TOTAL SCORE	-36	10

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 3a Benefits		Scenario 3a Residual AAD	
Total Average Annual Damages (AAD)		$78,368,516		$38,209,917	
Building-related (Direct, Displacement, Intangible)	Overland	$39,641,198	50.6%	$10,678,769	27.9%
	Groundwater	$4,897,738	6.2%	$21,068,523	55.1%
Infrastructure, Traffic, Habitat, Emergency Response		$16,100,067	20.5%	$3,657,204	9.6%
Isolated (all categories)		$17,966,624	22.9%	$2,008,344	5.3%
Evacuation (no direct damage)		-$237,112	-0.3%	$797,078	2.1%
Bow River		$50,236,642	64.1%	$24,891,069	65.1%
Elbow River		$28,131,872	35.9%	$13,318,849	34.9%

Location



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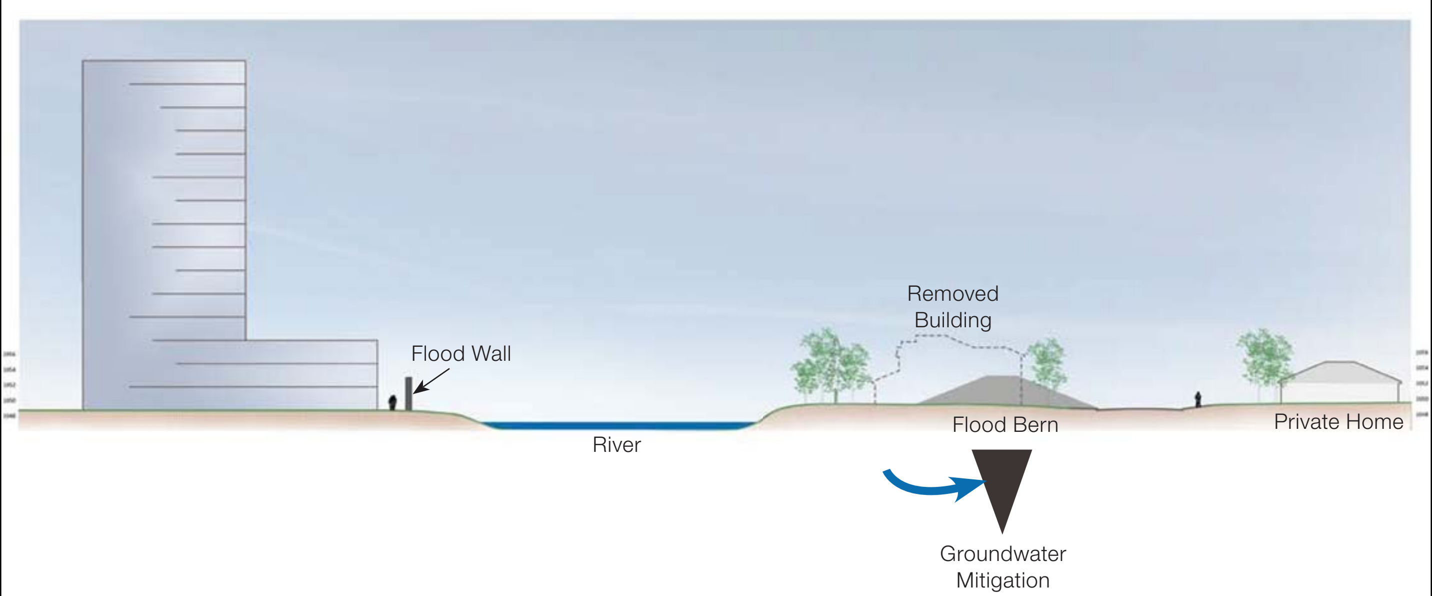


4.6.8 EVALUATION OF FLOOD MITIGATION SCENARIO 4

Description & Discussion

Scenario 4 includes the SR1 reservoir along with barriers on the Bow River. Barriers would be required in 21 locations and total nearly 30 km. The average barrier height would be lower than that required on the Elbow River, averaging between 0.9 and 2.8 m.

This scenario provides the second highest B/C ratio at 2.43 as a result of the $81 million of damages averted (second highest) along with the second lowest costs. Many barriers will require purchase of land along the river where space is needed to build them. They will also change the visual aesthetics of the river and nearby communities and may affect the location and number of access points for recreational activities. There is also significant impact of the natural riverbank environment including drainage and interactions between the river and floodplain areas. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

Benefit/Cost Analysis

Development Cost	$903,286,859
O&M*	$5,100,000
PV Benefits (average annual damages)	$2,773,550,000
PV Costs (development & operating total cost)	$1,094,352,000
Benefit / Cost Ratio	2.53
Net Present Value	$1,679,198,000

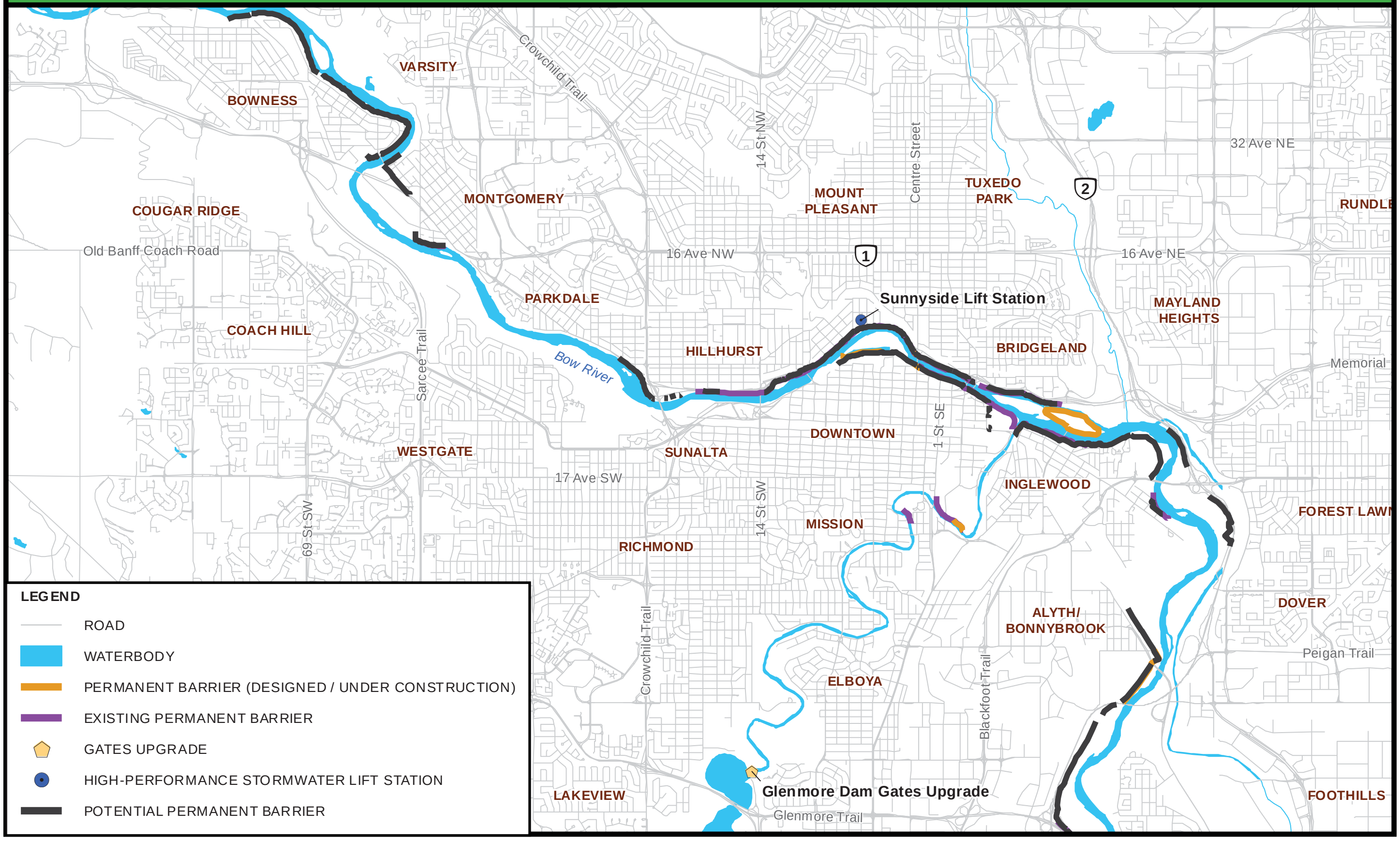
Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-10	8
	Equitable protection	6	5
	Vulnerable populations	2	5
	River aesthetics	-8	7
	Recreation access	-10	9
	Emergency access	-1	6
	Risk transparency	3	3
ENVIRONMENTAL	Water security	6	5
	Riparian health and ecosystem functions	-16	7
	Water quality and contamination prevention	-4	9
IMPLEMENTATION	Timeliness of Implementation	4	3
	Adaptability/Flexibility	6	6
	Jurisdictional control	3	5
	Regulatory complexity	-6	8
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	7	3
	Damages Averted	16	5
	Total Cost	7	3
	TOTAL SCORE	11	6

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 4			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$81,944,251		$34,634,182	
Building-related (Direct, Displacement, Intangible)	Overland	$36,060,137	44.0%	$14,259,830	41.2%
	Groundwater	$11,963,763	14.6%	$14,002,498	40.4%
Infrastructure, Traffic, Habitat, Emergency Response		$16,169,739	19.7%	$3,587,532	10.4%
Isolated (all categories)		$18,082,192	22.1%	$1,892,776	5.5%
Evacuation (no direct damage)		-$331,580	-0.4%	$891,546	2.6%
Bow River		$54,352,922	66.3%	$20,774,789	60.0%
Elbow River		$27,591,329	33.7%	$13,859,392	40.0%

Location



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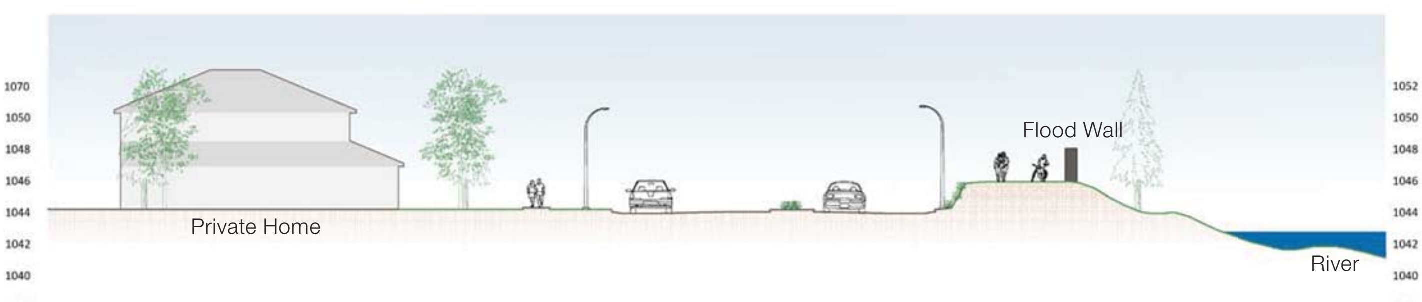


4.6.9 EVALUATION OF FLOOD MITIGATION SCENARIO 4a

Description & Discussion

This is a variation of Scenario 4 with groundwater controls installed as part of the barrier construction. Scenario 4 includes the SR1 reservoir along with barriers on the Bow River. Barriers would be required in 21 locations and total nearly 30 km. The average barrier height would be lower than that required on the Elbow River, averaging between 0.9 and 2.8 m.

The benefit/cost ratio is less than the without groundwater protection option because the present value of the costs increase is greater than the present value of the additional benefits. Additionally, there is no groundwater protection for the Elbow River. Many barriers will require purchase of land along the river where space is needed to build them. They will also change the visual aesthetics of the river and nearby communities and may affect the location and number of access points for recreational activities. There is also significant impact of the natural riverbank environment including drainage and interactions between the river and floodplain areas. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

Benefit/Cost Analysis

Development Cost	$1,134,672,408
O&M*	$5,100,000
PV Benefits (average annual damages)	$2,773,550,000
PV Costs (development & operating total cost)	$1,325,737,000
Benefit / Cost Ratio	2.09
Net Present Value	$1,447,813,000

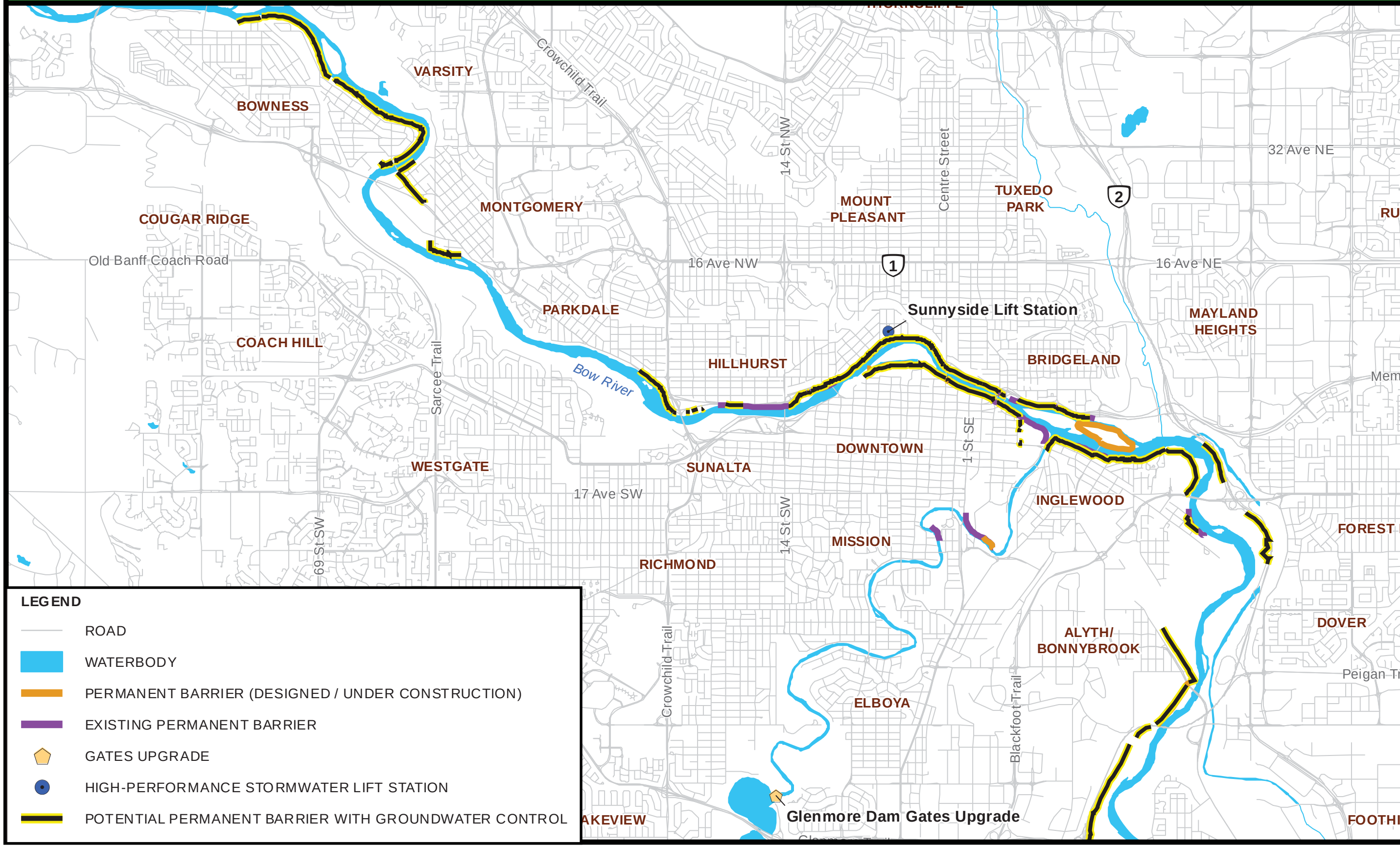
Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-10	8
	Equitable protection	6	5
	Vulnerable populations	2	5
	River aesthetics	-8	7
	Recreation access	-10	9
	Emergency access	-1	6
	Risk transparency	3	3
ENVIRONMENTAL	Water security	6	5
	Riparian health and ecosystem functions	-16	7
	Water quality and contamination prevention	-4	9
IMPLEMENTATION	Timeliness of Implementation	4	3
	Adaptability/Flexibility	6	6
	Jurisdictional control	3	5
	Regulatory complexity	-6	8
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	1	4
	Damages Averted	20	1
	Total Cost	2	5
	TOTAL SCORE	4	7

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 4a			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$87,773,605		$28,804,828	
Building-related (Direct, Displacement, Intangible)	Overland	$36,690,150	41.8%	$13,629,817	47.3%
	Groundwater	$17,080,853	19.5%	$8,885,408	30.8%
Infrastructure, Traffic, Habitat, Emergency Response		$16,240,358	18.5%	$3,516,913	12.2%
Isolated (all categories)		$18,133,617	20.7%	$1,841,351	6.4%
Evacuation (no direct damage)		-$371,373	-0.4%	$931,339	3.2%
Bow River		$60,008,834	68.4%	$15,118,877	52.5%
Elbow River		$27,764,770	31.6%	$13,685,951	47.5%

Location



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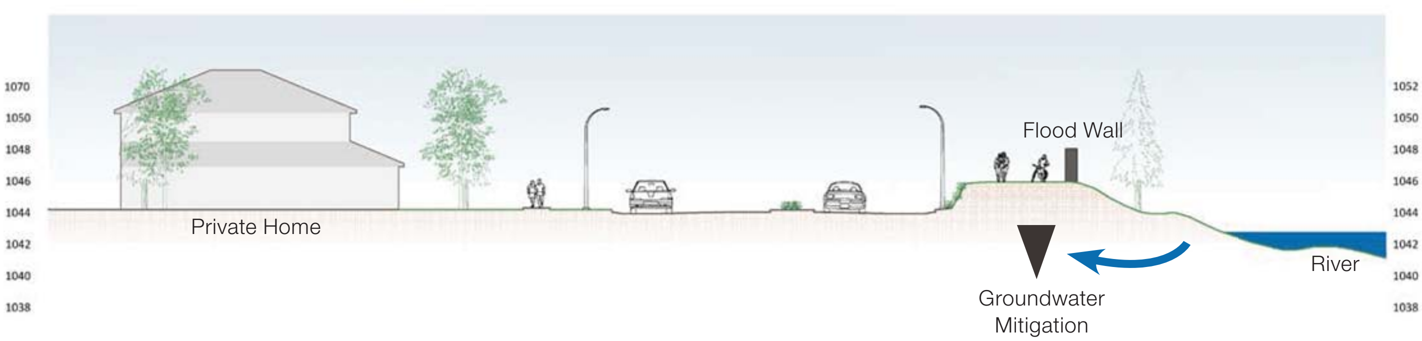


4.6.10 EVALUATION OF FLOOD MITIGATION SCENARIO 5

Description & Discussion

This option includes barriers on both the Bow and Elbow Rivers in the absence of any new upstream storage facilities. Protecting to a 1:200 year level, the barriers are extensive and total nearly 44 km of along both rivers. Average barrier height is between 0.7 m and 2.9 m. Many barriers will require purchase of land along the river where space is needed to build them. They will also change the visual aesthetics of the river and nearby communities and may affect the location and number of access points for recreational activities. There is also significant impact of the natural riverbank environment including drainage and interactions between the river and floodplain areas. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

The benefit/cost ratio is 1.69. This option has the lowest benefits of all the structural options because once overtopped, barriers provide no protection.

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-12	11
	Equitable protection	15	1
	Vulnerable populations	1	9
	River aesthetics	-12	11
	Recreation access	-12	11
	Emergency access	-2	10
	Risk transparency	4	1
ENVIRONMENTAL	Water security	0	9
	Riparian health and ecosystem functions	-24	11
	Water quality and contamination prevention	0	3
IMPLEMENTATION	Timeliness of Implementation	-16	9
	Adaptability/Flexibility	-3	11
	Jurisdictional control	9	2
	Regulatory complexity	4	3
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	-3	6
	Damages Averted	10	10
	Total Cost	2	6
	TOTAL SCORE	-33	8

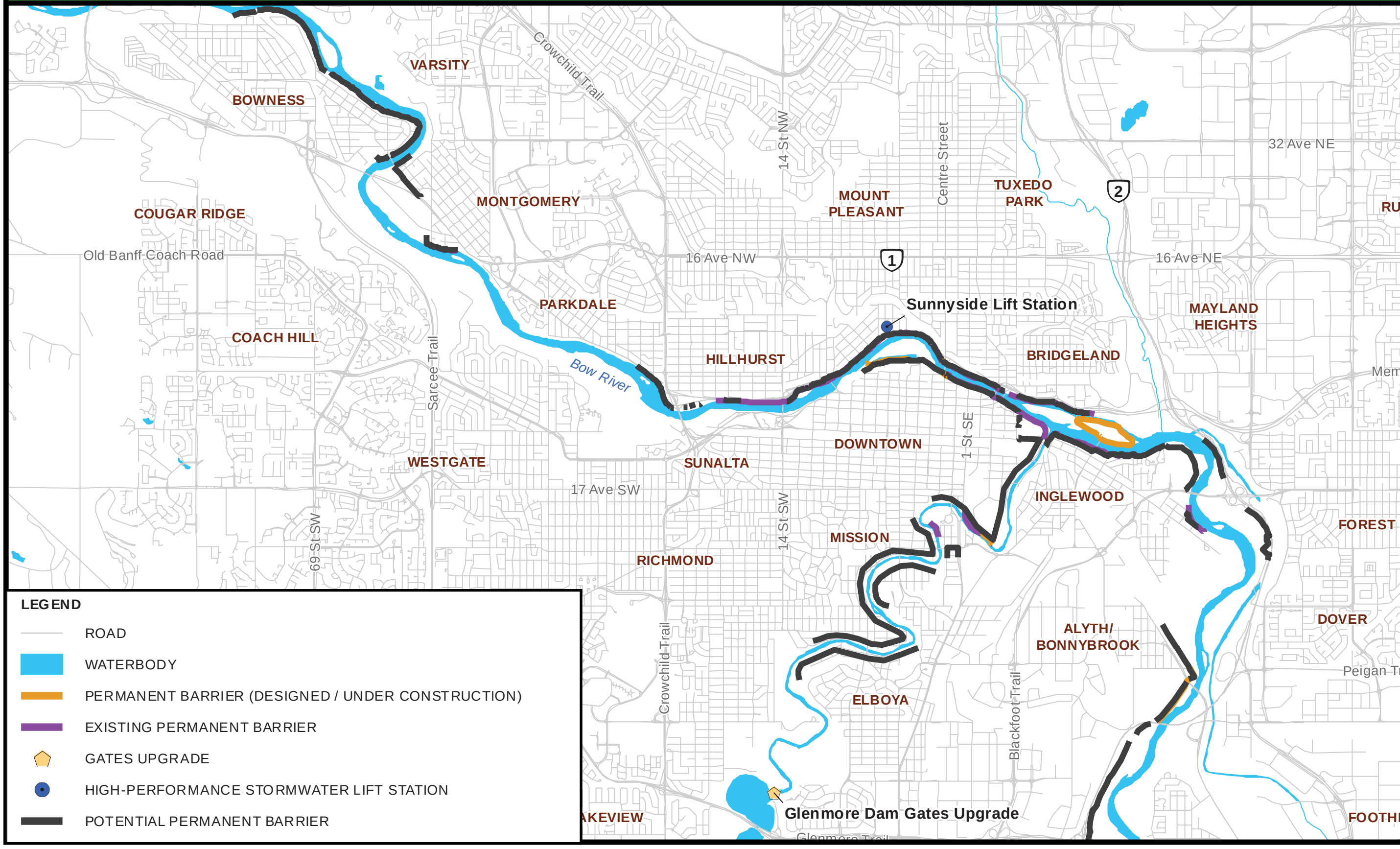
Benefit/Cost Analysis

Development Cost	$1,323,036,113
O&M*	$100,000
PV Benefits (average annual damages)	$2,241,871,000
PV Costs (development & operating total cost)	$1,326,782,000
Benefit / Cost Ratio	1.69
Net Present Value	$915,089,000

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 5			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$70,947,758		$45,630,675	
Building-related (Direct, Displacement, Intangible)	Overland	$31,771,895	44.8%	$18,548,072	40.6%
	Groundwater	$5,899,627	8.3%	$20,066,634	44.0%
Infrastructure, Traffic, Habitat, Emergency Response		$15,602,116	22.0%	$4,155,155	9.1%
Isolated (all categories)		$17,916,899	25.3%	$2,058,069	4.5%
Evacuation (no direct damage)		-$242,778	-0.3%	$802,744	1.8%
Bow River		$50,139,681	70.7%	$24,988,030	54.8%
Elbow River		$20,808,077	29.3%	$20,642,644	45.2%

Location



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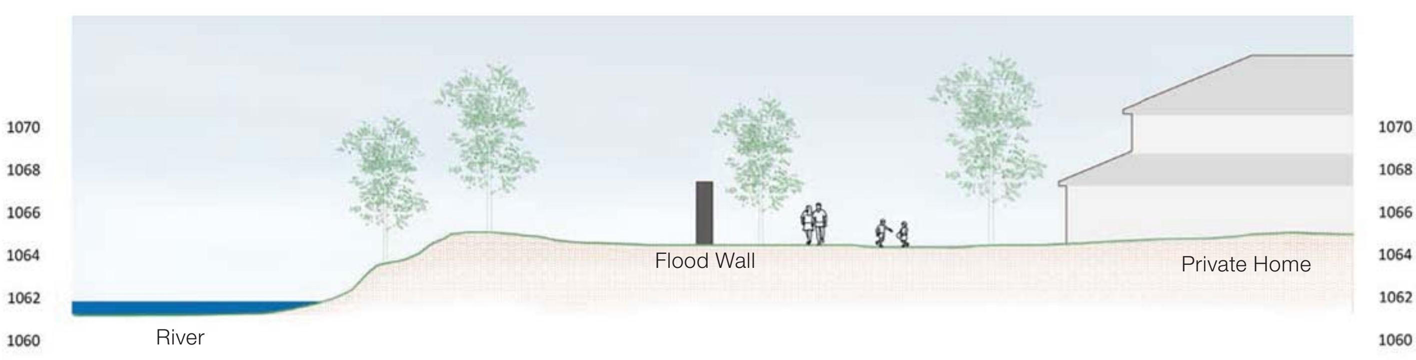


4.6.11 EVALUATION OF FLOOD MITIGATION SCENARIO 5a

Description & Discussion

This option includes barriers on both the Bow and Elbow Rivers as in Scenario 5 but with added groundwater protection. Protecting to a 1:200 year level, the barriers are extensive and total nearly 44 km of along both rivers. Average barrier height is between 0.7 m and 2.9 m. Many barriers will require purchase of land along the river where space is needed to build them. They will also change the visual aesthetics of the river and nearby communities and may affect the location and number of access points for recreational activities. There is also significant impact of the natural riverbank environment including drainage and interactions between the river and floodplain areas. Barriers do not provide any additional benefits to the watershed such as drought management, energy generation or recreation and depending upon the size of the flood event, communities protected by barriers may still need to be evacuated for safety.

The benefit/cost ratio is 1.55. Although providing substantially higher benefits than Scenario 5, the benefit/cost ratio is lower due to the increased cost of the groundwater protection on all barriers.

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-12	11
	Equitable protection	15	1
	Vulnerable populations	1	9
	River aesthetics	-12	11
	Recreation access	-12	11
	Emergency access	-2	10
	Risk transparency	4	1
ENVIRONMENTAL	Water security	0	9
	Riparian health and ecosystem functions	-24	11
	Water quality and contamination prevention	0	3
IMPLEMENTATION	Timeliness of Implementation	-16	9
	Adaptability/Flexibility	-3	11
	Jurisdictional control	9	2
	Regulatory complexity	4	3
ECONOMIC	Economic Environment	6	5
	Economic Efficiency	-5	7
	Damages Averted	18	4
	Total Cost	-6	7
	TOTAL SCORE	-36	11

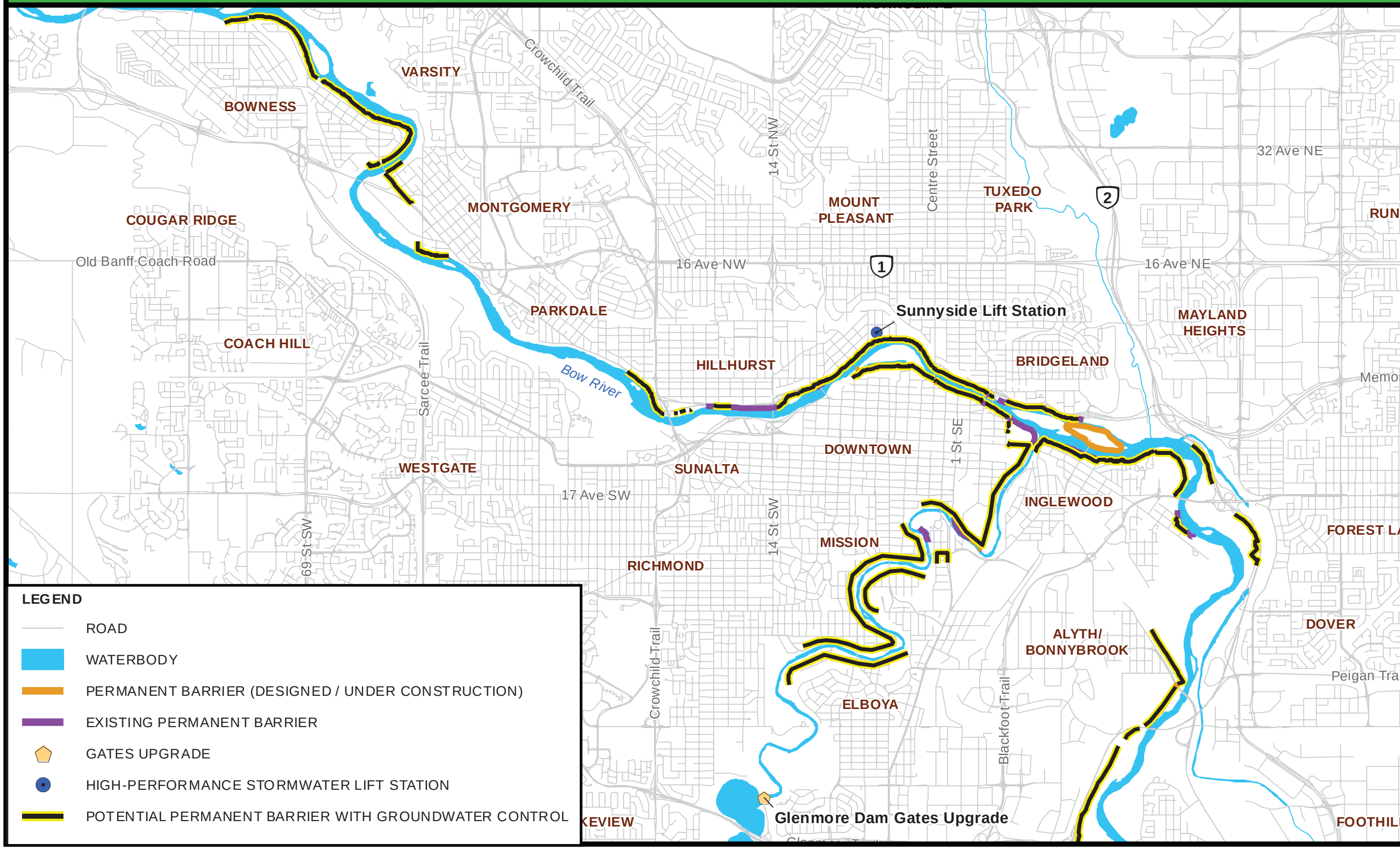
Benefit/Cost Analysis

Development Cost	$1,725,662,291
O&M*	$100,000
PV Benefits (average annual damages)	$2,672,673,000
PV Costs (development & operating total cost)	$1,729,409,000
Benefit / Cost Ratio	1.55
Net Present Value	$943,264,000

* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 5a			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$84,581,198		$31,997,235	
Building-related (Direct, Displacement, Intangible)	Overland	$32,213,694	38.1%	$18,106,273	56.6%
	Groundwater	$19,194,016	22.7%	$6,772,245	21.2%
Infrastructure, Traffic, Habitat, Emergency Response		$15,602,039	18.4%	$4,155,232	13.0%
Isolated (all categories)		$17,916,899	21.2%	$2,058,069	6.4%
Evacuation (no direct damage)		-$345,450	-0.4%	$905,416	2.8%
Bow River		$57,036,702	67.4%	$18,091,009	56.5%
Elbow River		$27,544,495	32.6%	$13,906,226	43.5%

Location



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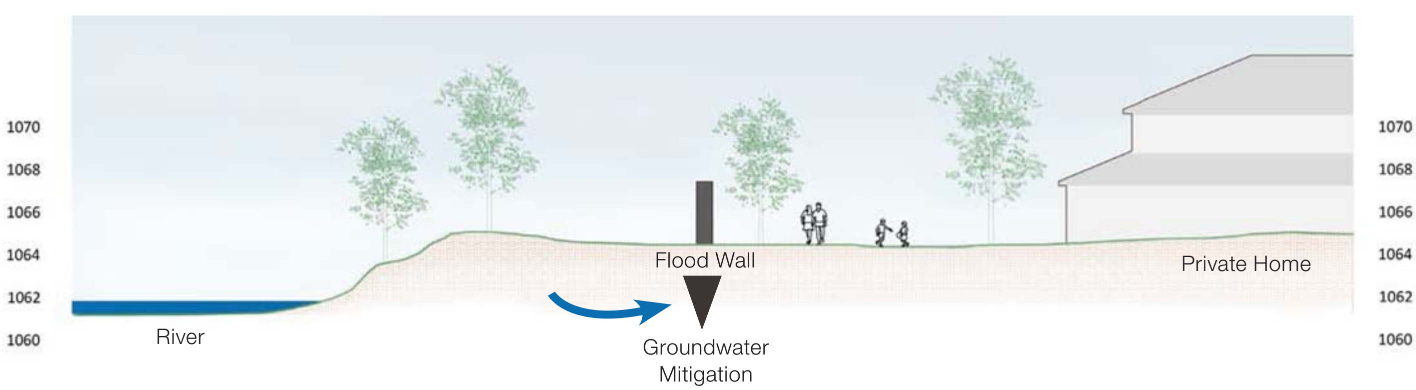


4.6.12 EVALUATION OF FLOOD MITIGATION SCENARIO 6

Description & Discussion

This option considers purchase of all residential properties within the approximate 1:200 year floodway (defined by a 1 m depth) at 2016 assessed values. The majority of properties within the approximate 1:200 floodway are residential. Non-residential properties in the floodway are varied and include the Calgary Stampede, the zoo, the Holy Cross Hospital site, and several schools. Because most non-residential properties would require individual assessment for buyout applicability, only residential properties were included in this analysis.

Within the 1:200 year floodway, there are approximately 980 residential buildings. The total assessed property value amounts to over $1.8 billion. Removal of all the damages associated with these buildings reduces the AAD by $27.2 million.

This option has a negative benefit/cost aspect with a ratio of 0.47. It achieves the lowest average annual benefits by not protecting anything beyond the floodway. In addition, no costs have been determined for restoration or rehabilitation of the land acquired, which could be significant.

Buyouts can be very disruptive to established communities, creating isolated and discontinuous pockets of housing. This can also make service provision less efficient.

Benefit/Cost Analysis

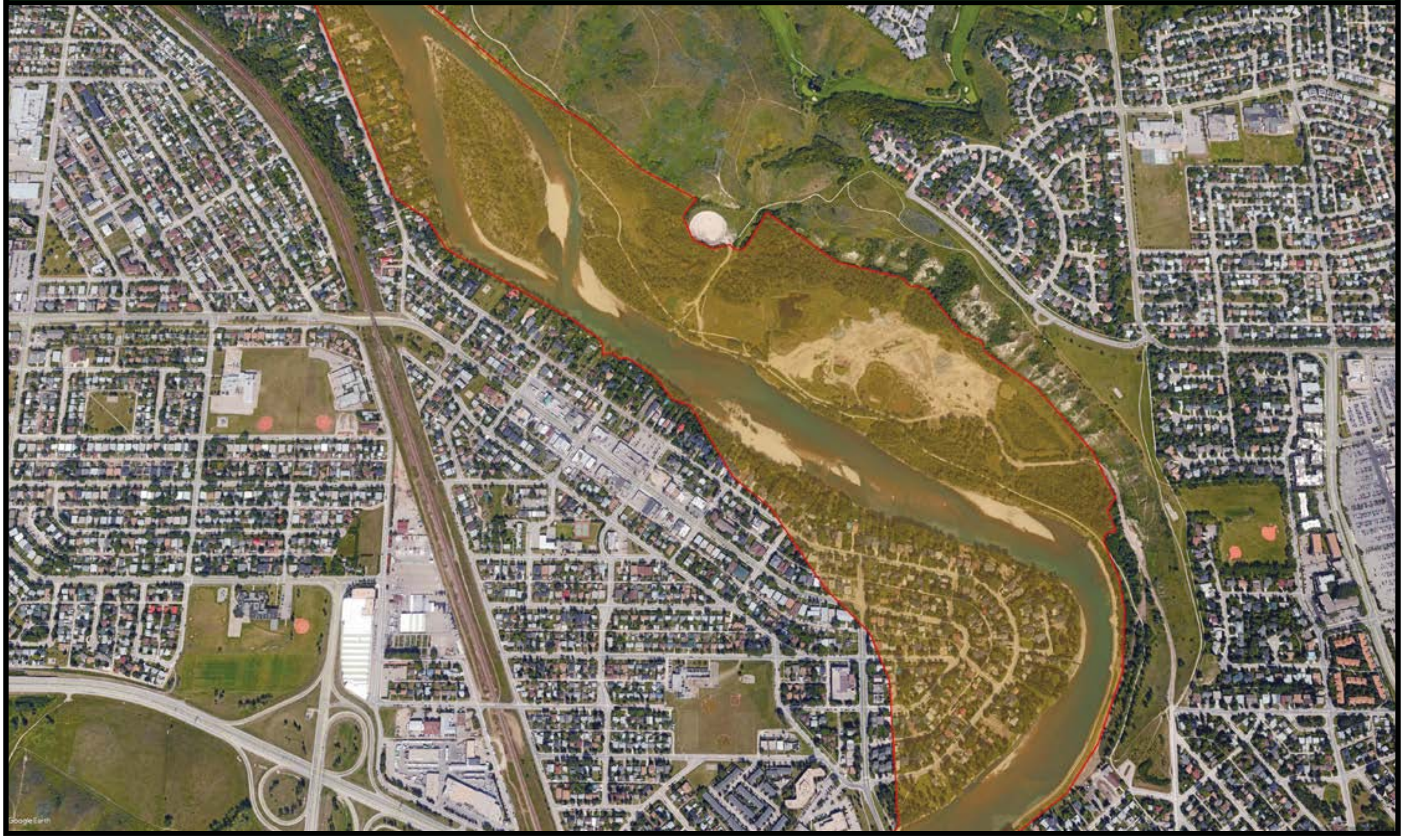
Development Cost	$1,818,000,000
O&M	$0
PV Benefits (average annual damages)	$853,170,000
PV Costs (development & operating total cost)	$1,818,000,000
Benefit / Cost Ratio	0.47
Net Present Value	-$964,830,000

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	-10	8
	Equitable protection	-9	10
	Vulnerable populations	-1	12
	River aesthetics	12	1
	Recreation access	6	4
	Emergency access	-2	10
	Risk transparency	1	10
ENVIRONMENTAL	Water security	0	9
	Riparian health and ecosystem functions	4	1
	Water quality and contamination prevention	0	3
IMPLEMENTATION	Timeliness of Implementation	-4	5
	Adaptability/Flexibility	9	3
	Jurisdictional control	6	4
	Regulatory complexity	-2	5
ECONOMIC	Economic Environment	-3	11
	Economic Efficiency	-18	12
	Damages Averted	-15	11
	Total Cost	-8	8
	TOTAL SCORE	-34	9

Approximate 1:200 Floodway - Elbow River

Approximate 1:200 Floodway - Bowness



4.6.13 EVALUATION OF FLOOD MITIGATION SCENARIO 7

Description & Discussion

As with scenario 2, this option includes a new upstream storage facility on the Bow River as well as SR1 upstream on the Elbow River. However, it adds barriers in three locations along the Bow River because a single upstream dam is not expected to provide full design-level protection. The required barriers would total nearly 4.5 km and average between 0.6 and 1.1 m.

This scenario provides the highest level of benefits/ protection. The additional barriers provide more uniform protections to all communities. The estimated development costs are in the middle of all other options and the benefit cost ratio is positive at 1.41. It also has the potential for very high incidental benefits related to water supply, irrigation, and recreation. As with other upstream options, the remaining groundwater damages may be conservatively high.

Triple Bottom Line Analysis

GOAL	CRITERIA	SCORE	RANK
SOCIAL	Complete communities	10	2
	Equitable protection	12	3
	Vulnerable populations	5	1
	River aesthetics	8	4
	Recreation access	8	3
	Emergency access	3	1
	Risk transparency	3	3
ENVIRONMENTAL	Water security	36	1
	Riparian health and ecosystem functions	-8	6
	Water quality and contamination prevention	0	3
IMPLEMENTATION	Timeliness of Implementation	-8	6
	Adaptability/Flexibility	15	1
	Jurisdictional control	-6	9
	Regulatory complexity	8	1
ECONOMIC	Economic Environment	15	1
	Economic Efficiency	-8	9
	Damages Averted	18	2
	Total Cost	-12	10
	TOTAL SCORE	99	1

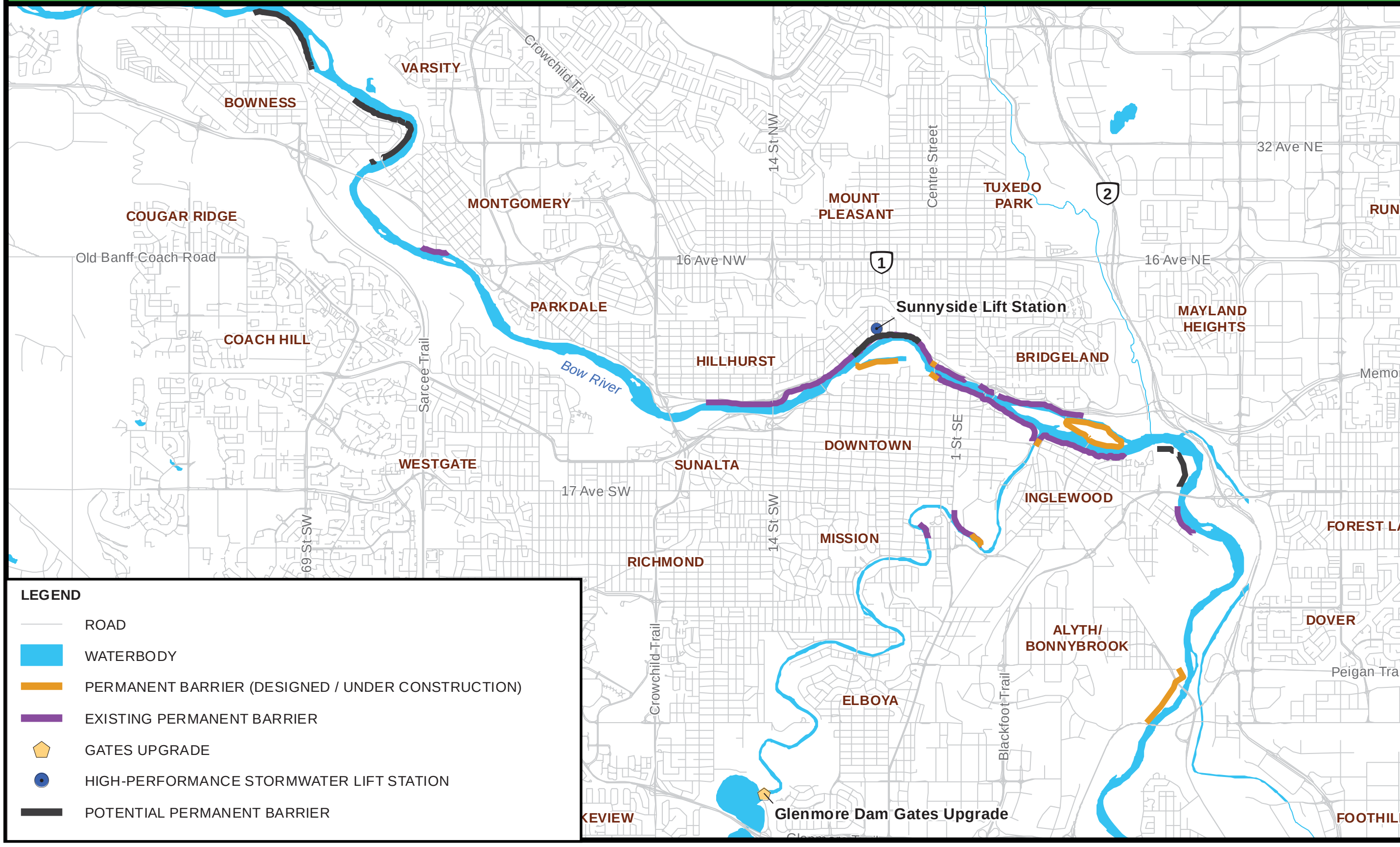
Benefit/Cost Analysis

Development Cost	$1,447,534,050
O&M*	$14,100,000
PV Benefits (average annual damages)	$2,688,400,000
PV Costs (development & operating total cost)	$2,026,531,000
Benefit / Cost Ratio	1.33
Net Present Value	$661,869,000

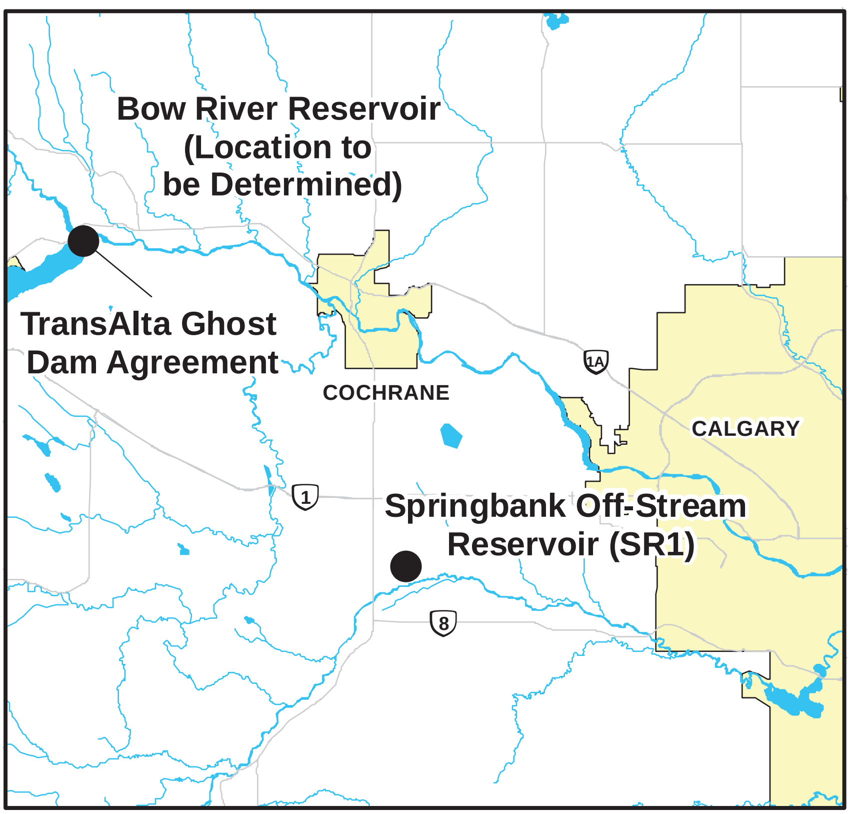
* Net present value of barrier operation and maintenance is included in Development Cost provided by Associated Engineering.

Category of Damages		Scenario 7			
		Benefits		Residual AAD	
Total Average Annual Damages (AAD)		$85,078,882		$31,499,551	
Building-related (Direct, Displacement, Intangible)	Overland	$43,800,492	51.5%	$6,519,475	20.7%
	Groundwater	$6,076,257	7.1%	$19,890,004	63.1%
Infrastructure, Traffic, Habitat, Emergency Response		$17,202,753	20.2%	$2,554,518	8.1%
Isolated (all categories)		$18,348,716	21.6%	$1,626,252	5.2%
Evacuation (no direct damage)		-$349,336	-0.4%	$909,302	2.9%
Bow River		$56,582,389	66.5%	$18,545,322	58.9%
Elbow River		$28,496,492	33.5%	$12,954,229	41.1%

Location



Reservoir Location Map



Appendix B – Highest and Best Use Study: The Springbank Reservoir Project Area - Prepared by Brown & Associates Planning Group

HIGHEST AND BEST USE STUDY

THE SPRINGBANK RESERVOIR PROJECT AREA

Prepared for:

Alberta Infrastructure

Prepared by:

Brown & Associates Planning Group
#600, 940 – 6 Avenue SW
Calgary, Alberta T2P 3T1

February 2015

TABLE OF CONTENTS

FIGURES

APPENDICES

1.0 INTRODUCTION, PURPOSE, & BRIEF SUMMARY

1.1 THE RESERVOIR PROJECT

The proposed location for the Springbank Off-stream reservoir site was identified in the AMEC 2014 flood mitigation study. The proposed site is located just west of Calgary approximately 18.5 km upstream of the Glenmore Reservoir in an area of relatively undeveloped farmland and ranch land valley. The location of the project is illustrated in **Figure 1: Regional Context**.

The Project will be designed as a dry pond (there will be no permanent pool of water in the reservoir). The Project concept considers diverting extreme flood flow from the Elbow River into an off-stream storage reservoir where it would be temporarily contained and later released back into the Elbow River after the flood peak has passed. Project components include a diversion structure constructed across the Elbow River and a diversion channel excavated through the adjacent uplands to transport flood water into an off-stream storage reservoir. The storage site includes an earthfill dam to temporarily contain the diverted flood water and a low level outlet structure incorporated into the dam to later release the stored water back into the Elbow River after the flood peak has passed. The expected location of the diversion system, off-stream dam site and reservoir area are illustrated in **Figure 2: Local Context** and **Figure 3: Project Area**.

1.2 THIS REPORT'S PURPOSE

Brown & Associates Planning Group (B&A) was retained by Alberta Infrastructure to identify the highest and best land use within the Project Area. Based on our review of the characteristics of the Project Area and the applicable municipal land use bylaws and policies, this report provides a professional opinion regarding the highest and best use for the proposed Springbank Reservoir Project Area as of January 1st, 2015.

1.3 REPORT PREPARATION METHODOLOGY

In preparing this report, we have looked carefully at the question of "highest and best use" for a land owner/developer who was holding the land for future development. Critical factors in determining highest and best use are summarized in Kenneth Boyd, *Expropriation in Canada - A Practitioner's Guide* (1988, Canada Law Book Inc., Aurora, Ont.), at p. 15:

1. *The use must be legal and must comply with land-use classifications or zoning regulations and with applicable building regulations;*
2. *The use must be probable within a reasonable period of time and not simply possible;*
3. *There must be a demand for the use selected and economic conditions which make it probable that such use will take place; and*
4. *The use must be profitable and provide the highest net return to the owner of the land.*

This report was prepared during the period from December 20, 2014 to January 31, 2015. We are familiar with the project area from occasional visits during the past 20 years and from previous experience of B&A staff in planning and development related projects while employed in Rocky View Planning and Development Services. Ron Wrigley visited the lands specifically to view the proposed Project Area on December 24, 2014. We relied on the following materials for this report:

- Rocky View County County Plan

- Rocky View County Land Use Bylaw

In this report, we have analysed the Project Area in relation to the published statutory and non-statutory plans and land use bylaws and guidelines. We used our familiarity with the Project Area in concert with municipal land planning processes to formulate our opinion.

1.4 OUR FIRM'S EXPERIENCE

Brown & Associates Planning Group is a firm of professional community planners. Ron Wrigley and Ken Venner are the joint authors of this report. Ron Wrigley is one of B&A's senior Partners with over 25 years' experience as a professional land use planner. Ron has prepared numerous highest and best use reports in support of land-taking procedures for public highway projects and for proposed energy projects. Ken Venner is a more recent Partner at B&A with 18 years of experience as a professional land use planner in Alberta. From 2000 to 2008 Ken served as Senior Planner / Current Planning Services Team Leader with the Rocky View County Planning & Development Services Department. Since joining B&A in 2008 he has continued to work as a consultant on many land use policy and development projects located in Rocky View County and other municipalities across the Calgary Region. Ken has also served as an expert witness for assessing potential land use impacts of a proposed energy project.

Curricula vitae for both Ron Wrigley and Ken Venner are provided as ***Appendix I***. All opinions expressed in this report are agreed opinions shared by both Ron Wrigley and Ken Venner.

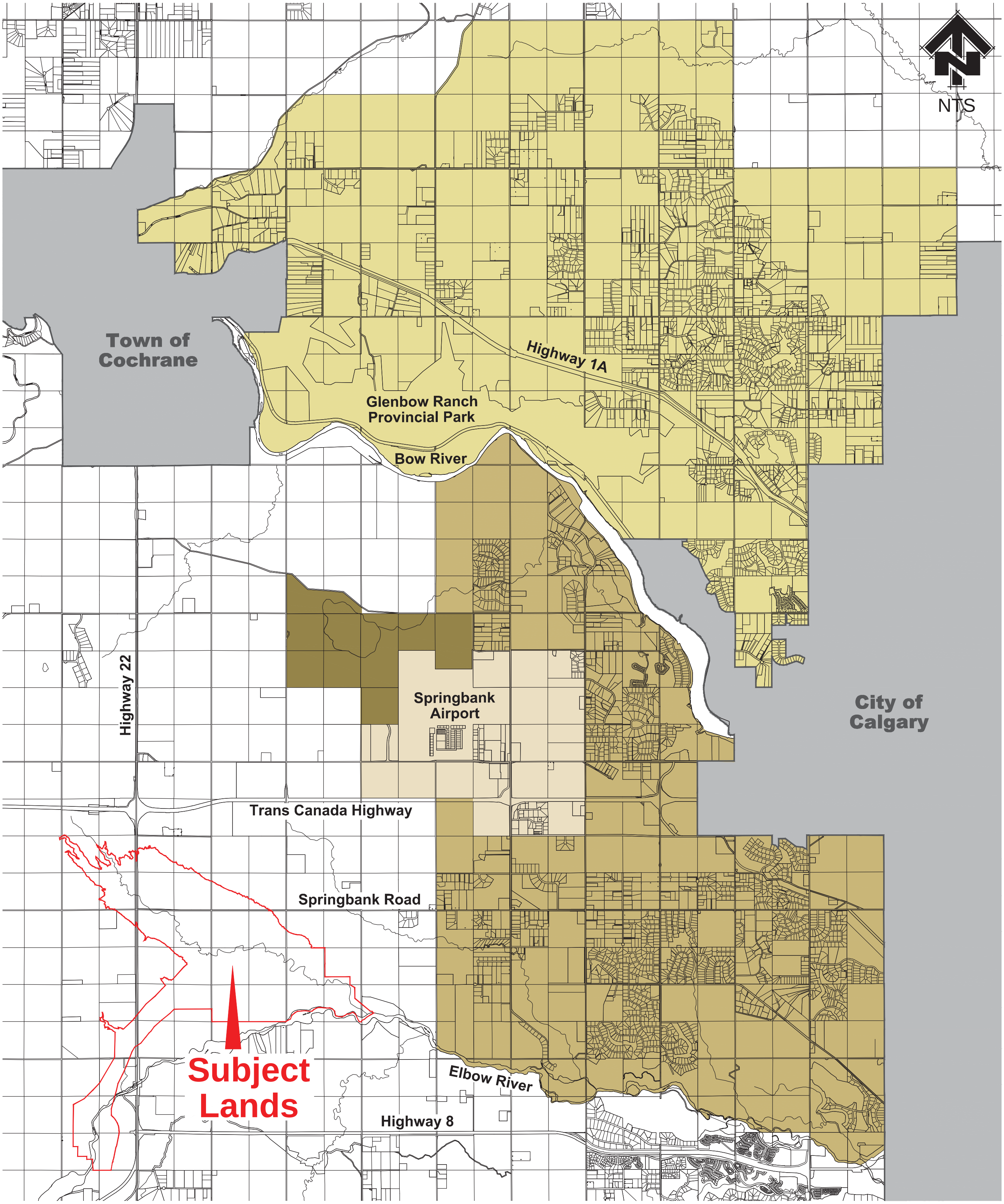
1.5 SUMMARY CONCLUSIONS

Rocky View County is a rural municipality grappling with a challenge of managing growth pressure resulting from its location on the edge of a large urban centre. The vision statement of the County's Municipal Development Plan (The County Plan) contemplates an inviting, thriving, and sustainable municipality that balances agriculture with diverse residential, recreational, and business opportunities. The County Plan lays out a framework for balancing these various and sometimes competing challenges by:

- Setting a moderate population goal that can be responsibly planned for the next 10 to 12 years;
- Identifying the preferred areas for residential growth for the next 10 to 12 years;
- Providing a financial strategy to ensure the costs of growth are addressed; and
- Recognizing all forms of growth must occur in an environmentally responsible manner.

The County expects to achieve the vision and goals of the County Plan by directing new residential and business developments to identified areas and encouraging agricultural activities to continue within all other areas. As illustrated on **Figure 4: County Growth Strategy**, the reservoir project area is not situated within a designated area that is expected to accommodate residential or business development.

As such, in our opinion, the highest and best land use for lands within this project area is for continued agricultural developments in accordance with the Rocky View County Municipal Development Plan's statutory policies and Land Use Bylaw's development prescriptions.



b&a PLANNING GROUP

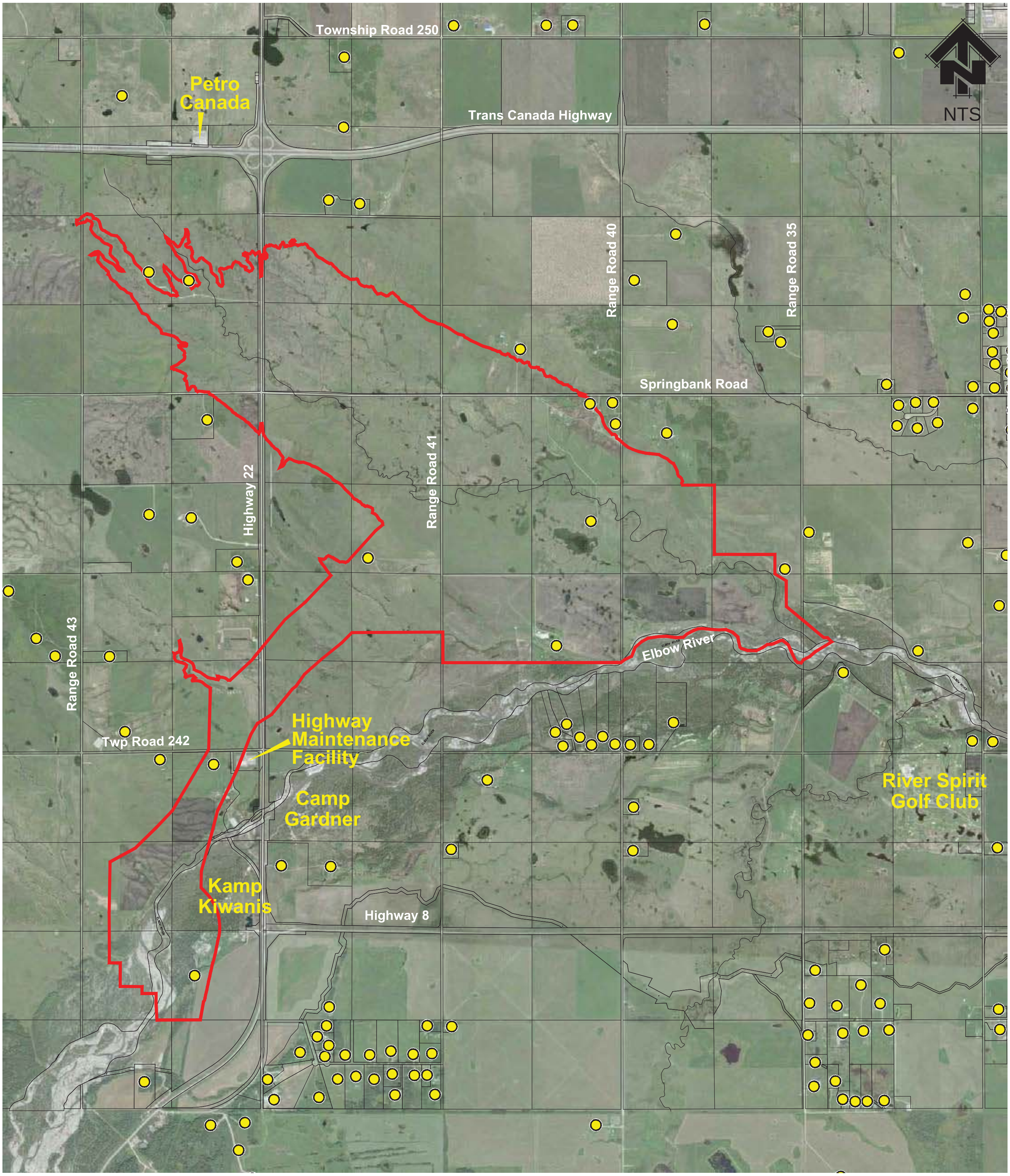
Legend

- Bearspaw Area Structure Plan
- Central Springbank Area Structure Plan
- North Springbank Area Structure Plan
- Harmony Community Conceptual Scheme

Alberta Infrastructure

Figure 1
Regional Context

January 2015



Legend

Provincial Land Requirement

Existing Building Site

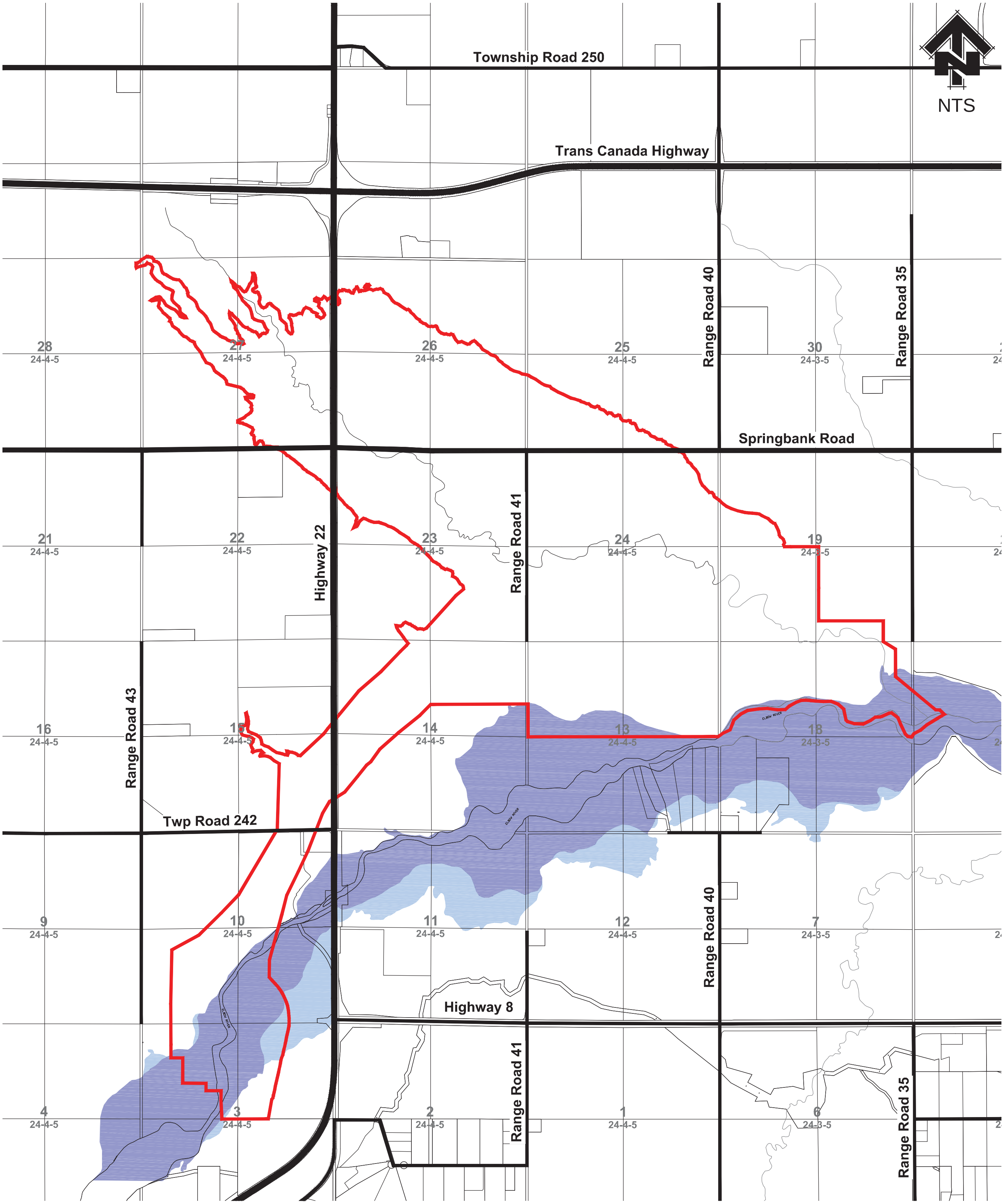
Alberta Infrastructure

Figure 2
Local Context

January 2015

b&a PLANNING GROUP

Jan 30, 2015 - 1:44pm W:\1771 Springbank Reservoir\Drawing CAD Files\1771 base Jan2015.dwg Layout:Local Context



b&a PLANNING GROUP

Legend

Provincial Land Requirement

Floodway*

Floodfringe*

* Source: Alberta Environment and Sustainable Resource Development

Alberta Infrastructure

Figure 3
Project Area

January 2015

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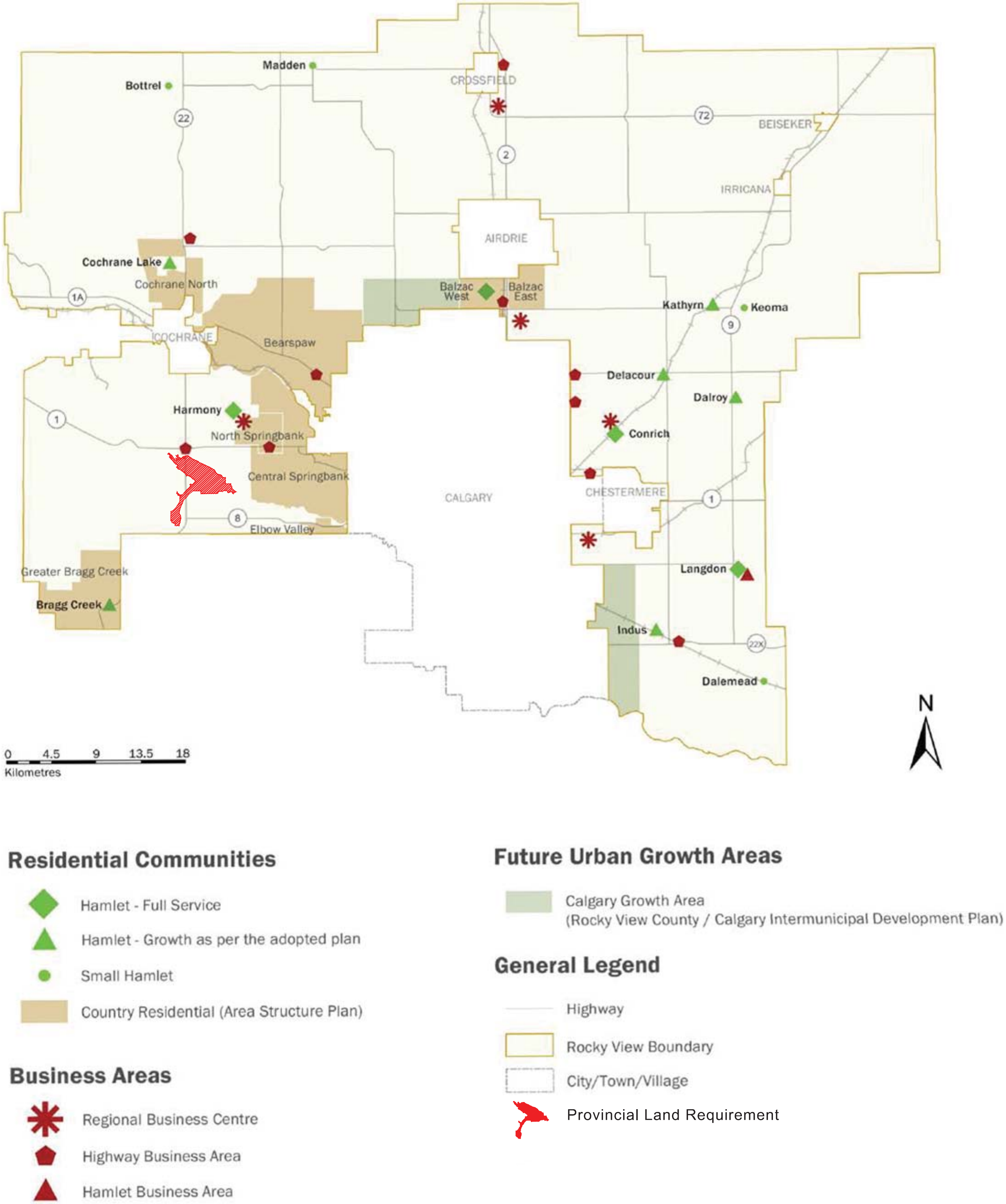


b&a PLANNING GROUP

Source: Rocky View County - County Plan

Alberta Infrastructure

Figure 4
County Growth Strategy

January 2015

Jan 30, 2015 - 1:27pm W:\1771 Springbank Reservoir\Drawing CAD Files\1771 base Jan2015.dwg Layout:Growth Strategy

2.0 PROJECT AREA DESCRIPTION

As illustrated on **Figure 2: Local Context** and **Figure 3: Project Area**, the Project Area is located in the rural southwest quadrant of Rocky View County. The landform within the area includes a tributary of the Elbow River and is characterized by undulating prairie rangeland with sparse vegetation. Most land is held in unfragmented quarter sections with occasional farmstead, residential first parcel-out subdivisions and/or small holding agricultural parcels. The predominant land use activities occurring within the Project Area include a mix of pasture for cattle grazing and limited crop production interspersed with occasional single family dwellings and accessory buildings.

The Project Area includes or is immediately adjacent to several recreational facilities including Kamp Kiwanis and Camp Gardner. These parcels are designated Public Service District (PS) and Direct Control District (DC21) and are situated in the vicinity of the Hwy 8 / Hwy 22 intersection. Each of these developments offer seasonal summer camp activities to residents of Rocky View County and across the Calgary Region.

Alberta Transportation operates a highway maintenance facility on a parcel designated Direct Control District (DC110) situated immediately west of Hwy 22 just north of the Elbow River Crossing. A Petro Canada service station is located on a parcel designated General Business District (B1) situated just west of the Hwy 1 / Hwy 22 interchange which services the travelling public heading to and from Banff National Park and beyond.

There are several concentrations of country residential (acreage) developments situated to the south of the Project Area including parcels designated with a mix of Residential Two District (R2) and Agricultural Holdings District (AH). These parcels generally include single family residences and accessory building serviced by individual groundwater wells and private sewage treatment systems.

Access within the Project Area is provided from a variety of public roadways with a mix of paved and gravel surface treatments, some under the jurisdiction of Rocky View County and some under the jurisdiction of Alberta Transportation.

Figure 5: Land Use Bylaw Districts illustrates the existing land uses designations that apply within the Project Area in accordance with the County's Land Use Bylaw C-4841-97. A copy of the applicable Land Use Bylaw map sheets and applicable Districts are also provided in ***Appendix II***.

As illustrated on **Figure 5**, the County's Ranch and Farm District (RF) applies to the majority of lands contained within the Project Area. The purpose of the Ranch and Farm (RF) District is to accommodate agricultural activities as the primary land use on quarter sections of land or on large balance lands from a previous subdivision.

3.0 MUNICIPAL POLICY FRAMEWORK (THE COUNTY PLAN)

In order to establish the highest and best land use it is necessary to understand the applicable statutory and non-statutory polices and how they apply to the Project Area. The policies establish the type of land use allowed along with the requirements and conditions to make land suitable for development. In addition, there must be a reasonable probability or expectation of obtaining land use approval by Rocky View Council. This report provides an analysis of key municipal bylaws and policies that influence the highest and best use.

The Project Area is subject to the policies contained in the Rocky View County Municipal Development Plan (Bylaw C-7280-2013) otherwise referred to as 'The County Plan' which provides Council's policy direction for future growth and development in Rocky View County. The pertinent policy sections are summarized and discussed in the following sections.

3.1 AGRICULTURE LAND USE CONSIDERATIONS (COUNTY PLAN SECTION 8)

Agriculture has been a mainstay of the County's economy and has guided its settlement pattern since the early 1900's. Traditional agriculture still dominates the County's rural landscape, but in recent times new agricultural ventures are emerging. The County Plan envisions Rocky View as a community where:

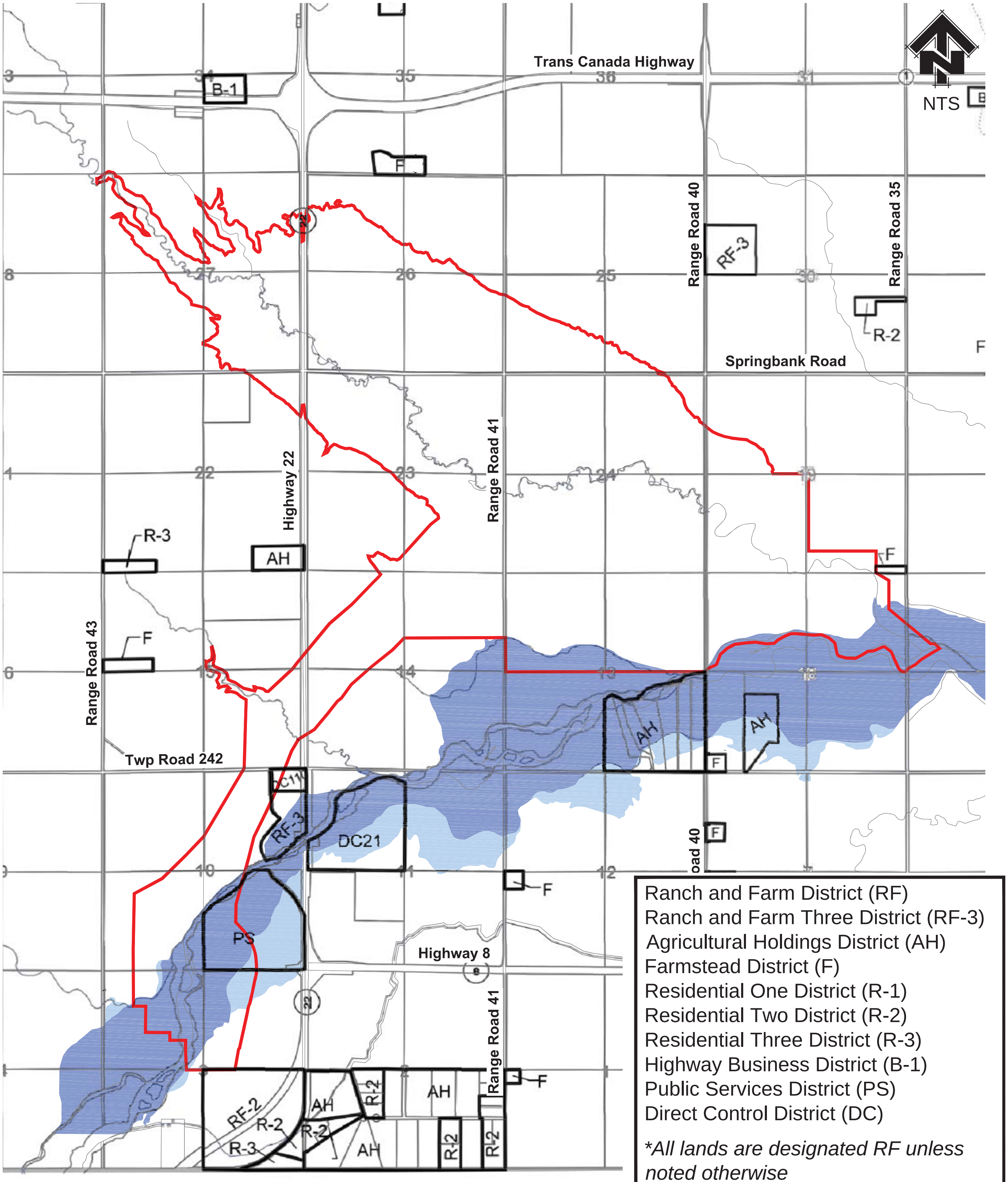
- traditional farming and ranching continues to be valued and respected;
- agriculture flourishes through innovation and diversification; and
- agriculture is promoted and recognized as vital to the County's social, economic, and environmental integrity (triple bottom line).

Achieving this vision requires a comprehensive approach to education, the business of agriculture, and land use planning. The County can assist by providing services, encouraging business opportunities, and supporting the diversity and flexibility of agriculture operations.

Growth Management Strategy
As illustrated on **Figure 5: Rocky View County Growth Management Strategy**, the County Plan's growth management framework deliberately intends to preserve the viability of agricultural lands by directing non-agricultural development into specific locations, thereby minimizing opportunity for land use conflict within agricultural areas. Concentrated residential land uses are expected to develop within existing Country Residential Area Structure Plans and Residential Hamlet Plans while business developments are directed to occur within identified Regional Business Centres and Highway Business Areas.

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 8.7**: Support and encourage agriculture operations and agricultural related economic activity.
- **Policy 8.12**: Support the Province in recognizing, preserving and accounting for the natural capital of land.
- **Policy 8.29**: Discourage intrusive and/or incompatible land use in the agricultural area.



Legend

- Provincial Land Requirement
- Floodway*
- Floodfringe*

b&a PLANNING GROUP

Alberta Infrastructure

Figure 5
Land Use Bylaw Districts

* Source: Alberta Environment and Sustainable Resource Development

January 2015

KEY CONCLUSION #1:

The Project Area is not located within County Residential Area Structure Plan or Residential Hamlet Plan or within a Regional Business Centre or a Highway Business Area. As such, agricultural land uses are expected to predominate within the Project Area.

Emerging Trends for smaller agricultural parcels

As described in *Section 2* of this report, the majority of land within the Project Area is designated Ranch & Farm District (RF) in accordance with the County's Land Use Bylaw. The RF designation is intended to provide for agricultural activities as the primary land use on a quarter section of land.

The County Plan's agricultural land use policies recognize and acknowledge the merits to consider opportunities to promote traditional agricultural activities. However, the Plan also encourages agricultural producers to adopt more innovate and diversified agricultural practices, some of which can occur on smaller parcels. The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 8.8**: Support and encourage small scale, value-added agriculture and agriculture services to locate in proximity to complementary agricultural producers.
- **Policy 8.15**: Support and encourage the viability and flexibility of the agricultural sector by allowing a range of parcel sizes, where appropriate.

KEY CONCLUSION #2:

Although the majority of the Project Area is presently designated Ranch & Farm District (RF) which contemplates traditional agricultural activities occurring on full quarter sections, the County Plan recognizes and promotes opportunities for agricultural innovation and diversification which could occur on smaller parcels.

Redesignation and subdivision of un-subdivided parcels

The County Plan provides opportunity for large traditional agricultural parcels to be further rezoned and subdivided into a variety of parcel sizes to accommodate a wide range of agricultural pursuits by acknowledging that emerging trends in agriculture may be successfully developed on smaller parcels of land. The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 8.22**: Redesignation and subdivision to smaller agriculture parcels as a new or distinct agricultural operation may be supported. Proposals will be evaluated on the following criteria:
    a. A similar pattern of nearby small agricultural operations;
    b. A planning rationale justifying why the existing land use and parcel size cannot accommodate the new or distinct agricultural operation;
    c. A demonstration of the need for the new agriculture operation;
    d. An assessment of the proposed parcel size and design, to demonstrate it is capable of supporting the new or distinct agricultural operation. Site assessment criteria include:
        i. suitable soil characteristics and topography;
        ii. suitable on-site infrastructure for the proposed use (required infrastructure may include access areas, water wells, irrigation and sewage infrastructure, and manure management capability; and
        iii. compatibility with existing uses on the parent parcel and adjacent lands;

e. An assessment of the impact on, and potential upgrades to, County infrastructure; and

f. An assessment of the impact on the environment including air quality, surface water, and groundwater.

KEY CONCLUSION #3:

The County Plan supports redesignation and subdivision of traditional agricultural parcels to accommodate agricultural developments that can occur on smaller parcels.

First Parcel Out Subdivisions

The County Plan provides opportunity for owners of un-subdivided agricultural parcels to subdivide a single parcel either as a farmstead, an agricultural first parcel out or a residential first parcel out. The key County Plan policy statements which apply to lands within the Project Area are as follows:

Farmstead

- **Policy 8.17**: Redesignation and subdivision to create a *farmstead* should be supported if the following criteria are met:
  a. the proposed site meets the definition of a farmstead;
  b. the proposed site is a minimum of 1.6 hectares (3.95 acres) and a maximum of 7.99 hectares (19.7 acres);
  c. access to the proposed site is acceptable to the County;
  d. there are no *physical constraints* to subdivision; and
  e. the balance of the quarter section is maintained as an agricultural land use.

Agriculture First Parcel Out

- **Policy 8.18:** First parcel out subdivision of a minimum of 20.23 hectares (50.00 acres) of land designated for agricultural use should be supported without redesignation if:
  a. the proposed site meets the definition of a first parcel out; and
  b. access to the proposed site is acceptable to the County.
- **Policy 8.19**: First parcel out subdivision of *isolated land* designated for agricultural use should be supported without redesignation if:
  a. it meets the definition of a first parcel out;
  b. the parcel size is greater than or equal to 8.10 hectares (20.01 acres);
  c. a minimum of 2 acres of developable land exists; and
  d. access to the proposed site is acceptable to the County;

Residential First Parcel Out

- **Policy 8.20**: A first parcel out residential redesignation and subdivision of a parcel of land between 1.60 hectares (3.95 acres) and a maximum of 2.50 hectares (6.18 acres) in size should be supported if the proposed site:
  a. meets the definition of a first parcel out;
  b. is redesignated to a residential land use whose minimum parcel size allows only one lot to be created at subdivision;

c. is located at least 300 metres from the right-of-way of a highway, or as otherwise allowed by the Province;

d. has direct access to a developed public roadway;

e. has no physical constraints to subdivision;

f. minimizes the need for new public infrastructure;

g. minimizes adverse impacts on agricultural operations by meeting agriculture location and agriculture boundary design guidelines; and

h. the balance of the *un-subdivided quarter section* is maintained as an agricultural land use.

KEY CONCLUSION #4:

The County Plan supports the subdivision of an un-subdivided quarter section to create a single 'first parcel out' subdivision.

AGRICULTURAL POLICY SUMMARY ANALYSIS AND COMMENTARY RELEVANT TO THE PROJECT AREA:

The Project Area is located within a predominantly agricultural area of Rocky View County. The Project Area's existing land use pattern is characterized by Ranch and Farm designation which is intended to provide for agricultural activities occurring on unsubdivided quarter sections. However, the County Plan recognizes emerging trends in the agricultural sector which accommodate smaller scale activities that can occur on smaller parcels.

The County Plan supports intensification of land use within unsubdivided agricultural parcels. As such, it is reasonable to assume that some of the parcels within the Project Area could accommodate additional agricultural developments and first parcel out subdivisions provided that appropriate access and servicing infrastructure is provided by the developer in support of same.

3.2 RESIDENTIAL LAND USE CONSIDERATIONS (COUNTY PLAN SECTIONS 9 & 10)

Hamlets

Hamlets form a traditional part of the rural landscape. The County's hamlets vary in size, appearance, and function, with each hamlet having a distinct character that reflects its particular history and environment. Hamlets range from those with a wide variety of services and relatively steady growth, to those with limited services and little or no growth.

Hamlet communities are encouraged to build on their historical character and to evolve over time. This Plan provides policies to ensure development strengthens these communities, is sensitive to the needs of all residents, and is as orderly and efficient as possible. Local community planning processes will determine hamlet form, amenities, and population size.

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 9.1**: Encourage and support the development of the Hamlets of Conrich, Harmony, Langdon, and Balzac as *full service* rural communities providing a range of land uses, housing types, and rural services to their residents and local area, in accordance with their area structure plan or conceptual scheme.
- **Policy 9.2**: Support the development of the Hamlets of Bragg Creek, Cochrane Lake, Kathyrn Delacour, Dalroy, and Indus as *small rural communities* with basic services, in accordance with their area structure plan or conceptual scheme.

- **Policy 9.6**: Development in a hamlet shall be guided by, and conform to, the adopted area structure plan or conceptual scheme.

KEY CONCLUSION #5:

The Project Area is not located within the boundaries of an Area Structure Plan that contemplates either a full service or a small rural community Hamlet. As such, the lands are not considered appropriate for concentrated residential development.

Country Residential Development

Country residential communities are a form of rural living. They play a significant role in shaping the landscape and providing a sense of belonging to their residents. The county has a number of country residential communities, some formally defined by area structure plan policy, while others have grown gradually over time.

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 10.1**: Development within Greater Bragg Creek, Bearspaw, North and Central Springbank, Elbow Valley, Balzac East (Sharp Hills/Butte Hills), and Cochrane North shall conform to their relevant area structure plan.
- **Policy 10.2**: Country residential development in the agriculture area shall be guided by the goals and policies of this Plan.

KEY CONCLUSION #6:

The Project Area is not located within the boundaries of an Area Structure Plan that contemplates country residential development. As such, the lands are not considered appropriate for country residential development.

New Country Residential Communities: Planning and Design

The Managing Growth section (5.0) of this Plan does not contemplate the development of new country residential area structure plans or the expansion of existing area structure plans until those plans reach build-out. However, if the County determines a new or amended country residential area structure plan is needed, the plan will be evaluated on the basis of its compliance with policy 10.6, as well as other policies of this Plan.

- **Policy 10.6**: Where a new country residential area structure plan is needed the plan should:
  a. ensure development supports rural character, is well designed, and conforms to current technical servicing requirements and master servicing plans and policies;
  b. propose alternative residential development forms, such as compact residential development or a Conservation Community, to reduce the development footprint on the rural landscape;
  c. provide for well-designed public gathering places such as parks, open spaces, and community facilities. Gathering places should:
     i. be safe, accessible, and attractive;
     ii. be centrally located;
     iii. respect and enhance community identity and character;
     iv. encourage social interaction; and
     v. address the needs of residents of all ages and abilities.

d. ensure development retains the area's natural features and that buildings are situated to create minimal visual impact on adjoining properties;

e. provide patterns of development and transportation networks that create linkages between subordinate plans; and

f. address the following matters:

   i. future land use concept, population at build-out, and
   ii. the phasing of development;
   iii. form, quality, design, and compatibility with existing development;
   iv. impact on municipal servicing costs and proximity
   v. of development to existing road and servicing infrastructure;
   vi. fiscal impact analysis;
   vii. efficient internal road network;
   viii. need for institutional uses, open space, recreational areas, amenities, and pedestrian connections;
   ix. impact on the environment;
   x. designing with the landscape;
   xi. interface design with adjacent agriculture land; and
   xii. other policies of this Plan.

<u>KEY CONCLUSION #7:</u>

The existing Bearspaw, Central Springbank and North Springbank Area Structure Plans have not achieved full build out. As such, the County is not expected to encourage additional country residential development within the Project Area.

Fragmented Country Residential Areas

Historical subdivision approval in parts of the County's agricultural area has resulted in fragmented pockets of country residential lots and small agricultural parcels. Incremental development in these areas divides viable agricultural land, impacts agriculture operators, and creates an inefficient settlement pattern. From a fiscal perspective, dispersed residential development is not cost effective; requiring increased road maintenance and impacting service providers such as the County and local school boards. In response to this development pattern, this Plan addresses the issues related to fragmented land and provides policies to enable a gradual transition to a more orderly and efficient residential development pattern within fragmented quarter sections.

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 10.11**: Within a fragmented quarter section, the redesignation of residential lots or agricultural parcels less than or equal to10 hectares (24.7 acres) in size to a new residential land use may be supported if the following criteria are met:

  a. A lot and road plan is provided that;

i. plans for an area determined by the County at the time of redesignation application. The plan shall include, at a minimum, all residential or small agricultural acreages that are adjacent to the application;

ii. includes design measures to minimize adverse impacts on existing agriculture operations; and

iii. demonstrates potential connectivity to residential or small agricultural acreages outside of the lot and road plan area.

b. A technical assessment of the proposed design is provided, to demonstrate that the lot and road plan area is capable of supporting increased residential development. The assessment shall address:

i. the internal road network, water supply, sewage treatment, and stormwater management; and

ii. any other assessment required by unique area conditions.

c. A technical assessment of the impact on off-site infrastructure, roads, and stormwater systems is be provided;

d. A report is provided that documents the consultation process undertaken to involve affected landowners within the plan area in the preparation and/or review of the lot and road plan.

- **Policy 10.12**: Within a fragmented quarter section, the redesignation or subdivision of agriculture parcels greater than 10 hectares (24.7 acres) in size to a residential use shall not be supported. Redesignation or subdivision to a new or distinct agricultural operation may be supported as per policy 8.22.

KEY CONCLUSION #8:

The Project Area does not contain areas of existing fragmented country residential development. As such, the lands would not be considered appropriate for additional fragmented country residential developments.

RESIDENTIAL POLICY SUMMARY ANALYSIS AND COMMENTARY RELEVANT TO THE PROJECT AREA:

The Project Area is not located within the boundaries of an area structure plan that contemplates a full service or a rural service community hamlet. As such, the lands would not be suitable for concentrated residential development. The County would expect additional concentrated residential developments to locate with the adopted Harmony Community Plan or within the Hamlet of Bragg Creek.

The Project Area is not located within the boundary of an adopted country residential area structure plan. As such, the lands would not be suitable for comprehensively planned country residential development. The County would expect additional comprehensively planned country residential development to continue within the Central and North Springbank Area Structure Plan as well as the Greater Bragg Creek Area Structure Plan. None of these plans are approaching build out, and as such, a planning rationale to justify additional country residential development within the Project Area would not likely be supported.

Although the County Plan contains policy support to justify additional country residential developments where same exists already, the Project Area does not contain any existing fragmented country residential developments. As such, the Project Area is not considered appropriate for country residential development.

3.3 BUSINESS LAND USE CONSIDERATIONS (COUNTY PLAN SECTION 14)

A strong local economy provides multiple benefits to the social, economic, and environmental fabric of the County. Businesses provide:

- employment and services;
- a commercial focus adding to the vitality of a hamlet;
- taxes to help provide community services; and
- local employment to reduce vehicle use.

The County Plan provides a number of business areas and development forms which accommodate the wide variety of businesses wishing to locate in the County. This Plan identifies regional business centres, highway business areas, and hamlet business areas as areas where the majority of commercial and industrial development should locate. By focusing development in these locations, the County provides for orderly growth and economic efficiencies in the development of its transportation and infrastructure systems.

The County Plan supports and encourages a robust market-driven economy by facilitating economic development and providing planning policies that help foster private and public investment within the county and encourages same to locate in key strategic locations.

Regional Business Centres

Regional business centres are large areas of commercial and industrial development within the County. The purpose of a regional business centre is to provide regional and national business services, and local and regional employment opportunities. Regional business centres make a significant contribution in achieving the County's fiscal goals. Substantive planning, time, and public and private investment have resulted in identifying and developing regional business centres.

This Plan does not contemplate developing other regional business centres until the identified centres are approaching full build-out. Identified regional business centres, shown on the County's Growth Strategy Map, have the following characteristics:

- existing businesses;
- an efficient road connection to the provincial highway network;
- significant scale and scope of operations;
- infrastructure with the potential to service the proposed development;
- potential of multiple transportation options (road, rail, or air); and
- regulated by existing statutory policy, and/or identified in annexation agreements.

As illustrated on **Figure 5**, the County have designated a Regional Business Centre to be developed within the Harmony Community situated immediately west of the Springbank Airport.

The <u>key County Plan policy statements</u> which apply to lands within the Project Area are as follows:

- **Policy 14.7**: Development of a new regional business centre should not be supported unless a need has been demonstrated, based on the following criteria:
  a. the proposal has regional or national significance;

b. existing regional business centres within the trade area of the proposed development are approaching full build out, and the County has determined the expansion of the existing regional business centres is not desirable;

c. existing regional business centres within the trade area do not meet market demand;

d. land uses and target markets are clearly defined;

e. the proposed development meets the environmental and infrastructure goals and policies of this Plan;

f. the proposed development has the potential to provide a substantial financial benefit to the County;

g. adverse impacts on existing residential communities and agriculture operations will be minimized; and

h. the proposed development is in close proximity to the provincial transportation network.

- **Policy 14.8**: Direct new commercial and industrial development to existing, identified regional business centres and ensure development complies with existing area structure plans.

KEY CONCLUSION #9:

The Project Area is not located within the boundaries of a designated regional business area. As such, the lands would not be appropriate for business development that would accommodate developments of a regional or national significance.

Highway Business Areas

Highway business areas are intended to take advantage of the provincial highway system. They are of limited size and should be located in proximity to highway intersections and interchanges. The purpose of a highway business area is to contribute to the County's fiscal goals, provide destination commercial and business services, provide services to the traveling public, and offer local employment opportunities.

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 14.10**: Highway business areas are identified on Map 1 and should have the following characteristics:

a. located along intersections or interchanges with the provincial highway network;

b. land uses consistent with the purpose of a highway business area;

c. limited development area close to one or all of the quadrants of the intersection or interchange;

d. planned in a comprehensive manner and not subject to incremental expansion;

e. meet the environmental, infrastructure, and financial goals and policies of this Plan;

f. minimize adverse impacts on existing agriculture or residential development;

g. developed in consultation with Alberta Transportation; and

h. consistent with the provincial freeway and access location plans.

The majority of the Project Area is not located in proximity to the provincial highway system, and as such, the County's Highway Business Area policies generally do not apply. However, the Project Area does impact lands situated directly south of the Hwy 1 / Hwy 22 interchange and immediately west of the Hwy 22 / Hwy 8 intersection.

Particular emphasis might be placed on the parcel affected by the Hwy 22 / Hwy 8 intersection given the direct applicability of County Plan Policy 14.10. However, it is acknowledged that this parcel appears to be significantly impacted by the floodway/flood fringe of the Elbow River. As such, the potential for this site to accommodate highway business development may be constrained. A site specific analysis of development potential may be warranted subsequent to this planning report's completion.

The lands situated south of the Hwy 1 / Hwy 22 interchange are not located within the quadrant of the intersection. However, subject to a determination of the first available location of access setback from the interchange itself, these lands could potentially be considered for business development when planned comprehensively with the lands directly north that are tangent to the interchange itself. It is noted that the County is anticipated to prepare an Area Structure Plan for this designated Highway Business Area sometime this year (2015). However, the County has not yet released a study area for this ASP.

KEY CONCLUSION #10:

The majority of the Project Area does not include sites that would qualify as a Highway Business Area in accordance with the County Plan's Policy 14.10 criteria. However, the parcels in proximity to the Hwy 1 / Hwy 22 interchange and the Hwy 22 / Hwy 8 intersection could be considered for such subject to the conclusions of detailed planning and technical reporting.

BUSINESS POLICY SUMMARY ANALYSIS AND COMMENTARY RELEVANT TO THE PROJECT AREA:

The Project Area is not included in the boundary of a designated regional business centre. As such, the lands would not be appropriate for business development subject to Section 14.7 of the County Plan.

The majority of the Project Area does not contain lands that would be suitable for Highway Business Areas subject to Section 14.10 of the County Plan. However, the parcels in proximity to the Hwy 1 / Hwy 22 interchange and the Hwy 22 / Hwy 8 intersection could be considered for such subject to the conclusions of detailed planning and technical reporting.

3.4 RECREATION LAND USE CONSIDERATIONS (COUNTY PLAN SECTION 21)

The quality of life of rural residents is enhanced when they are able to access a variety of recreational, social, and cultural opportunities. Strong social networks and positive relationships reinforce the ability of individuals and communities to meet needs, support one another, and adapt to change.

The County, as the most visible and accessible level of government, has a role to advocate, empower, and support residents and organizations in improving their community. This requires partnerships, cooperation, and support from all levels of government, neighbouring municipalities, community groups, nongovernmental organizations, and individual residents.

The Project Area is partially bound by the bed and shore of the Elbow River, a water feature that is popular regionally with rafters, campers, hikers and other recreationalists. It is noted that existing developments situated within and in vicinity of the Project Area include recreational uses (i.e. Camp Kiwanis, Camp Gardner and River Spirit Golf Course).

The key County Plan policy statements which apply to lands within the Project Area are as follows:

- **Policy 21.1**: Identify and support the different recreational, leisure, and cultural characteristics of the County's communities.

- **Policy 21.2**: Provide a fair and equitable distribution of facilities, services, and programs across the County, while recognizing the unique needs of communities and regions.
- **Policy 21.9**: Support projects and programs that develop a sense of community, empower residents, and encourage social inclusion.

KEY CONCLUSION #11:

The Project Area is partially bound by the bed & shore of the Elbow River, a popular water feature that serves up opportunities for regional recreation amenities. As such, the Project Area may be considered appropriate for additional recreational land uses.

4.0 KEY CONCLUSIONS & SUMMARY ANALYSIS

KEY CONCLUSIONS

This report summarizes a detailed review of land development policies derived from the Rocky View County Plan with particular reference to lands contained within the Project Area. The key conclusions of their review are listed as follows:

1. The Project Area is not located within County Residential Area Structure Plan or Residential Hamlet Plan or within a Regional Business Centre or a Highway Business Area. As such, agricultural land uses are expected to predominate within the Project Area.
2. Although the majority of the Project Area is presently designated Ranch & Farm District (RF) which contemplates traditional agricultural activities occurring on full quarter sections, the County Plan recognizes and promotes opportunities for agricultural innovation and diversification which could occur on smaller parcels.
3. The County Plan supports redesignation and subdivision of traditional agricultural parcels to accommodate agricultural developments that can occur on smaller parcels.
4. The County Plan supports the subdivision of an unsubdivided quarter section to create a single 'first parcel out' subdivision.
5. The Project Area is not located within the boundaries of an Area Structure Plan that contemplates either a full service or a small rural community Hamlet. As such, the lands are not considered appropriate for concentrated residential development.
6. The Project Area is not located within the boundaries of an Area Structure Plan that contemplates country residential development. As such, the lands are not considered appropriate for country residential development.
7. The existing Bearspaw, Central Springbank, and North Springbank Area Structure Plans have not achieved full build out. As such, the County is not expected to encourage additional country residential development within the Project Area.
8. The Project Area does not contain areas of existing fragmented country residential development. As such, the lands would not be considered appropriate for additional fragmented country residential developments.
9. The Project Area is not located within the boundaries of a designated regional business area. As such, the lands would not be appropriate for business development that would accommodate developments of a regional or national significance.
10. The majority of the Project Area does not include sites that would qualify as a Highway Business Area in accordance with the County Plan's Policy 14.10 criteria. However, the parcels in proximity to the Hwy 1 / Hwy 22 interchange and the Hwy 22 / Hwy 8 intersection could be considered for such subject to the conclusions of detailed planning and technical reporting.
11. The Project Area is partially bound by the bed & shore of the Elbow River, a popular water feature that serves up opportunities for regional recreation amenities. As such, the Project Area may be considered appropriate for additional recreational land uses.

SUMMARY ANALYSIS

The Project Area is located within a predominantly agricultural area of Rocky View County. The Project Area's existing land use pattern is characterized by Ranch and Farm designation which is intended to provide for agricultural activities occurring on unsubdivided quarter sections. However, the County Plan recognizes emerging trends in the agricultural sector which accommodate smaller scale activities that can occur on smaller parcels.

The County Plan supports intensification of land use within unsubdivided agricultural parcels. As such, it is reasonable to assume that some of the parcels within the Project Area could accommodate additional agricultural developments and first parcel out subdivisions provided that appropriate access and servicing infrastructure is constructed by the developer in support of same.

The Project Area is not located within the boundaries of an area structure plan that contemplates a full service or a rural service community hamlet. As such, the lands would not be suitable for concentrated residential development. The County would expect additional concentrated residential developments to locate with the adopted Harmony Community Plan or within the Hamlet of Bragg Creek.

The Project Area is not located within the boundary of an adopted country residential area structure plan. As such, the lands would not be suitable for comprehensively planned country residential development. The County would expect additional comprehensively planned country residential development to continue within the Central and North Springbank Area Structure Plan as well as the Greater Bragg Creek Area Structure Plan. None of these plans are approaching build out, and as such, a planning rationale to justify additional country residential development within the Project Area would not likely be supported.

Although the County Plan contains policy support to justify additional country residential developments where same exists already, the Project Area does not contain any existing fragmented country residential developments. As such, the Project Area is not considered appropriate for country residential development.

5.0 RECOMMENDATION OF HIGHEST AND BEST USE

We believe that given the County land use policies that continued agricultural uses are the highest and best uses of land within the project area. Unsubdivided agricultural parcels within the Project Area can be expected to accommodate first parcel out subdivisions and limited development with additional smaller scale agricultural parcels where site specific access and limited servicing opportunities (i.e. groundwater well and private sewage treatment systems) can accommodate same and the proponents can demonstrate the need for such smaller scale uses. Overall, the general predominant use of land in the area should be expected to remain agriculture.

As discussed, the parcels in proximity to the Hwy 1 / Hwy 22 interchange and the Hwy 22 / Hwy 8 intersection appear to have limited potential to accommodate Highway Business Area uses in accordance with the specified County Plan policy provisions. These parcels may require additional detailed assessment to determine the likelihood of non-agricultural developments therein.

Some parcels in proximity to the Elbow River may be considered appropriate for recreational uses such as summer camps and/or golf courses. However, the specific nature of this development would require detailed technical assessment outside the scope of this report.

Timing of development in the area for land uses other than agricultural uses would depend on a significant change in County Council direction towards growth, changes to the County Plan policy pertaining to new country residential development, and the provision of regional servicing to the area. Timing for the approval of land uses other than Farmstead or Residential First Parcel Out development or agricultural land uses cannot be ascertained with any certainty at this time.

6.0 CLOSING

We hereby certify that we have personally inspected the lands described herein and have personally prepared this report. To the best of our knowledge, the statements contained in the report are true and correct, and we have no present or contemplated interest in the lands.

Respectfully submitted,

BROWN & ASSOCIATES PLANNING GROUP

Ron Wrigley, MEDes, RPP, MCIP
Principal

Ken Venner, BA, RPP, MCIP
Principal

Dated: February 5th, 2015

***APPENDIX I : Curriculum Vitae for* Ron Wrigley and Ken Venner**

RON
WRIGLEY

Principal, MCIP, MEDes

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PROFESSIONAL HISTORY

1 **PRINCIPAL**, Brown & Associates Planning Group
May 1986 - Present

2 **PROJECT PLANNER**, Calgary Regional Planning Commission
1982 - 1983

3 **ASSISTANT PLANNER**, City of Calgary Planning Department
1980 - 1981

CAREER SYNOPSIS

Since joining Brown & Associates, Ron has been responsible for the preparation of pre-development feasibility studies and municipal land use policy and design projects. His feasibility studies have included residential and commercial demand/absorption forecasts, multi-family residential design studies, office and mixed-use floorspace opportunity analyses, retail market studies, and business area revitalization planning. This knowledge of land development markets and patterns has supported Ron's recent work as consultant to municipalities for urban growth studies, annexation approval processes and municipal development plans. (over)

b&a PLANNING GROUP

EDUCATION

U of C Masters of Environmental Design

UB Bachelor of Arts (cum laude)

PROFESSIONAL AFFILIATIONS

Registered Alberta Community Planner

Member of Canadian Institute of Planners

AWARDS

AACIP Award of Excellence
AACIP Award of Distinction
AACIP Awards of Distinction
City of Calgary Heritage Award

RON
WRIGLEY
Principal, MCIP, MEDes

CAREER SYNOPSIS CONTINUED

Ron's policy and design planning work has focused on the preparation of statutory land use policy plans, master plans for new recreational communities, and public involvement for large urban redevelopment sites.

His experience includes Area Structure Plans in urban, rural and sensitive natural environment settings, client representation in Area Redevelopment Plan processes, planning and approvals processing for industrial operations, re-use of former heavy industrial sites, and planning for major retail centres, residential and rural recreational developments throughout western Canada. Client representation, community participation, coordination of multi-disciplinary project teams, and preparation of written and graphic communications are commonly a significant component of his work.

Ron is often called upon to provide expert land development reports and/or testimony before the Alberta Energy and Utilities Board, the Alberta Municipal Government Board and in support of pre-expropriation negotiations for municipal and provincial land takings.

Prior to joining the firm, Ron worked as a land use planner in municipal and regional planning commission offices. In these positions he prepared Area Structure Plans for new suburban growth areas and Area Redevelopment Plans for downtown areas and older residential areas.

PUBLIC CONSULTATION

- Parsons Creek Aggregates Environmental Impact Assessment, Fort McMurray, 2008.
- Greater Bragg Creek Area Structure Plan, Phase 1 Visioning Workshops, MD of Rocky View, 2004.
- Spy Hill Lands Development Project/Calgary, for Alberta Infrastructure and Transportation, 2004.
- Bow Valley Centre Concept Plan, Public Consultation Advisor, for City of Calgary, 2000.
- Sifton, Lansdowne, Mission Urban Streetscape Design and Traffic Safety Enhancement Plan, for City of Calgary, 2005.
- Prince's Island Master Plan, Phase 1 Vision Statement, for City of Calgary, 2000.
- Former Greenhouse Site Redevelopment Plan, for City of Medicine Hat, 2000.

DEVELOPMENT MARKET RESEARCH

- Calgary Long-Term Industrial Land Requirements Study, for City of Calgary, 2003 and 2006.
- Calgary Airport Industrial Opportunity Analysis, Calgary, for Calgary Airport Authority.
- West Park Multi-Family Opportunity Study and Product Design Strategy, Calgary.
- 1st Avenue NE (Bridgeland-Riverside) Retail Market Study, for City of Calgary.
- West Calgary Multi-Family Residential Market Study, for Melcor Developments, Calgary.
- Comprehensive Edmonton Housing Market. Opportunity Analysis, for Genstar, Edmonton
- Shouldice Park Multi-Family Residential Market Study, Calgary.
- Southeast Calgary Multi-Family Residential Market Study, Calgary, for Intrawest Developments.

MASTER PLANS

- Fort McMurray Master Accommodation Plan, for Alberta Infrastructure, Fort McMurray, 2006.
- Grande Prairie Master Accommodation Plan, for Alberta Infrastructure, Grande Prairie, 2008.
- Michener Centre Master Plan, for Alberta Infrastructure, Red Deer, 2009.
- Motor Vehicles SIte Master Plan, for Calgary Health Region, Calgary, 2005.
- Three Sisters Resorts Master Zoning Bylaw, for Municipal Affairs, Town of Canmore and TSR Ltd.
- Master Plan for End-Use of Landfill Sites, for City of Calgary Parks and Solid Waste Departments.

RON
WRIGLEY

Principal, MCIP, MEDes

STATUTORY LAND USE POLICY PLANS

- Town of Chestermere Municipal Development Plan, Town of Chestermere, 2009.
- Town of Canmore Municipal Development PLan, Town of Canmore, 2003.
- Real Martin West Area Structure Plan, for Regional Municipality of Wood Buffalo, 2003
- Northwest Okotoks Area Structure Plan, Town of Okotoks, 2003.
- Middle Springs Area Structure Plan, Town of Banff.
- Southland ASP and Phase 1 Commercial Conceptual Scheme, City of Medicine Hat .

URBAN GROWTH STUDIES

- City of Camrose Growth Study 2006.
- City of Airdrie Growth Study 2000.
- Town of Chestermere Growth Study, 2006.
- Town of High River Growth Study, 2008.
- Town of Peace River Growth Study, 2006.
- Town of Slave Lake Growth Study, 2007.

SUBDIVISION DESIGN/APPROVALS

- Westbrook Light Rail Transit Station Area Land Use and Subdivision, for City of Calgary, 2009.
- Youth Treatment Centre Subdivision, Fort McMurray, for Alberta Infrastructure, 2009.
- Buffalo Hills Comprehensive Mixed Use Land Use and Subdivision, MD of Rocky View, 2009.
- City of Camrose Downtown Housing Design Guidelines, City of Camrose, 2005.
- Burnswest Industrial Park Land Use and Subdivision, Town of Okotoks, 2005.
- Husky Lloydminister Upgrader Eco-Industrial Park, for Husky Energy, 2002.

EXPERT WITNESS

- Sour gas well impact reports and testimony before the Alberta Energy and Utilities Board, 2000, 2003, 2004, and 2005 - various clients.
- Land taking for Highway 2 interchange in Airdrie, for Rooney Prentice, 2004.
- Report regarding shopping centre development obligations dispute, for Bennet Jones, Toronto, 2004.

KEN VENNER

Principal, BA, RPP, MCIP

CONTACT

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Address Suite 600 940 6 Ave SW, Calgary, AB T2P 3T1

PROFESSIONAL HISTORY

1 **PRINCIPAL**, Brown & Associates Planning Group
June 2012 - Present

1 **ASSOCIATE**, Brown & Associates Planning Group
February 2008 - June 2012

2 **SENIOR PLANNER/TEAM LEADER CURRENT PLANNING SERVICES**
PLANNER II - LONG RANGE PLANNING SERVICES
PLANNER - CURRENT PLANNING SERVICES, Rocky View County
August 2000 - February 2008

3 **PLANNING & DEVELOPMENT OFFICER**, Town of Slave Lake
March 1998 - August 2000

4 **COMMUNITY PLANNER**, New Era Municipal Services
August 1997 - March 1998

CAREER SYNOPSIS

Ken brings a unique and versatile perspective to Brown & Associates gained from over 17 years of diverse planning experience working with a variety of urban and rural municipalities.

At Brown & Associates, Ken has successfully managed approval processes for the CN Calgary Logistics Park Intermodal Railway Facility in Conrich, AB and the High Plains Industrial Park in East Balzac, AB – both projects having regional economic development significance. (Over)

EDUCATION

U of A Bachelor of Arts (Geography)

PROFESSIONAL AFFILIATIONS

Canadian Institute of Planners

Alberta Professional Planners Institute

American Planning Association (provisional)

CAREER SYNOPSIS CONTINUED

Ken also continues to manage a variety of other commercial / industrial residential and recreational projects in various municipalities across the Calgary Region.

His expertise is utilized in preparing development opportunity analyses, market research and a variety of feasibility studies. All of Ken's projects involve strategic communications programming and he is adept at developing and implementing public consultation processes. Ken has experience providing expert witness testimony to government regulatory bodies.

Prior to joining Brown & Associates, Ken worked with Rocky View County as Senior Planner / Team Leader. As Senior Planner, Ken worked alongside private consultants to prepare a variety of significant Area Structure Plans, Conceptual Schemes, Land Use Redesignation and Subdivision proposals. Utilizing expertise acquired from extensive, varied and progressively more responsible professional experiences, Ken coordinated a team of multi-jurisdictional professionals and stakeholders to review and implement these proposals. As a Team Leader, Ken mentored a group of Municipal Planners to implement a share of Section's work program.

Prior to employment with Rocky View County, Ken worked as Planning & Development Officer with the Town of Slave Lake to prepare a variety of statutory plans and subdivision/land use proposals. He also served as the Town's Development Authority with responsibility for development permitting and land use bylaw compliance / enforcement.

Prior to working with the Town, he worked with New Era Municipal Services to provide a wide variety of professional planning services to over 30 member - municipalities situated in northwest Alberta.

Ken has experience providing expert land development reports and testimony before the Alberta Energy and Utilities Board.

Ken is a dynamic & innovative self-starter with a proven record of successfully managing a wide-range of business relationships. He continues to build upon and broaden these relationships as a member of the Brown & Associates team.

CONCEPTUAL SCHEME

- High Plains Industrial Park, East Balzac Rocky View County, Highfield Investment Group, 2010.

OUTLINE PLAN

- Netook Crossing North, Mountain View County, AB, Neuroese Properties, 2009.
- High Plains Industrial Park, Stage 1, 2, and 3 Outline Plans, East Balzac, Rocky View County, AB, Highfield Investment Group, 2011-2013.
- The Springs at DeWinton Cluster Residential Community, MD Foothills, AB, Sincerus Capital Group, 2012.

MASTER SITE DEVELOPMENT PLANS

- Calgary Logistics Park at Conrich, Rocky View County, AB, CN, 2010.
- Riocan/Tanger Outlets
- Calaway Park, Rocky View County, AB, CA, 2014
- Rocky View Motor Sports, Park Rocky View County, AB, CA, 2014 .
- New Life Centre Rocky View Men's Treatment Centre, Rocky View County, AB, CA, 2014.

LAND USE AMENDMENT & SUBDIVISION/APPROVALS

- Youth Treatment Centre Subdivision, Fort McMurray, AB, Alberta Infrastructure, 2009.
- Serenity Golf Course, Dalmead, AB, HeatherGlen Land Company, 2009.
- Line Training Facility & Field Office, Langdon, AB, AltaLink, 2012.

STRATEGIC PLANS

- Michener Centre Master Plan, Red Deer, AB, Alberta Infrastructure, 2009.
- Town of Slave Lake Master Accommodation Plan, Slave Lake, AB, Alberta Infrastructure, 2011.
- Residential Treatment Centre Facility Needs Assessment, Teen Challenge Priddis, AB, CA, 2014.

EXPERT WITNESS

- Sour gas well impact reports and testimony, Rocky View County, AB, The Bancroft Family, Alberta Energy and Utilities Board, 2012.

APPENDIX II **: Rocky View County Land Use Bylaw Districts**

SECTION 43 RANCH AND FARM DISTRICT (RF)

43.1 Purpose and Intent

The purpose and intent of this District is to provide for agricultural activities as the primary land use on a quarter section of land or on large balance lands from *a* previous subdivision.

43.2 Minimum Parcel Size

In order to facilitate the purpose and intent of this District and ensure the sustainability of agricultural uses within the District, for the purpose of subdivision applications, the Minimum Parcel Size in this District is as follows:

(a) an *unsubdivided quarter section;*

(b) the area in title at the time of passage of this *Bylaw;*

(c) that portion of a *parcel* remaining after approval of a redesignation which facilitates a subdivision and after the subsequent registration of said subdivision reduces the area of the parent *parcel* providing the remainder is a minimum of 20.23 hectares (50.00 acres)*;*

(d) the portion created and the portion remaining after registration of an *Agriculture First Parcel Out* subdivision; or,

(e) the portion created and the portion remaining after registration of a subdivision of *Isolated Land* consisting of a minimum of 8.10 hectares (20.01 acres).

LUB 10/12/2013

43.3 Uses, Permitted

Accessory buildings (not exceeding 500.00 sq. m. (5,381.95 sq. ft.)

Accessory Dwelling Unit (may be a Secondary Suite, a Suite within a Building, or a Garden Suite)

Agriculture, General
Farm dwelling, single detached
Government Services
Home-Based Business, Type I
Keeping of livestock (See Section 24 for regulations)
Private Swimming Pools

LUB 21/09/2010

43.4 Uses, Discretionary

A second Accessory Dwelling Unit, not including a Garden Suite (for the purposes of family care or farm help, and when associated with a second Farm Dwelling, single detached).

Accessory building greater than 500.00 sq. m. (5,381.95 sq. ft.)

Additional Farm Dwellings
Agricultural Processing, Minor
Animal Health Care Services
Bed and Breakfast Home
Bee Keeping
Commercial Communications Facilities - Type "A", Type "B", Type "C"
Equestrian Centre I and Equestrian Centre II
Farm dwelling, mobile home
Farm dwelling, moved-in
Farm Gate Sales
Farmers Market
Fish Farms
Home-Based Business, Type II
Horticulture Development
Keeping of livestock (See Section 24 for regulations)
Kennels
Kennels, Hobby
Museums
Private Riding Arena
Public Buildings and utilities
Signs
Special Care Facility
Special Events Parking
Working Dogs

LUB 08/10/2013

43.5 General Regulations

The General Regulations apply as contained in Part 3 of this Land Use *Bylaw* as well as the following provisions:

43.6 Minimum Requirements

(a) *Yard, Front*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service.

(b) *Yard, Side*:

(i) 45.00 m (147.64 ft.) from any road, County;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, internal subdivision or road, service;

(iv) 6.00 m (19.69 ft.) all other.

(c) *Yard, Rear*:

(i) 30.00 m (98.43 ft.) from any road, highway;

(ii) 15.00 m (49.21 ft.) all other.

LUB 10/12/2013

43.7 Minimum Habitable floor area, excluding basement

(a) 92.00 sq. m (990.28 sq. ft.) single *storey dwelling;*

(b) 92.00 sq. m (990.28 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 74.00 sq. m (796.53 sq. ft.) split entry or bi-level and the main floor;

(d) 18.00 sq. m (193.75 sq. ft.) finished lower level;

(e) 92.00 sq. m (990.28 sq. ft.) combined *floor area*, two *storey dwelling;*

(f) 92.00 sq. m (990.28 sq. ft.) main floor for *dwelling, moved-in*.

43.8 Exceptions to Ranch and Farm District (RF)

The following described properties held a designation of Agriculture (2) District or Agricultural (4) under the former Land Use *Bylaw* C-1725-84 and pursuant to that *Bylaw* the subdivision of one (1) *parcel* from the parent *parcel* was provided for, subject to conformity with all other County *Bylaws* and policies.

Notwithstanding Section 43.5.(a) this *Bylaw* therefore continues to provide for the subdivision of one (1) *parcel* or lot from the following described properties:

Section	C-1725-84/This Bylaw	Map #
SE-36-22-29	AG-2-RF	24
SW-10-23-27	AG-2-RF	32
SW-27-23-28	AG-2-RF	33
SE-1-24-28	AG-2-RF	43
SE-13-24-28	AG-2-RF	43
SE-11-25-27	AG-4-RF	52 80 acre *parcel*
NE-8-26-28	AG-2-RF	63
NW-11-26-28	AG-2-RF	63
SE-5-21-1	AG-2-RF	65
SW-23-26-1	AG-2-RF	65
NW-11-26-3	AG-2-RF	67
SW-34-26-4	AG-2-RF	68

Section	C-1725-84/This Bylaw	Map #
NE-22-27-29	AG-2-RF	74
NW-20-27-2	AG-2-RF	76
SE-12-27-4	AG-2-RF	78
SW-32-27-5	AG-2-RF	79
NW-21-28-25	AG-2-RF	80
NW-35-28-25	AG-2-RF	80
NW-23-28-25	AG-2-RF	80
SW-21-28-26	AG-2-RF	81
NE-3-28-27	AG-2-RF	82
NW-8-28-27	AG-2-RF	82
SW-16-28-27	AG-2-RF	82
NE-15-28-29	AG-2-RF	84
NW-30-28-1	AG-2-RF	85
SE-22-28-4	AG-2-RF	88
SE-23-28-4	AG-2-RF	88
SE-15-28-5	AG-2-RF	89
SE-13-29-1	AG-2-RF	95
SW-13-29-1	AG-2-RF	95

LUB 11/12/2012

SECTION 44 RANCH AND FARM TWO DISTRICT (RF-2)

44.1 Purpose and Intent

The purpose and intent of this District is to provide for a range of mid-sized *parcels* for agricultural use. Residential uses are accessory to the agricultural use.

44.2 Uses, Permitted

Accessory Dwelling Unit (*may* be a *Secondary Suite*, a *Suite within a Building*, or a *Garden Suite*)
Accessory buildings (not exceeding 500.00 sq. m (5,381.95 sq. ft.)
Agriculture, General
Farm Dwelling, single detached
Government Services
Home-Based Business, Type I
Keeping of *livestock* (See Section 24 for regulations)
Private Swimming Pools

LUB 21/09/2010

44.3 Uses, Discretionary

A second *Accessory* Dwelling Unit, not including a *Garden Suite* (for the purposes of family care or farm help, and when associated with a second *Farm Dwelling, single detached).*
Accessory building greater than 500.00 sq. m. (5,381.95 sq. ft.) building area
Additional Farm Dwellings
Agricultural Processing, Minor
Animal Health Care Services
Bed and Breakfast Home
Bee Keeping
Commercial Communications Facilities - Type "A", Type "B", Type "C"
Equestrian Centre I & Equestrian Centre II
Farm Dwelling, mobile home
Farm Dwelling, moved-in
Farm Gate Sales
Farmers Market
Fish Farms
Home-Based Business, Type II
Horticulture Development
Keeping of livestock (See Section 24 for regulations)
Kennels
Kennels, Hobby
Museums
Private Riding Arena
Public Buildings and utilities
Signs
Special Care Facility
Special Events Parking
Working Dogs

LUB 08/10/2013

44.4 General Regulations

The General Regulations apply as contained in Part 3 of this Land Use *Bylaw* as well as the following provisions:

44.5 Minimum Requirements

(a) *Parcel Size:*

20.23 hectares (49.98 acres) or the area in title at the time of passage of this *Bylaw*.

(b) *Yard, Front:*

(i) 45.00 m (147.64 ft.) from any road*, County;*

(ii) 60.00 m (196.85 ft.) from any road*,* highway.

(iii) 15.00 m (49.21 ft.) from any *road*, *internal subdivision* or road, service.

(c) *Yard, Side:*

(i) 45.00 m (147.64 ft.) from any road*, County*;

(ii) 60.00 m (196.85 ft.) from any road*,* highway*;*

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service;

(iv) 6.00 m (19.69 ft.) all other.

(d) *Yard, Rear:*

(i) 30.00 m (98.43 ft.) from any road*,* highway

(ii) 15.00 m (49.21 ft.) all other.

LUB 21/09/2010

44.6 Minimum Habitable floor area, excluding basement

(a) 92.00 sq. m (990.28 sq. ft.) single *storey dwelling;*

(b) 92.00 sq. m (990.28 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 74.00 sq. m (796.53 sq. ft.) split entry or bi-level and the main floor;
18.00 sq. m (193.75 sq. ft.) finished lower level;

(d) 92.00 sq. m (990.28 sq. ft.) combined *floor area*, two *storey dwelling;*

(e) 92.00 sq. m (990.28 sq. ft.) main floor for *dwelling, moved-in*.

SECTION 45 RANCH AND FARM THREE DISTRICT (RF-3)

45.1 Purpose and Intent

The purpose of this District is to provide for a range of smaller *parcel* sizes for agricultural uses. The intent is to accommodate traditional and emerging trends in agriculture which *may* successfully be developed on smaller *parcel*s of land. Residential uses are accessory to the agricultural use.

45.2 Uses, Permitted

Accessory buildings less than 500.00 sq. m (5,381.95 sq. ft.) building area
Accessory Dwelling Unit (may be a Secondary Suite, a Suite within a Building, or a Garden Suite)
Agriculture, General
Farm Dwelling, single detached
Government Services
Home-Based Business, Type I
Keeping of livestock (See Section 24 for regulations)
Private swimming pool

LUB 21/09/2010

45.3 Uses, Discretionary

A second *Accessory Dwelling Unit*, not including a *Garden Suite* (for the purposes of family care or farm help, and when associated with a second *Farm Dwelling, single detached*)
Accessory buildings greater than 500.00 sq. m (5,381.95 sq. ft.) building area
Additional Farm Dwellings
Agricultural Processing, Minor
Animal Health Care Services
Bed and Breakfast Home
Bee Keeping
Commercial Communications Facility - Type "A", Type "B", Type "C"
Equestrian Centre I and Equestrian Centre II
Farm Dwelling, mobile home
Farm Dwelling, moved-in
Farm Gate Sales
Farmers Market
Fish Farms
Home-Based Business, Type II
Horticulture Development
Keeping of livestock (See Section 24 for regulations)
Kennels
Kennels, Hobby
Museums
Private Riding Arena
Public Buildings and utilities
Signs
Special Care Facility
Special Events Parking
Working Dogs

LUB 08/10/2013

45.4 General Regulations

The General Regulations apply as contained in Part 3 of this Land Use *Bylaw* as well as the following provisions:

45.5 Minimum Requirements

(a) *Parcel* Size:

12.14 hectares (29.99 acres) or the area in title at the time of passage of this *Bylaw*.

(b) *Yard, Front*:

(i) 45.00 m (147.63 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service.

(c) *Yard, Side*:

(i) 45.00 m (147.63 ft.) from any road, *County*;

(ii) 60.00 m (196.82 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service;

(iv) 6.00 m (19.68 ft.) all other.

(d) *Yard, Rear*:

(i) 30.03 m (98.43 ft.) from any road;

(ii) 15.00 m (49.21 ft.) all other.

45.6 Minimum Habitable Floor Area, excluding basement

(a) 92.00 sq. m (990.28 sq. ft.) single *storey dwelling*;

(b) 92.00 sq. m (990.28 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 74.00 sq. m (796.53 sq. ft.) split entry or bi-level on the main floor;
18.00 sq. m (193.75 sq. ft.) finished lower level;

(d) 92.00 sq. m (990.28 sq. ft.) combined floor area, two *storey dwelling*;

(e) 92.00 sq. m (990.28 sq. ft.) main floor for *dwelling*, moved-in.

45.7 Maximum height of buildings

(a) *principal building* - 10.00 m (32.81 ft.);

(b) *accessory building* - 5.50 m (18.04 ft.).

SECTION 46 AGRICULTURAL HOLDINGS DISTRICT (AH)

46.1 Purpose and Intent

The purpose and intent of this District is to provide for a range of parcel sizes for agricultural uses. This district provides for traditional agricultural pursuits on large parcels of land. It also recognizes the emerging trends towards new agricultural uses which may be successfully developed on smaller parcels of land.

46.2 Uses, Permitted

Accessory buildings less than 190.00 sq. m (2,045.14 sq. ft.) building area on parcels less than 16.20 hectares (40.03 acres)
Accessory buildings less than 500.00 sq. m (5,381.95 sq. ft.) building area on parcels greater than 16.20 hectares (40.03 acres)
Accessory Dwelling Unit (may be a Secondary Suite, a Suite within a Building, or a Garden Suite)
Agriculture, General
Dwelling, single detached
Government Services
Home-Based Business, Type I
Keeping of livestock (See Section 24 for regulations)
Private swimming pool

LUB 21/09/2010

46.3 Uses, Discretionary

Accessory buildings greater than 190.00 sq. m (2,045.14 sq. ft.) *building area* on *parcels* less than 16.20 hectares (40.03 acres.)
Accessory buildings greater than 500.00 sq. m (5,381.95 sq. ft.) *building area* on *parcels* greater than 16.20 ha (40.03 acres)
Agricultural Processing, Minor
Animal Health Care Services
Bed and Breakfast Homes
Commercial Communication Facilities - Type "A", Type "B", Type "C"
Equestrian I and Equestrian Centre II
Facilities owned and operated by the *County*
Farm Dwelling, mobile home
Farm Dwelling, moved-in
Farm Gate Sales
Farmers Market
Fish Farms
Home-Based Business, Type II
Horticulture Development
Keeping of livestock (See Section 24 for regulations)
Kennels
Kennels, Hobby
Private Riding Arena
Public Buildings and utilities
Signs
Special Events Parking
Working Dogs

LUB 08/10/2013

46.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Land Use Bylaw* as well as the following provisions:

46.5 Minimum Requirements

(a) Parcel Size:

The minimum parcel size shall be 8.10 hectares (20.01 acres) or the area in title at the time of passage of this *Bylaw*.

(b) Yard, Front:

(i) 45.00 m (147.64 ft.) from any road, County;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.0 m (49.2 ft.) from any road, internal subdivision or road, service.

(c) Yard, Side:

(i) 45.00 m (147.64 ft.) from any road, County;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, internal subdivision or road, service;

(iv) 6.00 m (19.69 ft.) all other.

(d) Yard, Rear:

(i) 30.00 m (98.43 ft.) from any road;

(ii) 15.00 m (49.21 ft.) all other.

46.6 Minimum Habitable Floor Area, excluding basement

(i) 92.00 sq. m (990.28 sq. ft.) single storey dwelling;

(ii) 92.00 sq. m (990.28 sq. ft.) split level dwelling, the total area of two finished levels;

(iii) 74.00 sq. m (796.53 sq. ft.) split entry or bi-level on the main floor; 18.00 sq. m (193.75 sq. ft.) finished lower level;

(iv) 92.00 sq. m (990.28 sq. ft.) combined floor area, two storey dwelling;

(v) 92.00 sq. m (990.28 sq. ft.) main floor for dwelling, moved-in.

46.7 **Maximum height of buildings**

(i) principal building - 10.00 m (32.81 ft.);

(ii) accessory building - 5.50 m (18.04 ft.).

SECTION 47 FARMSTEAD DISTRICT (F)

47.1 Purpose and Intent

The purpose of this District is to provide for a single *parcel* of land containing an existing *Farmstead* from an *unsubdivided* quarter section.

47.2 Uses, Permitted

Accessory buildings less than 80.00 sq. m (861.11 sq. ft.) building area
Agriculture, General
Dwelling, Single detached
Home-Based Business, Type I
Keeping of livestock (See Section 24 for regulations)
Private Swimming Pool

LUB 21/09/2010

47.3 Uses, Discretionary

Accessory buildings in excess of 80.00 sq. m (861.00.sq.ft.) but not more than 223.0 sq. m (2,400.35 sq. ft.)
Accessory Dwelling Unit (may be a *Secondary Suite,* a *Suite* within a *Building*, or a *Garden Suite*)
Animal Health Care Services
Bed and Breakfast Home
Child care facilities
Commercial Communication Facilities – Type "A", Type "B", Type "C"
Farm Dwelling, mobile home
Farm Dwelling, moved-in
Farm Gate Sales
Farmers Market
Home-Based Business, Type II
Horticulture Development
Keeping of *livestock* (See Section 24 for regulations)
Kennels on parcels greater than 5.00 hectares (12.36 acres)
Kennels, Hobby
Signs
Special Events Parking

LUB 11/12/2012

47.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Bylaw* as well as the following provisions:

47.5 Minimum & Maximum Requirements

(a) *Parcel Size:*
The *parcel* size *shall* be 1.60 hectares (3.96 acres) or such area as deemed necessary to accommodate the existing *farmstead*.

(b) *Yard, Front*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service.

(c) *Yard, Side*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service;

(iv) 6.00 m (19.69 ft.) all other.

(d) *Yard, Rear*:

(i) 30.0 m (98.4 ft.) from any road;

(ii) 15.0 m (49.2 ft.) all other.

LUB 21/09/2010

47.6 Minimum Habitable *floor area*, excluding basement

(a) 92.00 sq. m (990.28 sq. ft.) single *storey dwelling;*

(b) 92.00 sq. m (990.28 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 74.00 sq. m (796.53 sq. ft.) split entry or bi-level on the main floor;
18.00 sq. m (193.75 sq. ft.) finished lower level;

(d) 92.00 sq. m (990.28 sq. ft.) combined *floor area*, two *storey dwelling;*

(e) 92.00 sq. m (990.28 sq. ft.) main floor for *dwelling, moved-in*.

47.7 Maximum height of buildings

(a) (principal building - 10.00 m (32.81 ft.);

(b) accessory buildings - 5.50 m (18.04 ft.).

SECTION 48 RESIDENTIAL ONE DISTRICT (R-1)

48.1 Purpose and Intent

The purpose of this District is to provide for a residential use on a small *parcel* of land which does not accommodate *agriculture, general*.

48.2 Uses, Permitted

Accessory buildings less than 80.27 sq. m (864.01 sq. ft.) *building* area
Dwelling, single detached
Home-Based Business, Type 1
Keeping of *livestock* (See Section 24 for regulations and parcel size requirements)
Private swimming pools

LUB 11/12/2012

48.3 Uses, Discretionary

Accessory Buildings greater than 80.27 sq. m (864.01 sq. ft.) *building* area and less that 120.00 sq. m (1,291.67 sq. ft.) *building area*
Accessory Dwelling Unit (may be a Secondary Suite, a Suite within a Building, or a Garden Suite)
Bed and Breakfast Homes
Child care facilities
Dwelling, moved-in
Keeping of *livestock* (See Section 24 for regulations and parcel size requirements)
Health Care Practice
Kennels, Hobby
Signs

LUB 11/12/2012

48.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Bylaw* as well as the following provisions:

48.5 Minimum and Maximum Requirements

(a) *Parcel* Size:
The minimum *parcel* size *shall* be 0.80 hectares (1.98 acres).

(b) *Yard, Front*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway *;*

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service.

(c) *Yard, Side*:

(ii) 60.00 m (196.85 ft.) from any road, highway*;*

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service;

(iv) 6.00 m (19.69 ft.) all other.

(d) *Yard, Rear*:

(i) 30.00 m (98.43 ft.) from any road;

(ii) 15.00 m (49.21 ft.) all other.

49.6 Minimum Habitable Floor Area, excluding basement

(a) 140.00 sq. m (1,506.95 sq. ft.) single *storey dwelling;*

(b) 140.00 sq. m (1,506.95 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 121.00 sq. m (1,302.43 sq. ft.) split entry or bi-level and the main floor; 28.00 sq. m (301.39 sq. ft.) finished lower level;

(d) 150.00 sq. m (1,614.59 sq. ft.) two *storey dwelling*, combined *floor area*s;

(e) 140.00 sq. m (1,506.95 sq. ft.) main floor - *dwelling, moved-in.*

49.7 Maximum height of buildings

(a) *principal building* - 11.00 m (36.09 ft.);

(b) *accessory buildings* - 6.50 m (21.32 ft.).

49.8 Maximum *Dwelling Units* per *lot* is one *Dwelling, single detached*, and one *Accessory Dwelling Unit*.

49.9 Maximum total *building* area for all *accessory building*s – 120.00 sq. m (1,291.67 sq. ft.)

49.10 Maximum number of *accessory building*s – 2.

SECTION 50 RESIDENTIAL TWO DISTRICT (R-2)

50.1 Purpose and Intent

The purpose of this District is to provide a residential use on a small *parcel* of land which accommodates minor agricultural pursuits and required *accessory buildings*.

50.2 Uses, Permitted

Accessory buildings less than 150.00 sq. m (1,614.59 sq. ft.) *building* area
Dwelling, single detached
Home-Based Business, Type I
Keeping of livestock (See Section 24 for regulations)
Private swimming pools

LUB 21/09/2010

50.3 Uses, Discretionary

Accessory buildings greater than 150.00 sq. m (1,614.59 sq. ft.) *building* area and less than 225.00 sq. m (2,421.87 sq. ft.) *building area*
Accessory Dwelling Unit (may be *a Secondary Suite, a Suite within a Building,* or a *Garden Suite)*
Bed and Breakfast Home
Child care facilities
Commercial Communication Facilities - Type "A"
Dwelling, moved-in
Health Care Practice
Home-Based Business, Type II
Keeping of livestock (See Section 24 for regulations)
Kennels, Hobby
Market Gardens and *Greenhouses* on *parcels* greater than 6.00 hectares (14.83 acres) in area where there is a surface supply of water
Private Riding Arena on *parcels* greater than 6.00 hectares (14.83) acres in area
Signs
Special Care Facilities
Special Events Parking
Tree Farms on *parcels greater* than 6.00 hectares (14.83 acres) in area where there is a surface supply of water

LUB 11/12/2012

50.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Bylaw,* as well as the following provisions.

50.5 Minimum and Maximum Requirements

(a) *Parcel* Size:
The minimum *parcel* size *shall* be 1.60 hectares (3.95 acres) or the area in title at the time of passage of this *Bylaw*.

(b) *Yard, Front*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway*;*

(iii) 15.00 m (49.21 ft.) from any *road, internal subdivision* or road, service.

(c) *Yard, Side*:

(i) 45.00 m (147.64 ft.) from any road, County;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, internal subdivision or road, service;

(iv) 3.00 m (9.84 ft.) all other.

LUB 11/12/2012

(d) *Yard, Rear*:

(i) 30.00 m (98.43 ft.) from any road;

(ii) 7.00 m (22.96 ft.) all other.

LUB 11/12/2012

50.6 Minimum Habitable Floor Area, excluding basement

(a) 112.00 sq. m (1,205.56 sq. ft.) single *storey dwelling;*

(b) 112.00 sq. m (1,205.56 sq. ft.) split level *dwelling*, the total area of two finished levels;

(c) 92.00 sq. m (990.28 sq. ft.) split entry or bi-level and the main floor; 18.00 sq. m (193.75 sq. ft.) finished lower level;

(d) 130.00 sq. m (1,399.31 sq. ft.) combined *floor area*, two *storey dwelling;*

(e) 112.00 sq. m (1,205.56 sq. ft.) main floor for *dwelling, moved-in*.

50.7 Maximum height of buildings

(a) principal building - 10.00 m (32.81 ft.);

(b) accessory buildings - 7.00 m (22.96 ft.).

LUB 11/12/2012

50.8 Maximum *dwelling units* per *lot* is one *Dwelling, Single Detached*, and one *Accessory Dwelling Unit*.

50.9 Total *building* area for all *accessory building*s – 225.00 sq. m (2,421.88 sq. ft.).

LUB 21/09/2010

50.10 Maximum number of *accessory building*s – 3.

SECTION 51 RESIDENTIAL THREE DISTRICT (R-3)

51.1 Purpose and Intent

The purpose of this district is to provide for a residential use on *parcel*s which can accommodate residential, more general agricultural uses, *home-based business* uses, and larger *accessory building*s.

51.2 Uses, Permitted

*Accessory building*s less than 190.0 sq. m (2,045.14 sq. ft.) *building* area
Dwelling, single detached
Home-Based Business, Type I
Keeping of *livestock* (See Section 24 for regulations)
Parcels 4.05 hectares (10.01 acres) or greater; and *accessory building*s on *parcel*s less than 4.05 hectares (10.01 acres), less than 150.00 sq. m (1,614.59 sq. ft.) *building* area
Private swimming pool

LUB 21/09/2010

51.3 Uses, Discretionary

Accessory buildings 190.00 sq. m (2,045.14 sq. ft.) to 250.00 sq. m (2,690.98 sq. ft.) *building* area on *parcels* 4.00 hectares (9.88 acres) or greater
Accessory Dwelling Unit (may be a *Secondary Suite, a Suite within a Building,* or a *Garden Suite)*
Animal Health Care Services
Bed and Breakfast Home
Bee Keeping
Child care facilities
Commercial Communications Facilities - Type "A"
Dwelling, moved-in
Equestrian Centre I
Health Care Services
Home based business, Type II
Keeping of *livestock* (See Section 24 for regulations)
Kennel, Hobby
Kennels
Market Gardens and *Greenhouses* on *parcels* greater than 6.00 hectares (14.83 acres) in area where there is a surface supply of water
Private Riding Arenas
Signs
Special Events Parking
Tree Farms on *parcels* greater than 6.00 hectares (14.80 acres) in area where there is a surface supply of water
Trout Farms

LUB 11/12/2012

51.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Bylaw* as well as the following provisions:

51.5 Minimum Requirements

(a) *Parcel* Size:

The minimum *parcel* size *shall* be 4.0 hectares (9.88 acres) or the area in title at the time of passage of this *Bylaw*.

(b) *Yard, Front*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, *internal subdivision* or road, service.

(c) *Yard, Side*:

(i) 45.00 m (147.64 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, *internal subdivision* or road, service;

(iv) 15.00 (49.21 ft.) all other.

(d) *Yard, Rear*:

(i) 30.00 m (98.42 ft.).

LUB 21/09/2010

51.6 Minimum Habitable Floor Area, excluding basement

(i) *112.00 sq. m (1,205.56 sq. ft.) single storey dwelling;*

(ii) *112.00 sq. m (1,205.56 sq. ft.) split level dwelling, the total area of two finished levels;*

(iii) *92.00 sq. m (990.28 sq. ft.) split entry or bi-level and the main floor; 18.00 sq. m (193.75 sq. ft.) finished lower level;*

(iv) *130.00 sq. m (1,399.31 sq. ft.) combined floor area, two storey dwelling;*

(v) *112.00 sq. m (1,205.56 sq. ft.) main floor for dwelling, moved-in.*

51.7 **Maximum Requirements**

(a) Height of *building*s:

(i) *principal building - 10.00 m (32.81 ft.);*

(ii) *accessory buildings - 5.50 m (18.04 ft.).*

51.8 Total *building* area for all *accessory building*s:

(i) *Parcels less than 10 acres - 285.00 sq. m (3,067.71 sq. ft.);*

(ii) *Parcels 10 acres or greater - 378.70 sq. m (4,076.29 sq. ft.).*

51.9 Number of *accessory building*s – 3.

SECTION 52 HIGHWAY BUSINESS DISTRICT (B-1)

52.1 Purpose and Intent

The purpose and intent of this District is to provide for *business* uses for the benefit of the travelling public.

52.2 Uses, Permitted

Accessory buildings less than 90.00 sq. m (969.75 sq. ft.).
Government Services
Tourist Information Services and Facilities

LUB 21/09/2010

52.3 Uses, Discretionary

Accommodation and Convention Services
Amusement and Entertainment Services
Automotive, Equipment and Vehicle Services
Campground, Tourist
Commercial Communication Facilities - Type "A", Type "B"
Drinking Establishment
Indoor Participant Recreation Services
One *dwelling unit*, accessory to the *principal business use*
Outdoor Café
Restaurants
Signs
Truck Trailer Service

52.4 General Regulations

The General Regulations apply as contained in Part 3 of this Land Use *Bylaw* as well as the following provisions:

(a) All *parcels* having this land use designation on the date of adoption of *Bylaw* C-6517-2007 *(October 2, 2007)* remain in full force and effect; however, this land use district is no longer available for any redesignation applications subsequent to that date.

52.5 Minimum Requirements

(a) *Parcel* Size:
The minimum *parcel* size *shall* be 1.00 hectare (2.47 acres).

(b) *Yard, Front* for *Buildings*:

(i) 30.00 m (98.43 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road*, internal subdivision;*

(iv) 10.00 m (32.81 ft.) from any road, service adjacent to a highway;

(v) 10.00 m (32.81 ft.) from any road, service adjacent to a road, *County*.

(c) *Yard, Side* for *Buildings*:

(i) 30.00 m (98.43 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 10.00 m (32.81 ft.) from any road, service adjacent to a road, highway;

(iv) 10.00 m (32.81 ft.) from any road, service adjacent to a road, *County*;

(v) 6.00 m (19.69 ft.) all other.

(d) *Yard, Rear* for *Buildings*:

(i) 30.00 m (98.43 ft.) from any road;

(ii) 6.00 m (19.69 ft.) all other.

(e) *Yard, Front* for Parking, Storage and Display of Products:

(i) 15.00 m (49.21 ft.) from any road, *County*, or road, highway;

(ii) 8.00 m (26.24 ft.) from any, *road, internal subdivision*, or road, service adjacent to a road, highway or road, *County*.

(f) *Yard, Side* for Parking, Storage and Display of Products:

(i) 15.00 m (49.21 ft.) from any road, *County*, or road, highway;

(ii) 8.00 m (26.24 ft.) from any *road internal subdivision*, or road, service adjacent to a road, highway or road;

(iii) 6.00 m (19.69 ft.) all other.

(g) *Yard, Rear* for Parking, Storage and Display of Products:

(i) 15.0 m (49.21 ft.) from any road;

(ii) 6.0 m (19.69 ft.) all other.

LUB 21/09/2010

52.6 Building Height

(a) maximum - 10.0 m (32.81 ft.).

52.7 Special Requirements

A minimum of 10% of the *site area shall* be *landscaped*

Municipal District of Rocky View No. 44
Bylaw C-4706-96

A Bylaw of the Municipal District of Rocky View No. 44 to amend Bylaw C-1725-84.

WHEREAS the Council deems it desirable to amend the said Bylaw; and

WHEREAS the Council of the Municipal District of Rocky View No. 44 has received an application to amend Section 7.3.0; Land Use Map No. 48 of Bylaw C-1725-84 to redesignate that portion of the NW 11-24-4-W5M, lying south of the Elbow River from Agricultural Conservation (1) District and Public and Quasi-Public District to Direct Control District, as shown on the attached Schedule "A"; and

WHEREAS a notice was published on November 26, 1996 and December 3, 1996 in the Calgary Rural Times, a newspaper circulating in the Municipal District of Rocky View No. 44 advertising the Public Hearing for December 10, 1996; and

WHEREAS Council held a Public Hearing and have given consideration to the representations made to it in accordance with Section 692 of the Municipal Government Act, being Chapter 24 of the Revised Statutes of Alberta 1995, and all amendments thereto.

NOW THEREFORE the Council enacts the following:

1.0.0 That Section 7.3.0; Land Use Map No. 48 of Land Use Bylaw C-1725-84 be amended by redesignating that portion of the NW 11-24-4-W5M lying south of the Elbow River from Agricultural Conservation (1) District and Public and Quasi-Public District to Direct Control District, as shown on the attached Schedule "A" forming part of this Bylaw.

2.0.0 That all lands lying south of the Elbow River in the NW 11-24-4-W5M are hereby redesignated tc Direct Control District as shown on the attached Schedule "A" forming part of this Bylaw.

3.0.0 That the guidelines of the Direct Control District comprise:

- 4.0 General Regulations
- 5.0 Land Use Regulations
- 6.0 Definitions
- 7.0 Implementation

4.0.0 **GENERAL REGULATIONS**

4.1.0 The General Land Use Regulations as contained in Section 8 of the Land Use Bylaw apply except where specifically noted herein.

4.2.0 The Development Officer shall consider and decide on applications for Development Permits for those uses which are listed as "Permitted Uses" and "Discretionary Uses" by this bylaw provided the provisions of Sections 4 and 5 herein are completed in form and substance satisfactory to the Municipality, except where specifically noted that Council approval is required.

4.3.0 The Development Officer shall cause to be issued Development Permits which have been approved.

4.4.0 For the purposes of this bylaw the floodway and flood fringe of the Elbow River shall be as delineated in the Flood Plain Delineation Study by AGRA Earth and Environmental, dated February 9, 1996, for Alberta Environmental Protection.

4.5.0 No use shall be made of all or any portion of the Lands in the floodway of the Elbow River for any buildings or structures of any kind, including fencing.

4.6.0 No use shall be made of all or any portion of the Lands in the flood fringe of the Elbow River, as described in 4.4, for any buildings or structures of any kind, except three-strand wire farm fencing and pathways, unless the proposed building or structure is elevated through grading and such other measures as may be necessary, at least one (1) metre above the 1:100 year flood contour, all to the satisfaction of Alberta Environmental Protection and the Municipality.

4.7.0 Notwithstanding 4.6.0, existing buildings and structures located in the flood fringe of the Elbow River shall be permitted to remain provided, however, that there shall be no structural repairs or alterations to such buildings or structures unless such repairs or alterations will bring the building into accordance with provision 4.6.0 of this bylaw.

5.0.0 LAND USE REGULATIONS

5.1.0 Purpose and Intent

The purpose and intent of this District is to accommodate an existing Recreation facility and provide for future development needs of the facility.

5.2.0 List of Permitted Uses

Extensive agricultural pursuits

5.3.0 List of Discretionary Uses

5.3.1 Recreational uses including but not limited to:

a) individual and group sports activities
b) 36 unit seasonal holiday trailer park

5.3.2 Principal buildings and structures

a) Office security and maintenance buildings including:

i) 2 single family dwellings for year-round, full-time manager residences
ii) 1 apartment dwelling for seasonal staff residence
iii) 1 tractor shop
iv) 1 garage
v) 1 barn
vi) 1 workshop
vii) 1 single family dwelling for year-round, full-time security staff
viii) 1 office facility

b) Patron buildings and structures, including:

i) 7 lodge buildings
ii) 1 washroom/laundry facility

iii) 1 kitchen building

5.3.3 **Accessory buildings and structures**

a) 1 pioneer centre
b) 1 open air chapel
c) 1 open air nature centre
d) 1 archery shed
e) 1 swimming pool and change facility
f) 5 seasonal cabins
g) 6 seasonal tent structures

5.4.0 <u>Minimum and Maximum Requirements</u>

5.4.1 Maximum area of site - 43.3 hectares (109.5 acres)

The following requirements apply to all principal and accessory buildings only

5.4.2 Minimum Front Yard:

a) 60m (196.84 ft.) from any primary highway
b) 15m (49.21 ft.) all other

5.4.3 Minimum side yard:

a) 15m (49.21 ft.)

5.4.4 Minimum rear yard:

a) 15m (49.21 ft.)

5.4.5 **Maximum area of buildings or structure**

a) single family dwelling - 120.7 sq.m (1,300 sq.ft.)
b) apartment dwelling - 74.3 sq.m (800 sq.ft.)
c) tractor shop - 74.3 sq.m (800 sq.ft.)
d) garage - 37.2 sq.m (400 sq.ft.)
e) barn - 46.5 sq.m (500 sq.ft.)
f) workshop - 139.4 sq.m (1,500 sq.ft.)
g) office - 46.5 sq.m (500 sq.ft.)
h) lodge buildings:
- Nat Christie Centre and Collicutt Lodge - 696 sq.m (7,500 sq.ft.)
- all others - 213.7 sq.m (2,300 sq.ft.)
i) washroom and laundry facility - 213.7 sq.m (2,300 sq.ft.)
j) kitchen building - 32.5 sq.m (350 sq.ft.)
k) open air chapel - 18.6 sq.m (200 sq.ft.)
l) open air nature centre - 97.5 sq.m (1,050 sq.ft.)
m) pioneer centre - 37.2 sq.m (400 sq.ft.)
n) archery shed - 18.6 sq.m (200 sq.ft.)
o) swimming pool and change facility - 139.35 sq.m (1,500 sq.ft.)
p) seasonal cabins - 18.6 sq.m (200 sq.ft.)

5.4.6 Height of Buildings

a) Principal buildings - 12m (39.4 ft.)
b) Accessory buildings - 5.5m (18.04 ft.)

5.4.7 Special Requirements - there shall be no storage or year-round use or parking of recreation vehicles permitted in the seasonal holiday trailer park area of the recreation facility.

5.5.0 Washroom Facilities

All washroom facilities for all purposes on the site shall be constructed and/or installed in accordance with the Alberta Building Code and to the requirements of Calgary Health Services as defined in a Development Permit.

5.6.0 Development Permits

All discretionary uses shall require a Development Permit and may include such conditions as the Development Officer deems appropriate.

5.7.0 Fire Protection

Fire protection and evacuation measures, where required, shall be included as a condition or conditions in a Development Permit.

6.0.0 DEFINITIONS

6.1.0 **Apartment Dwelling** - for the purposes of this bylaw only, means a dwelling unit located within a multi-use building.

6.2.0 **Building** - includes anything constructed or placed on, in, over or under land but does not include a highway or public roadway.

6.3.0 **Developable Lands** - means those portions of the Lands which are considered to be suitable for development by the Council and the Development of which is not precluded by this Bylaw.

6.4.0 **Developer** - means a person or corporation who/which is responsible for any undertaking that requires a permit or action pursuant to this bylaw (C-4706-96).

6.5.0 **Kitchen Building** - means a building where meals for the patrons of the recreation facility are prepared.

6.6.0 **Lodge** - means a building where food preparation facilities, dining facilities, washrooms and overnight accommodation is provided for patrons of the recreation facility.

6.7.0 **Office Facility** - is a building where the administration of the recreation complex is carried out.

6.8.0 **Seasonal Cabins** - means an unheated building where sleeping accommodation only is available for patrons of the recreation facility.

6.9.0 **Tractor Shop** - means a building where tractors and other landscaping implements are stored.

6.10.0 **Washroom and Laundry Facility** - is a building providing sanitary, laundry and bathing facilities for the patrons of the recreation facility.

7.0.0 IMPLEMENTATION

7.1.0 The Bylaw comes into effect upon the date of its third reading.

File: 4811003

First reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on November 19, 1996, on a motion by Councillor Fullerton.

Second reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on, December 10, 1996, on a motion by Councillor Fullerton.

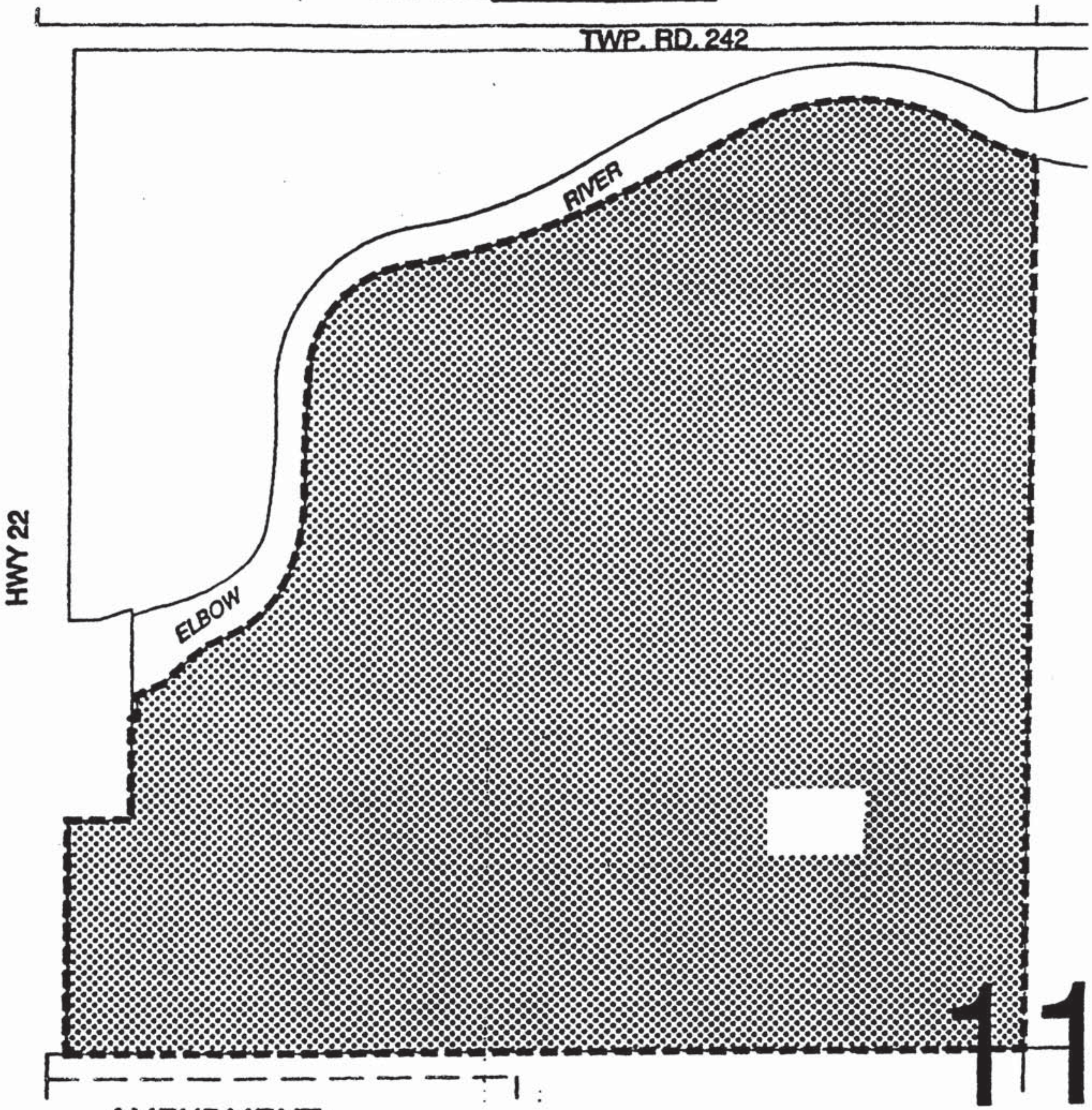
Third and final reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on December 10, 1996, on a motion by Councillor Vincent.

REEVE OR DEPUTY REEVE

Valerie Schmaltz
MUNICIPAL SECRETARY

SCHEDULE "A"

BYLAW: C-4706-96



AMENDMENT:

FROM Agricultural Conservation (1) District TO Direct Control District

FROM Public and Quasi-Public District TO Direct Control District

SUBJECT LAND: ▬▬▬

N

LEGAL DESCRIPTION: Ptn. NW 11-24-4-W5M

FILE: 4811003

ROCKY VIEW MUNICIPAL DISTRICT NO 44

MUNICIPAL DISTRICT OF ROCKY VIEW #44
BYLAW C-6242-2006

A Bylaw of the Municipal District of Rocky View No. 44 to amend Bylaw C-4841-97.

WHEREAS the Council deems it desirable to amend the said Bylaw; and

WHEREAS the Council of the Municipal District of Rocky View No. 44 ("the Municipality") has received an application to amend Section 5; Land Use Map No. 48 of Bylaw C-4841-97 to redesignate the NE ¼ 10-24-4-W5M from Ranch and Farm Two District and Agricultural Holdings District to Ranch and Farm District, Ranch and Farm Three District and Direct Control District as shown on attached Schedule "A" ("the Lands"); and,

WHEREAS a notice was published on April 11th, 2006 and April 18th, 2006 in the Rocky View / Five Village Weekly, a newspaper circulating in the Municipal District of Rocky View No. 44 advertising the Public Hearing for May 9th, 2006;

WHEREAS Council held a Public Hearing and have given consideration to the representations made to it in accordance with Section 692 of the Municipal Government Act, being Chapter 24 of the Revised Statutes of Alberta 1995 and all amendments thereto.

NOW THEREFORE the Council enacts the following:

1. That Part 5, Land Use Map No. 48 of Bylaw C-4841-97 be amended by redesignating the use of the Lands from Ranch and Farm Two District and Agricultural Holdings District to Ranch and Farm District, Ranch and Farm Three District and Direct Control District with special regulations.

2. That the special regulations of the Direct Control District comprise:

   1.0.0 General Regulations

   2.0.0 Land Use Regulations

   3.0.0 Development Regulations

   4.0.0 Definitions

   5.0.0 Implementation

1.0.0 GENERAL REGULATIONS

1.1.0. For the purposes of this Bylaw, the boundaries and description of the Lands shall be more or less as indicated in Schedule "A" attached hereto and forming part hereof, except as otherwise approved by Council.

1.2.0. That the Development Officer shall be responsible for the issuance of Development Permit(s) for the Lands subject to this Bylaw.

1.3.0. Parts One, Two, and Three of Land Use Bylaw C-4841-97 are applicable unless otherwise stated in this Bylaw.

1.4.0. All development upon the Lands shall be in accordance with all plans and specifications submitted pursuant to this Bylaw and all licenses, permits and approvals pertaining to the Lands.

2.0.0 LAND USE REGULATIONS

2.1.0 Purpose and Intent

The purpose and intent of this District is to allow for a Highway Maintenance Facility to be developed within the subject lands that does not adversely affect the surrounding land uses.

2.2.0 Uses:

2.2.1 Agriculture, General

2.2.2 Highway Maintenance Facility

2.2.3 Fencing

2.2.4 Landscaping

2.2.5 Parking

2.2.6 Signs

2.3.0 General Land Use Regulations

The General Regulations apply as contained in Part 3 of this Land Use Bylaw as well as the following provisions:

2.4.0 Minimum & Maximum Requirements

2.4.1 Parcel size:
(a) The maximum parcel size shall be 7.5 hectares (18.5 acres)

2.4.2 Minimum Yard, North:
(a) 30.0 m (98.4 ft.)

2.4.3 Minimum Yard, East:
(a) 30.0 m (98.4 ft.)

2.4.4 Minimum Yard, South & West:
(a) 15.0 m (49.2 ft.)

2.4.5 Building Height
(a) maximum - 18.0 metres (59.0 ft.)

3.0.0 DEVELOPMENT REGULATIONS

3.1.0 No Development Permit shall be issued by the Development Authority and no *development* shall occur on the lands until:

3.1.1 The Owner has prepared a Stormwater Management Plan that is satisfactory to both the Municipality and Alberta Infrastructure and Transportation and which shows that the development will not adversely affect the adjacent lands and/or highways;

3.1.2 An Emergency Response Plan has been prepared by the *Applicant* and submitted to the satisfaction of the Municipality, and which plan establishes, among other things, measures for emergency response and fire suppression;

3.1.3 A Chemical Management Plan has been prepared by the *Applicant* and submitted to the satisfaction of the Municipality, and which plan establishes, among other things, measures for chemical and salt containment and remediation, the storage of fuels, salts and other chemicals, and soil contamination;

3.1.4 The Owner has completed a Traffic Impact Analysis for the entire *development*, and it has been approved by both the M.D. of Rocky View and Alberta Transportation, and further, that all road improvements identified in the Traffic Impact Analysis be completed by the *Owner* to the satisfaction of the Municipality and Alberta Infrastructure and Transportation.

3.1.5 The Owner has submitted a Construction Management Plan completed by a qualified professional engineer licensed to practice in the Province of Alberta, satisfactory to the Municipality, which details amongst other items, erosion, dust and noise control measures and stormwater management during construction.

3.1.6 The Owner has received all necessary permits and/or approvals from Alberta Infrastructure and Transportation, in accordance with the Public Highways Development Act and the Highway Development Control Regulation.

3.2.0 <u>Water Supply and Sewage Treatment</u>

a) Potable water for all development on the site shall be provided through the use of water wells, licensed and approved for commercial use by Alberta Environment, to the satisfaction of the Municipality or hauled to the site and stored in cisterns, as approved by the Municipality and to the satisfaction of the Municipality.

b) Disposal of wastewater from the development on the site shall be subject to all requirements of Alberta Environment and all Municipal approvals pursuant to this Bylaw. Waste water shall be treated and disposed of by septic tank and field, installed to the satisfaction of the Municipality or stored in holding tanks and removed on a regular basis for disposal and treatment at an approved disposal facility

c) Any non-domestic waste water, anti-freeze, oil or fuels accumulated on site shall be held in sealed tanks, the contents of which shall be pumped out and properly disposed of off-site to the satisfaction of the Municipality and/or Alberta Environment

d) Solid waste shall be disposed of on a regular basis at an approved disposal site.

e) A caveat regarding a Deferred Services Agreement is registered on the Lands, notifying the Owner any future owners and all lessees of the requirement to connect to Municipally owned piped water and wastewater systems at their own cost when such services become available. This Agreement is to outline the location of existing services within the Lands, the operation and maintenance of these services, the requirements for their decommissioning once Municipal Servicing becomes available and a commitment from the Owner to participate in mutually beneficial discussions with the Municipality regarding the provision of future Municipal Services including the possible future ownership of their facilities by the Municipality, all to the satisfaction of the Municipality.

3.2.1 Access

a) No direct access to Highway #22 shall be permitted. All access to the land shall be from Township Road 242 and shall be a minimum of 45 m (147.63 feet) west of Highway #22, or as otherwise approved by Alberta Infrastructure and Transportation and the Municipal District of Rocky View.

3.3.0 Development and Building Standards

3.3.1 Landscaping

a) Landscaping shall be provided in accordance with a Landscape Plan to be submitted to the Municipality upon application for a Development Permit. The Landscape Plan shall identify the location, type and extent of all landscaping proposed for the lands, and shall require that a minimum of 10% of the site be landscaped. Within this landscaped area, there shall be a minimum of one (1) tree for every 50 square m (538.2 square feet); a combination of deciduous trees with a minimum caliper of 2.5 inches; and, coniferous trees with a minimum height of 5 feet.

A contoured and rolling landscaped berm shall be developed on the entire perimeter of the site. The berm shall not be higher than two (2) meters measured perpendicular from any road and shall be in accordance with all site line distance requirements.

b) The Landscape Plan contemplated herein shall identify the location and extent of the landscaping areas, the plant material proposed and the methods of irrigation and maintenance of landscaped areas.

c) All areas of the site not disturbed as part of the Development Permit shall be maintained in a natural state or under cultivation.

d) The Landscape Plan should incorporate a weed control program for all areas of the site in accordance with the Weed Control Act of Alberta, and confirmed in a Development Permit.

3.4.0 Controlled Appearance

a) Parking and loading facilities, where proposed, shall be provided for in accordance with the requirements of the Land Use Bylaw, except that parking shall be screened and/or integrated into building architecture and/or landscaped pursuant to 3.2.1 above. Parking shall not be permitted within any minimum setback area.

b) All outside storage of sand and salt, and other road maintenance related materials shall be to the satisfaction of the Development Authority.

c) Signage shall be considered concurrently with a Development Permit application and may be integrated into building architecture and shall be consistent with the overall development theme.

d) Lighting shall be located, oriented and shielded to prevent adverse affects on adjacent properties and the safe and efficient function of Highway #22

3.4.1 The design, character and appearance of any buildings, structures or signs proposed to be erected or located on the lands must be acceptable to the Development Authority having due regard to:

i) the compatibility with and the affect on adjacent properties and the surrounding rural area; and,

ii) the visual enhancement of Highway #22 as an important transportation corridor.

3.4.2 Building form should be consistent with the following:

i) building materials should reflect the architectural heritage of the surrounding rural landscape by emphasizing natural textures and/or original and historic building materials;

ii) building massing should present a profile that is more horizontal than vertical to reflect the traditional rural building forms associated with agricultural communities;

iii) building facades parallel to Highway #22 should avoid long unbroken expanses through the use of architectural detailing and window placement; and,

iv) colours should reflect and complement natural colour tones evident in the surrounding rural landscape.

3.5.0 Performance Standards

3.5.1 Air Contaminants, Visible and Particulate Emissions

a) No use within any building or structure on the lands shall cause or create air contaminants, visible emissions or particulate emissions beyond the building which contains them.

3.5.2 Odorous Matter

a) No use or operation within a building shall cause or create the emission of odorous matter or vapour beyond the building which contains the use or operation.

3.5.3 Toxic Matter

a) No use or operation on the lands or within a building shall cause or create the emission of toxic matter beyond the lands or the building which contains it. The handling, storage and disposal of any toxic or hazardous materials or waste shall be in accordance with the regulations of any government authority having jurisdiction and in accordance with any Chemical Management Plan that may be required by the Municipality.

3.5.4 Garbage Storage

a) Garbage and waste material shall be stored in weatherproof and animal-proof containers. Such containers shall be located within buildings or adjacent to the side or rear of buildings, and shall be screened from view by all adjacent properties and roadways, all to the satisfaction of the Development Authority.

3.5.5 Fire and Explosive Hazards

a) Uses and operations on the site which handle, store or utilize products which may be hazardous due to their corrosive, poisonous, flammable, or explosive characteristics shall comply with the applicable fire regulations of the Municipality or the regulations of any other government authority having jurisdiction and in accordance with any hazardous materials or emergency management plan that may be require by the Municipality, and as defined in a Development Permit.

3.5.6 Fire Protection:

a) Fire protection measures shall be provided as may be required by the Municipality

4.0.0 DEFINITIONS

4.1.0 **Highway Maintenance Facility** – means a use or development providing a service directly related to the maintenance of Alberta Infrastructure and Transportation's Provincial Road Network and public roadways within the MD of Rocky View.

4.2.0 **The Lands -** means the lands as shown on Schedule "A" attached hereto.

4.3.0 Terms not defined above have the same meaning as defined in Section 9.0.0 of Land Use Bylaw C-4841-97.and included in a Development Permit.

5.0.0 IMPLEMENTATION

5.1.0 The bylaw comes into effect upon the date of its third and final reading.

File: 04810004/007/010 --- 2005-RV-432

First reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on Tuesday, April 4, 2006, on a motion by Councillor Everett.

Second reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on Tuesday, May 9, 2006, on a motion by Councillor Everett.

Third and final reading passed in open Council, assembled in the City of Calgary, in the Province of Alberta, on Tuesday, May 9, 2006, on a motion by Councillor Neustaedter.

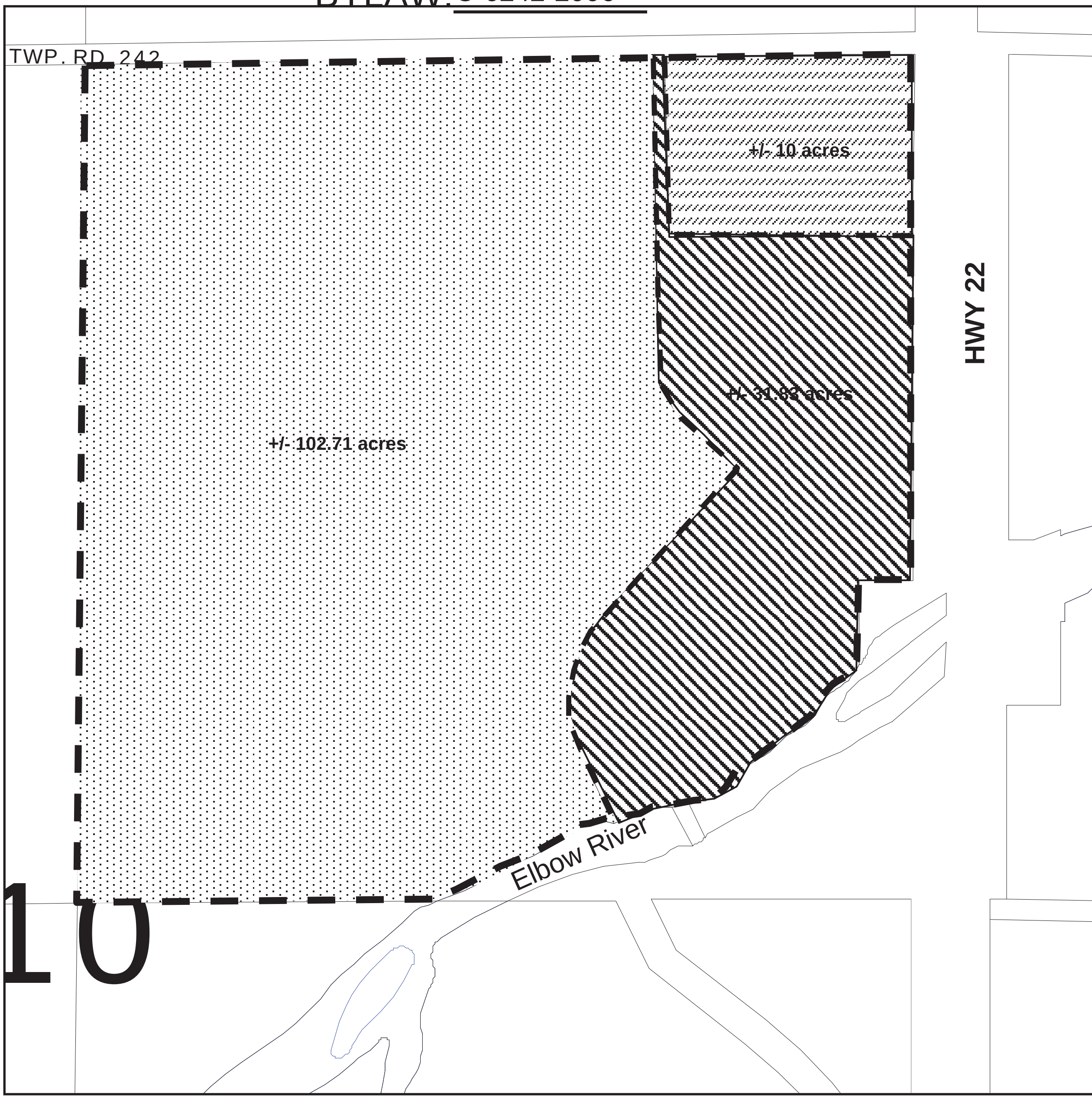
REEVE OR DEPUTY REEVE

MUNICIPAL SECRETARY

DC-110

SCHEDULE “A”

BYLAW: C-6242-2006



AMENDMENT

Subject Land

FROM Ranch and Farm Two District TO Ranch and Farm District

FROM Ranch and Farm Two District & Agricultural Holdings District TO Ranch and Farm Three District

FROM Ranch and Farm Two District & Agricultural Holdings District TO Direct Control District

LEGAL DESCRIPTION: NE 10-24-4-W5M

FILE: 04810004/007/010-2005-RV-432 **DIVISION: 1**

N

ROCKY VIEW MUNICIPAL DISTRICT No. 44

SECTION 63 PUBLIC SERVICES DISTRICT (PS)

63.1 Purpose and Intent

The purpose and intent of this District is to provide for the *development* of Institutional, Educational and Recreational uses.

63.2 Uses, Permitted

*Accessory building*s less than 90.00 sq. m (968.75 sq. ft.) *building* area.
Government Services

LUB 21/09/2010

63.3 Uses, Discretionary

Athletic and Recreation Services
Campground, Institutional
Child Care Facilities
Cemetery and Interment Services
Commercial Communications Facilities - Type "A", Type "B"
Dormitory, accessory to schools
Government Services
Dwelling Unit, accessory to the *principal use*
Farmers Market
Funeral Services and Entombment
Indoor Participant Recreation Services
Medical Treatment Services
Museums
Private Clubs and Organizations
Public or Quasi-Public Building
Public Park
Religious Assembly
School, Public or Separate
School, Private
Schools*, Universities & Colleges*
Signs
Special Events Parking

LUB 11/12/2012

63.4 General Regulations

The General Regulations apply as contained in Part 3 of this *Bylaw,* as well as the following provisions:

63.5 Minimum Requirements

(a) *Parcel* Size:

(i) 0.50 hectares (1.24 acres).

(b) *Yard, Front* (on all *parcel*s except those within a *Hamlet*):

(i) 30.00 m (98.43 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, *highway*;

(iii) 15.00 m (49.21 ft.) from any *road*, *internal subdivision;*

(iv) 15.00 m (49.21 ft.) from any road, service adjacent to a road, highway;

(v) 10.00 m (32.81 ft.) from any road, service adjacent to a road, *County*.

(c) *Yard, Side*: (on all *parcel*s except those within a *Hamlet*)

(i) 30.00 m (98.43 ft.) from any road, *County*;

(ii) 60.00 m (196.85 ft.) from any road, highway;

(iii) 15.00 m (49.21 ft.) from any road, service adjacent to a road, highway;

(iv) 10.00 m (32.81 ft.) from any road, service adjacent to a road, *County*;

(v) 6.00 m (19.69 ft.) from all other.

(d) *Yard, Rear*: (on all *parcel*s except those within a *Hamlet*)

(i) 30.00 m (98.43 ft.) from any road;

(ii) 15.00 m (49.21 ft.) all other.

(e) *Yard, Front*: (within a *Hamlet*)

(i) 6.00 m (19.69 ft.).

(f) *Yard, Side:* (within a *Hamlet*)

(i) 3.00 m (9.84 ft.).

(g) *Yard, Rear* (within a *Hamlet*)

(i) 8.00 m (26.25 ft.).

(h) Notwithstanding Section 63.5(b) to 65.5(g), at the discretion of the *Development Authority,* a *setback* of zero (0) metres is allowed if:

(i) two Public Service districts are adjacent to each other; and

(ii) built structures are in accordance with the Alberta Building Code.

LUB 21/09/2010

63.6 Maximum Requirements

(a) Maximum Height:

(i) 10.0 m (32.81 ft.) - *principal building;*

(ii) 5.5 m (18.04 ft.) - *accessory building*s.

63.7 Special Requirements

A minimum of 10% of the *site area shall* be landscaped.

APPENDIX III : Site Photos

Looking south from Springbank Road, east of Highway 22

January 2015

IMAGE: 1518

Looking south From Range Road 41, within Project Area

January 2015

IMAGE: 1520

Looking north From Highway 22, south of Springbank Road

January 2015

IMAGE: 1456

Looking northwest from Highway 22, south of Springbank Road

January 2015

IMAGE: 1462

Appendix C – SR1 Land Value Analysis

SR1 Residential Only Land Valuation

Residential Only

												2017 Rocky View Assessment Values											
ID No.	LINC	Title Number*	Legal Parcel Description	Connected to Adjacent Parcel?	Parcel Classification	Road Access?	Power to Parcel?	Highest + Best Use	View?	Size of Parcel (acres)	Acres of Land to be Valued	Residence	Farmland (AUV)	Other	Total Assessment	Exemptions	Residential Market Value	Land Adjustments	Total Value	Value per Acre	Can be Subdivided?	Residence and improvements	Improvements Inside Project Boundary?
I31	0033341314	081226216002	SE 10-24-4-5	N	C	Y	Y	Rec	Y	133.37	130.37	$147,140			**$147,140**	$1,724,210	$151,481	$1,724,210	**$1,875,691**	$14,064	Y	Y	N
I33	0013792361	071156422	SE 13-24-4-5	N	R	Y	Y	Res	Y	9.98	6.98	$946,100			**$946,100**		$974,014		**$974,014**	$97,597	N	Y	N
I36	0018231670	131304968	SE 13-24-4-5	N	R	Y	Y	Res	Y	25.98	22.98	$761,700			**$761,700**		$784,173		**$784,173**	$30,184	N	Y	N
I37	0018546152	991375584	SE 13-24-4-5	N	R	Y	Y	Res	Y	19.99	16.99	$937,100			**$937,100**		$964,748		**$964,748**	$48,262	N	Y	N
I38	0018546169	911281959	SE 13-24-4-5	N	R	Y	Y	Res	Y	21.47	18.47	$1,361,500			**$1,361,500**		$1,401,670		**$1,401,670**	$65,285	N	Y	N
I40	0020064663	151024830	SE 13-24-4-5	N	R	Y	Y	Res	Y	20.00	17.00	$1,083,100			**$1,083,100**		$1,115,056		**$1,115,056**	$55,753	N	Y	N
I41	0020092060	121179433	SE 13-24-4-5	N	R	Y	Y	Res	Y	8.09	5.09	$949,000			**$949,000**		$976,999		**$976,999**	$120,766	N	Y	N
I57	0018057117	151092358	SW 10-24-4-5	N	P	Y	Y	C	Y	135.00	132.00	$266,300			**$266,300**		$274,157	$2,640,000	**$2,914,157**	$21,586	N	Y	Y
I73	0027101633	101321273001	SW 34-24-4-5	Y	Q	Y	Y	C	Y	31.58	28.58	$757,500			**$757,500**		$779,849		**$779,849**	$24,694	Y	N	N
									Total	**405.46**	**378.46**	**$7,209,440**			**$7,209,440**	**$1,724,210**	**$7,422,147**	**$4,364,210**	**$11,786,357**				
									Median	**21.47**	**18.47**	**$937,100**			**$937,100**	**$1,724,210**	**$964,748**		**$976,999**				

Residential Price Adjustment Factor=1.029504

Residential/Commercial with Land

												2017 Rocky View Assessment Values															
ID No.	LINC	Title Number*	Legal Parcel Description	Connected to Adjacent Parcel?	Parcel Classification	Highest + Best Use	Road Access?	Power to Parcel?	View?	Size of Parcel (acres)	Acres of Land to be Valued	Residence	Farmland (AUV)	Other	Total Assessment	Exemptions	Residential Market Value	Base Value (Highest and Best Use)	Road Access	Power	View	Total Value per Acre	Total Land Value	Total Parcel Value	Can be Subdivided?	Residence and improvements	Improvements Inside Project Boundary?
I1	0032350365	131202774	NE 10-24-4-5	N	P	REC	Y	Y	Y	102.15	99.15	$638,930	$16,380		**$655,310**	$40,870	$674,644	$20,000	$875	$250	$500	$21,625	$2,144,119	**$2,818,763**	N	Y	N
I3	0032350381	071172845002	NE 10-24-4-5	N	P	C	Y	Y	Y	10.01	10.01			$2,384,600	**$2,384,600**		$2,454,955	$40,000	$875	$250	$500	$41,625	$416,666	**$2,871,621**	N	C	N
I5	0016481012	141189459009	NE 13-24-4-5	N	Q	A	Y	Y	Y	160.00	157.00	$698,880	$24,120		**$723,000**	$24,120	$744,331	$12,000	$875	$250	$500	$13,625	$2,139,125	**$2,883,456**	Y	Y	Y
I9	0015673354	041177836	NE 22-24-4-5; Block A, Plan 8110352	N	R	Res	Y	Y	Y	37.76	34.76	$837,630	$1,970		**$839,600**	$1,970	$864,372	$15,000	$875	$250	$500	$16,625	$577,885	**$1,442,257**	N	Y	N
I11	0021351408	111291631	NE 24-24-4-5	Y	Q	B	Y	Y	Y	160.00	157.00	$959,340	$26,420		**$985,760**	$54,860	$1,014,844	$8,000	$875	$250	$500	$9,625	$1,511,125	**$2,525,969**	Y	Y	Y
I13	0016876880	891264410E	NE 27-24-4-5	Y	Q	B	Y	Y	Y	156.01	153.01	$479,700	$12,820		**$492,520**		$507,051	$8,000	$875	$250	$500	$9,625	$1,472,721	**$1,979,773**	Y	Y	N
I15	0033341306	081226216001	NE 3-24-4-5	N	P	A	Y	Y	Y	154.08	151.08	$5,211,100	$19,500		**$5,230,600**	$20,490	$5,384,924	$12,000	$875	$250	$500	$13,625	$2,058,465	**$7,443,389**	N	Y	Y
I21	0021373782	081026830006	NW 17-24-3-5	Y	Q	A	Y	Y	Y	160.00	157.00	$1,320,780	$18,330		**$1,339,110**	$184,620	$1,378,619	$12,000	$875	$250	$500	$13,625	$2,139,125	**$3,517,744**	Y	Y	N
I23	0020201604	121017526001	NW 19-24-3-5	N	Q	A	Y	Y	Y	160.00	157.00	$397,640	$14,960		**$412,600**	$14,960	$424,773	$12,000	$875	$250	$500	$13,625	$2,139,125	**$2,563,898**	Y	Y	N
I28	0016876344	891264410E	NW 27-24-4-5	Y	Q	B	Y	Y	Y	160.00	157.00	$1,480,750	$7,830		**$1,488,580**	$20,650	$1,532,499	$8,000	$875	$250	$500	$9,625	$1,511,125	**$3,043,624**	Y	Y	N
I44	0016481202	911010827	SE 19-24-3-5	N	Q	B	Y	Y	Y	160.00	157.00	$744,480	$22,320		**$766,800**	$22,320	$789,424	$8,000	$875	$250	$500	$9,625	$1,511,125	**$2,300,549**	Y	Y	N
I45	0016481160	131084514004	SE 23-24-4-5	N	Q	A	Y	Y	Y	160.00	157.00	$1,062,780	$18,520		**$1,081,300**	$18,520	$1,113,203	$12,000	$875	$250	$500	$13,625	$2,139,125	**$3,252,328**	Y	Y	Y
I46	0018285503	161013695001	SE 24-24-4-5	Y	Q	C	Y	Y	Y	160.00	157.00	$662,250	$20,650		**$682,900**	$1,550	$703,048	$5,000	$875	$250	$500	$6,625	$1,040,125	**$1,743,173**	Y	Y	Y
I47	0025987660	941085054	SE 25-24-4-5	N	Q	A	Y	Y	Y	159.03	156.03	$674,190	$11,700		**$685,890**	$92,310	$706,126	$12,000	$875	$250	$500	$13,625	$2,125,854	**$2,831,981**	Y	Y	N
I50	0030251672	031434346001	SE 3-24-4-5; Block 1, Lot 2	N	R	REC	Y	Y	Y	8.40	5.40	$609,310	$230		**$609,540**	$14,690	$627,524	$20,000	$875	$250	$500	$21,625	$116,775	**$744,299**	Y	Y	N
I65	0025987686	941085054002	SW 25-24-4-5	Y	Q	C	Y	Y	Y	159.03	156.03	$534,260	$22,070		**$556,330**	$61,540	$572,744	$12,000	$875	$250	$500	$13,625	$2,125,854	**$2,698,598**	Y	Y	N
I69	0032186710	151046814	SW 3-24-4-5	N	P	C	Y	Y	Y	154.98	151.98	$534,650	$9,930	$146,330	**$690,910**	$402,220	$711,295	$27,000	$875	$250	$500	$28,625	$4,350,428	**$5,061,722**	N	Y + C	N
									Total	**2,221.44**	**2,173.44**	$16,846,670	$247,750	$2,530,930	$19,625,350	$975,690	$20,204,376	$243,000				**$270,625**	**$29,518,767**	**$49,723,144**			
									Median	**159.03**	**156.03**	$686,535	$17,355	$1,265,465	$723,000	$22,320	$744,331	$12,000				**$13,625**	**$2,058,465**	**$2,818,763**			

SR1 Residential/Commercial and Combined Land Valuation

Land Only												2017 Rocky View Assessment Values															
ID No.	LINC	Title Number*	Legal Parcel Description	Connected to Adjacent Parcel?	Parcel Classification	Highest + Best Use	Road Access?	Power to Parcel?	View?	Size of Parcel (acres)	Acres of Land to be Valued	Residence	Farmland (AUV)	Other	Total Assessment	Exemptions	Plus Exemptions	Base Value (Highest and Best Use)	Road Access	Power	View	Total Value per Acre	Total Land Value	Total Parcel Value	Can be Subdivided?	Residence and improvements	Improvements Inside Project Boundary?
I2	0032350373	071172845001	NE 10-24-4-5	N	P	REC	Y	N	Y	29.23	29.23		$2,650		$2,650		$0	$20,000	$875	$0	$500	$21,375	$21,375	$624,791	N	N	N
I4	0021436746	871218985	NE 10-24-4-5	N	R	REC	Y	N	Y	4.84	4.84				$0	$200	$200	$20,000	$875	$0	$500	$21,375	$21,375	$103,655	N	N	N
I6	0021355517	121019893001	NE 14-24-4-5	Y	Q	A	N	N	Y	160.00	160.00		$21,490		$21,490		$0	$12,000	$0	$0	$500	$12,500	$12,500	$2,000,000	Y	N	N
I7	0020860144	121014596	NE 18-24-3-5	N	Q	A	Y	N	Y	160.00	160.00		$10,750		$10,750		$0	$12,000	$875	$0	$500	$13,375	$13,375	$2,140,000	Y	N	N
I8	0026089599	951074749	NE 22-24-4-5	N	P	B	Y	N	Y	118.63	118.63		$13,040		$13,040		$0	$8,000	$875	$0	$500	$9,375	$9,375	$1,112,156	N	N	N
I10	0016874133	0021351424	NE 23-24-4-5	N	Q	C	Y	N	Y	160.00	160.00		$21,670		$21,670		$0	$5,000	$875	$0	$500	$6,375	$6,375	$1,020,000	Y	N	N
I12	0021349139	891264410C	NE 26-24-4-5	Y	Q	B	Y	N	Y	155.99	155.99		$15,870		$15,870		$0	$8,000	$875	$0	$500	$9,375	$9,375	$1,462,406	Y	N	N
I14	0021349329	971046105	NE 28-24-4-5	Y	Q	B	N	N	Y	160.00	160.00		$26,360		$26,360		$0	$8,000	$0	$0	$500	$8,500	$8,500	$1,360,000	Y	N	N
I16	0025671603	081226216001	NE 4-24-4-5	Y	Q	A	Y	N	Y	160.00	160.00		$15,930		$15,930		$0	$12,000	$875	$0	$500	$13,375	$13,375	$2,140,000	Y	N	N
I18	0016481004	121014589002	NW 13-24-4-5	Y	Q	A	Y	N	Y	160.00	160.00		$22,180		$22,180		$0	$12,000	$875	$0	$500	$13,375	$13,375	$2,140,000	Y	N	N
I19	0021355509	941016917001	NW 14-24-4-5	Y	Q	REC	Y	N	Y	4.00	4.00		$20,030		$20,030		$0	$50,000	$875	$0	$500	$51,375	$51,375	$205,500	Y	N	N
I20	0021298922	921158795	NW 17-24-3-5	Y	Q	A	Y	N	Y	131.76	131.76		$9,260		$9,260		$0	$12,000	$875	$0	$500	$13,375	$13,375	$1,762,290	Y	N	N
I24	0021351416	941016917	NW 23-24-4-5	Y	Q	B	Y	N	Y	155.68	155.68		$21,290		$21,290		$0	$8,000	$875	$0	$500	$9,375	$9,375	$1,459,500	Y	N	N
I25	0021404074	851185626	NW 24-24-4-5	N	Q	C	Y	N	Y	160.00	160.00		$21,120		$21,120		$0	$5,000	$875	$0	$500	$6,375	$6,375	$1,020,000	Y	N	N
I27	0021349121	891264410C	NW 26-24-4-5	Y	Q	B	Y	N	Y	152.16	152.16		$18,900		$18,900		$0	$8,000	$875	$0	$500	$9,375	$9,375	$1,426,500	Y	N	N
I29	0025671603	81226216001	NW 3-24-4-5	Y	Q	REC	Y	N	Y	160.00	160.00		$4,280		$4,280		$0	$20,000	$875	$0	$500	$21,375	$21,375	$3,420,000	Y	N	N
I32	0021412168	131202774001	SE 10-24-4-5	N	P	REC	Y	N	Y	26.63	26.63		$1,280		$1,280		$0	$20,000	$875	$0	$500	$21,375	$21,375	$569,216	N	N	N
I34	0013792379	141031675	SE 13-24-4-5	N	R	REC	Y	Y	Y	9.98	9.98				$0	$496,300	$496,300	$20,000	$875	$250	$500	$21,625	$21,625	$712,118	N	N	N
I35	0016256753	121014589001	SE 13-24-4-5	N	R	REC	Y	N	N	102.60	102.60		$2,450		$2,450		$0	$20,000	$875	$0	$0	$20,875	$20,875	$2,141,775	N	N	N
I39	0018554734	163M13	SE 13-24-4-5	N	R	REC	Y	N	Y	3.68	3.68				$0	$10	$10	$50,000	$875	$0	$500	$51,375	$51,375	$189,070	N	N	N
I42	0021355525	121019893001	SE 14-24-4-5	Y	Q	A	N	N	Y	160.00	160.00		$15,270		$15,270		$0	$12,000	$0	$0	$500	$12,500	$12,500	$2,000,000	Y	N	N
I43	0021355541	931326472004	SE 15-24-4-5	Y	Q	A	Y	Y	Y	154.43	154.43		$25,200		$25,200		$0	$12,000	$875	$250	$500	$13,625	$13,625	$2,104,109	Y	N	N
I48	0025987710	941085054004	SE 26-24-4-5	Y	Q	B	Y	Y	Y	150.00	150.00		$20,880		$20,880		$0	$8,000	$875	$250	$500	$9,625	$9,625	$1,443,750	Y	N	N
I49	0021404066	011035400001	SE 27-24-4-5	Y	Q	B	Y	Y	Y	156.11	156.11		$16,690		$16,690		$0	$8,000	$875	$250	$500	$9,625	$9,625	$1,502,559	Y	N	N
I51	0030251680	031434406	SE 3-24-4-5; Block 2, Lot 1	N	R	REC	Y	N	Y	54.81	54.81		$8,670		$8,670		$0	$20,000	$875	$0	$500	$21,375	$21,375	$1,171,564	N	N	N
I52	0030251698	31434406002	SE 3-24-4-5; Block 3, Lot 1	N	R	REC	Y	N	Y	69.46	69.46		$10,360		$10,360		$0	$20,000	$875	$0	$500	$21,375	$21,375	$1,484,708	N	N	N
I58	0018057117	151092358	SW 10-24-4-5; Portion lying east of the	N	P	REC	Y	N		15.93	15.93				$0		$0	$20,000	$875	$0	$0	$20,875	$20,875	$332,539	N	N	N
I59	0020092053	051023708	SW 13-24-4-5	Y	Q	REC	Y	N	Y	50.00	50.00		$530		$530		$0	$20,000	$875	$0	$500	$21,375	$21,375	$1,068,750	Y	N	N
I60	0021382651	941016917002	SW 14-24-4-5	Y	Q	A	Y	Y	Y	157.65	157.65		$15,820		$15,820		$0	$12,000	$875	$250	$500	$13,625	$13,625	$2,147,981	Y	N	N
I63	0021351424	941016917	SW 23-24-4-5	Y	Q	A	Y	y	Y	155.34	155.34		$11,870		$11,870		$0	$12,000	$875	$250	$500	$13,625	$13,625	$2,116,508	Y	N	N
I64	0018285735	871212597	SW 24-24-4-5	N	Q	C	Y	y	Y	160.00	160.00		$23,570		$23,570		$0	$5,000	$875	$250	$500	$6,625	$6,625	$1,060,000	Y	N	N
I66	0025987702	941085054004	SW 26-24-4-5	Y	Q	C	Y	Y	Y	153.99	153.99		$16,660		$16,660		$0	$5,000	$875	$250	$500	$6,625	$6,625	$1,020,184	Y	N	N
I67	0016876328	011035400	SW 27-24-4-5	Y	Q	B	Y	N	Y	160.00	160.00		$10,000		$10,000		$0	$8,000	$875	$0	$500	$9,375	$9,375	$1,500,000	Y	N	N
I68	0026007154	941105831	SW 3-24-4-5	Y	P	REC	Y	N	N	15.00	15.00		$630		$630		$0	$20,000	$875	$0	$0	$20,875	$20,875	$313,125	N	N	N
I74	0027101641	971188175001	SW 34-24-4-5	Y	Q	B	Y	Y	Y	103.41	103.41		$13,870		$13,870		$0	$8,000	$875	$250	$500	$9,625	$9,625	$995,321	Y	N	N
									Total	3,891.31	3,891.31		$438,570		$438,570	$496,510						$566,250	$566,250	$47,270,074			
									Median	155.16	154.21		$15,820		$13,870	$200						$13,375	$13,375	$1,426,500			

SR1 Land Assessment Legend

Parcel Classifications

Q=QUARTER SECTION, NO SUBDIVISION
P=ONE PARCEL OUT OR FARMSTEAD
R=COUNTRY RESIDENTIAL
C=CAMP
U=UTILITY

Parcel Attributes

C=COMMERCIAL BUILDINGS
U=UTILITY RIGHT OF WAY/GOVERNMENT OWNED
M=MOUNTAIN VIEWS
NM=NO MOUNTAIN VIEW

Land Use

AH=AGRICULTURAL HOLDINGS DISTRICT
CRES=COMMERCIAL RESIDENTIAL
DC129=DIRECT CONTROL 129
F=FARMSTEAD DISTRICT
R-1=RESIDENTIAL ONE DISTRICT
R-2=RESIDENTIAL TWO DISTRICT
RF=RANCH AND FARM DISTRICT
RF-2=RANCH AND FARM TWO DISTRICT
RUR4=RURAL

Highest and Best Use

A=Agricultural
Rec=Recreational
Res=Residential (previously zoned)
C=Commercial (Previously zoned)

Appendix D – 2013 Southern Alberta Disaster Recovery Program

Rocky View County Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Emergency Operations	Ongoing	Y	Sept. 19, 2013	450000.00	Approved inspection estimate
2	Hamlet of Bragg Creek water intake	Ongoing	Y	Sept. 19, 2013	110000.00	Approved inspection estimate
3	Hamlet of Bragg Creek road damage	Ongoing	Y	Sept. 19, 2013	20000.00	Approved inspection estimate
4	Balsam Ave Erosion	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
5	Access to Hamlet of Bragg Creek Snowbirds Chalet	Ongoing	Y	Sept. 19, 2013	5000.00	Approved inspection estimate
6	Hamlet of Bragg Creek Community Centre	Ongoing	Y	Sept. 19, 2013	35000.00	Approved inspection estimate
7	Wood debris site	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
8	Wintergreen road	Ongoing	Y	Sept. 19, 2013	10000.00	Approved inspection estimate
9	Slapping Tail Pond	Ongoing	Y	Sept. 19, 2013	75000.00	Approved inspection estimate
12	RR 54, S of TWP road 234	Ongoing	Y	Sept. 19, 2013	10000.00	Approved inspection estimate
14	Bracken Road gate and spillway	Ongoing	Y	Sept. 19, 2013	15000.00	Approved inspection estimate
15	Bracken Road	Ongoing	Y	Sept. 19, 2013	25000.00	Approved inspection estimate
16	Bracken Road S TWP Rd 232, Bragg Creek BF72292	Ongoing	Y	Sept. 19, 2013	29000.00	Approved inspection estimate
18	RR 41, S of Springbank Road, Gross Creek BF74057	Ongoing	Y	Sept. 19, 2013	15000.00	Approved inspection estimate
19	Springbank road W of RR 35, Springbank Creek BF9024	Ongoing	Y	Sept. 19, 2013	20770.00	Approved inspection estimate
33	Bragg Creek Municipal Park	Ongoing	Y	Sept. 19, 2013	20000.00	Approved inspection estimate
34	Springbank Park for All Seasons	Ongoing	N	Dec. 9, 2013	194000.00	Applicant initial estimate only
TOTAL BUDGET ESTIMATES FOR ROCKY VIEW COUNTY ONGOING PROJECTS					$1,083,770.00	

Townsite of Redwood Meadows Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Northern berm breach	Ongoing	Y	Sept. 10, 2013	838000.00	Approved inspection estimate
2	Sleigh Drive berm breach	Ongoing	Y	Sept. 10, 2013	75000.00	Approved inspection estimate
3	Use of existing rip rap for flood protection	Ongoing	Y	Sept. 10, 2013	465000.00	Approved inspection estimate
4	Water treatment plant	Ongoing	Y	Sept. 10, 2013	75000.00	Approved inspection estimate
5	Playground berm breach	Ongoing	Y	Sept. 10, 2013	690000.00	Approved inspection estimate
6	Berm breach, #18 Redwood Meadows Drive	Ongoing	Y	Sept. 10, 2013	444000.00	Approved inspection estimate
7	Sanitary sewer pumping station	Ongoing	Y	Sept. 10, 2013	70000.00	Approved inspection estimate
TOTAL BUDGET ESTIMATES FOR TOWNSITE OF REDWOOD MEADOWS ONGOING PROJECTS					$2,657,000.00	

Tsuu T'ina Ongoing Project Estimates

Project Number	Project Name	Status	Approved Estimate (Y/N)	Latest Estimate Date	Estimate ($)	Comments
1	Emergency Operations	Ongoing	N	Sept. 25, 2013	60384.22	Applicant initial estimate only
2	Infrastructure Damage	Ongoing	N	Sept. 25, 2013	211611.26	Applicant initial estimate only
3	Housing	Ongoing	N	Sept. 25, 2013	29914.77	Applicant initial estimate only
4	Band Works	Ongoing	Y	Nov. 11, 2013	800000.00	Approved inspection estimate
5	Redwood Meadows Golf Course	Ongoing	Y	Nov. 11, 2013	800000.00	Approved inspection estimate
TOTAL BUDGET ESTIMATES FOR TSUU T'INA FIRST NATION ONGOING PROJECTS					$1,901,910.25	

TOTAL ESTIMATE OF ONGOING PROJECTS	$5,642,680.25

2. Hemmera Report

Elbow River at McLean Creek Dam (MC1) Environmental Impact Screening Report

EXECUTIVE SUMMARY

Prepared for:
Alberta Transportation

Prepared by:
Hemmera Envirochem Inc.
Suite 302, 322 11th Avenue SW
Calgary AB TR 0C5

File: 2025-001.01
September 2017

EXECUTIVE SUMMARY

INTRODUCTION

In 2013, flooding within the Bow River and tributaries inundated downtown Calgary and several other communities in southern Alberta, causing loss of life and major damage to infrastructure. In response to the June 2013 flood event (2013 flood), the Alberta Government committed to providing flood mitigation to prevent future damage from similar flood events.

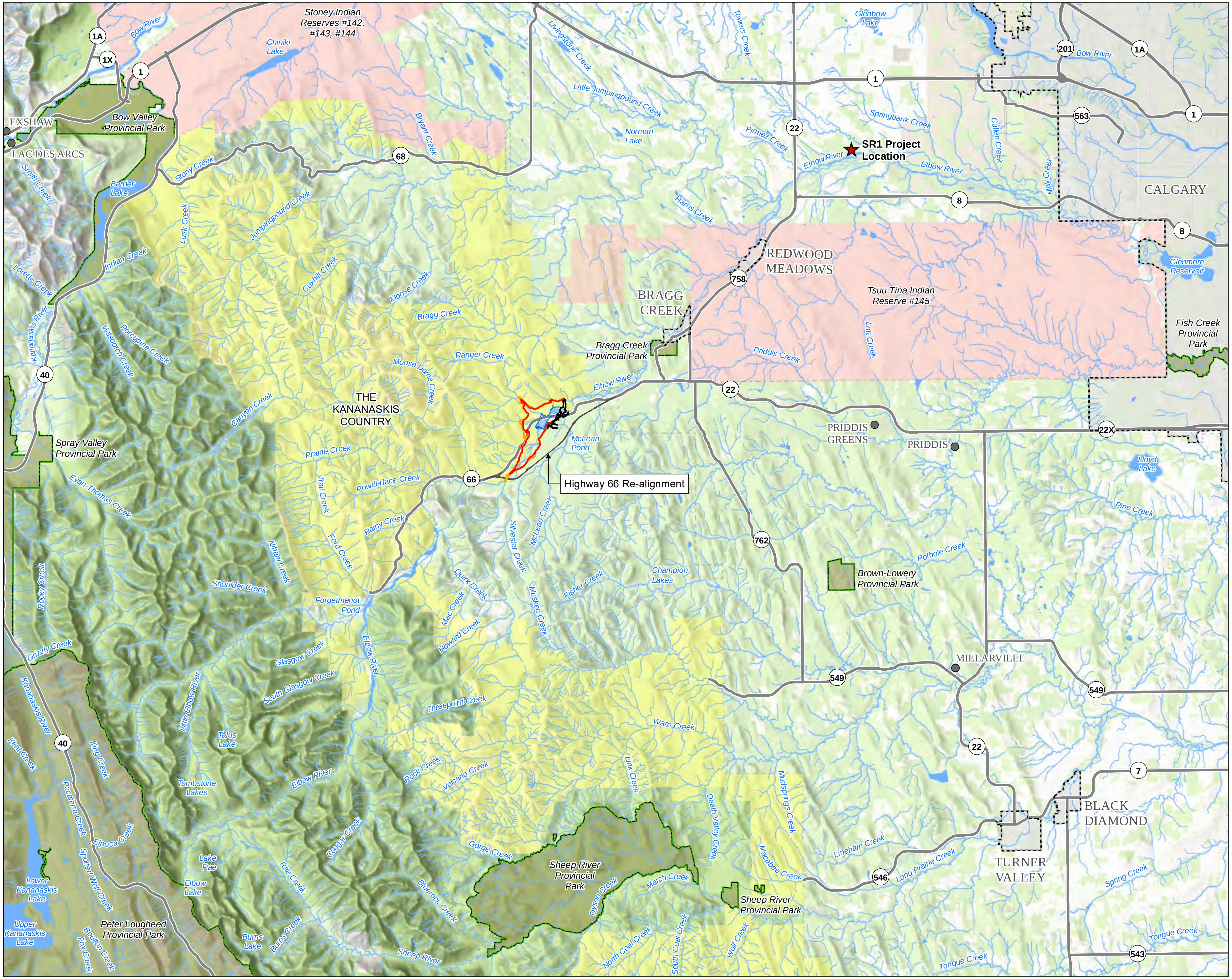
The Alberta Government, through Alberta Transportation (AT), is currently in the planning and design stage of the Springbank Off-stream Reservoir Project (SR1 Project), which is located within Rocky View County approximately 15 kilometres (km) west of Calgary in southern Alberta. The SR1 Project is subject to review under the *Environmental Protection and Enhancement Act*, RSA 2000, c. e-12 (EPEA) and the *Canadian Environmental Assessment Act, 2012*, SC 2012, c.19, s.52 (CEAA 2012). The EPEA Terms of Reference (Section 7.1[A]) require AT to describe the SR1 Project alternatives considered for flood mitigation. Section 19(1)(g) of CEAA 2012 also requires the environmental assessment of a designated project (i.e., the SR1 Project) to consider alternative means of carrying out the designated project that are technically and economically feasible and the potential environmental effects of any such alternative means.

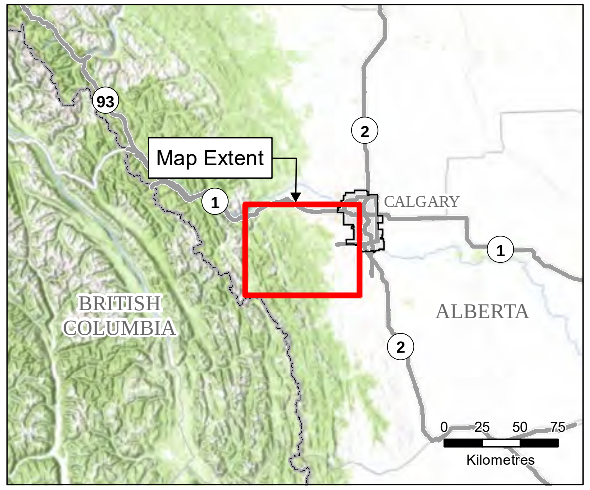
Alberta Transportation investigated the Elbow River at McLean Creek Dam (MC1) Option (MC1 Option, or Option) as the alternative means to the SR1 Project. The MC1 Option would be located in Kananaskis Country, approximately 10 km upstream from the hamlet of Bragg Creek and 40 km west of Calgary (**Figure 1**) and has been developed to a conceptual level of design. This Environmental Impact Screening Report is intended to describe the environmental effects of the MC1 Option, and propose mitigation strategies to eliminate or reduce potential environmental effects. The potential environmental effects described in this report include those listed in Section 5 of CEAA 2012, as well as those related to accidents and malfunctions and cumulative effects in accordance with section 19(1)(a) of CEAA 2012. The findings of this Environmental Impact Screening Report have been used to support the alternatives assessment presented in the SR1 Environmental Impact Assessment.

The Alberta *Water Act*, RSA 2000, c. W-3, regulates activities that alter flows or water levels in a water body, and the Water (Ministerial) Regulation of the *Water Act* regulates dam safety. Constructing MC1 would alter water levels upstream of the dam and flows in the Elbow River downstream of the dam. Accordingly, the MC1 Option would require approval under the *Water Act* prior to construction as well as a licence under the *Water Act* to operate the dam.

Elbow River at McLean Creek Dam (MC1)

Option Location





Legend

- SR1 Project Location

MC1 Option Footprint

- 2013 Flood Event (1424.1 m)
- Dam Footprint
- Probable Maximum Flood (PMF) Level
- Highway 66 Re-alignment
- Permanent Pond
- Hamlet or Townsite
- Highway
- Reserve
- Provincial Park
- The Kananaskis Country
- Urban Area
- Watercourse
- Waterbody

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of Alberta
- Dam and flood details: Opus International Consultants Limited, 2017
- Borrow Areas: Hatch Ltd., 2017
- Background Image: ESRI World Topographic Map
- Inset Maps: ESRI World Topographic Map

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HEMMERA

Alberta Transportation

Option Setting, Option Benefit, and Alternatives

Option Setting

The MC1 Option would be located on land traditionally used by the Treaty 7 First Nations and is located within the Métis Nation of Alberta (Region 3). There are no First Nations reserves within or adjacent to the Option area; however, the Elbow River and lower reaches of its tributaries are areas where Indigenous groups hunt or participate in other traditional activities.

MC1 would manage flows in the Elbow River, which is a tributary of the Bow River, within the South Saskatchewan River basin in southern Alberta. The headwaters of the Elbow River begin outside of Peter Lougheed Provincial Park, located approximately 70 km southwest of Calgary. The Elbow River meanders northeast for approximately 90 km before entering the Glenmore Reservoir, which then flows into the Bow River. The Red Deer River basin to the north, the South Saskatchewan River basin to the east, and the Old Man River basin to the south comprise the boundaries of the Bow River basin. Tributaries of the Elbow River within, upstream, and downstream of the MC1 Option area include McLean Creek, Canyon Creek, Prairie Creek, Powderface Creek, Silvester Creek, Ranger Creek, and Connop Creek. The Elbow River is unregulated upstream of the Glenmore Reservoir, although embankments or dams are present on some of the tributaries.

Option Benefits

The 2013 flood demonstrated the need for further flood mitigation along the Elbow River to reduce the effect of larger flood events and protect the communities of Bragg Creek, Redwood Meadows, and Calgary. The MC1 Option would provide flood mitigation for Calgary, as well as the communities of Bragg Creek, Redwood Meadows, and the Tsuu T'ina Nation IR No. 145.

In addition to property impacts associated with flooding, the adverse health effects associated with flooding events are recognized globally, varying from physical harm in the short-term to delayed mental health problems in the long-term. The health benefits of flood reduction are numerous; implementing flood reduction and flood damage mitigation strategies would reduce adverse health effects associated directly with pre-flooding, flooding, and post-flooding events.

Alternatives to the Option

Workshops were conducted to identify and review alternative designs and methods of construction of MC1. An option to construct MC1 as a central concrete gravity dam flanked by embankments (anchored dam) was eliminated due to prohibitive costs. Similarly, elimination of the permanent pond was considered but was not carried forward as an option for operational reasons.

MC1 OPTION DESCRIPTION

The Alberta Government would own and operate MC1, and AT would be responsible for its development, design, and construction. If constructed, Alberta Environment and Parks (AEP) would assume control and responsibility for the management and operation of the MC1 Option as part of its water management operations. Currently, AEP is responsible for managing, operating, and maintaining provincially owned water management infrastructure throughout Alberta.

MC1 would include an earth fill dam across the Elbow River valley, which would provide flow regulation within the river upstream of its confluence with McLean Creek. Normal river flows would be controlled through two gated, 6-m-diameter, low-level diversion tunnels located along the south side of the Elbow River channel. Other elements of the MC1 Option include an ungated service spillway and an auxiliary spillway to protect the dam during more extreme flood events. The permanent pond created by the dam would be approximately 3.5 million cubic metres (m^3) of water (**Table 1**).

MC1 would be designed to withstand the probable maximum flood (PMF). The peak reservoir inflow rate for the PMF would be 2,770 m^3/s (cubic metres per second) and the maximum reservoir volume would be 93 million m^3. In the event of the PMF, the auxiliary spillway located along the south abutment of the dam would be activated. **Table 1** outlines the design criteria for the MC1 Option.

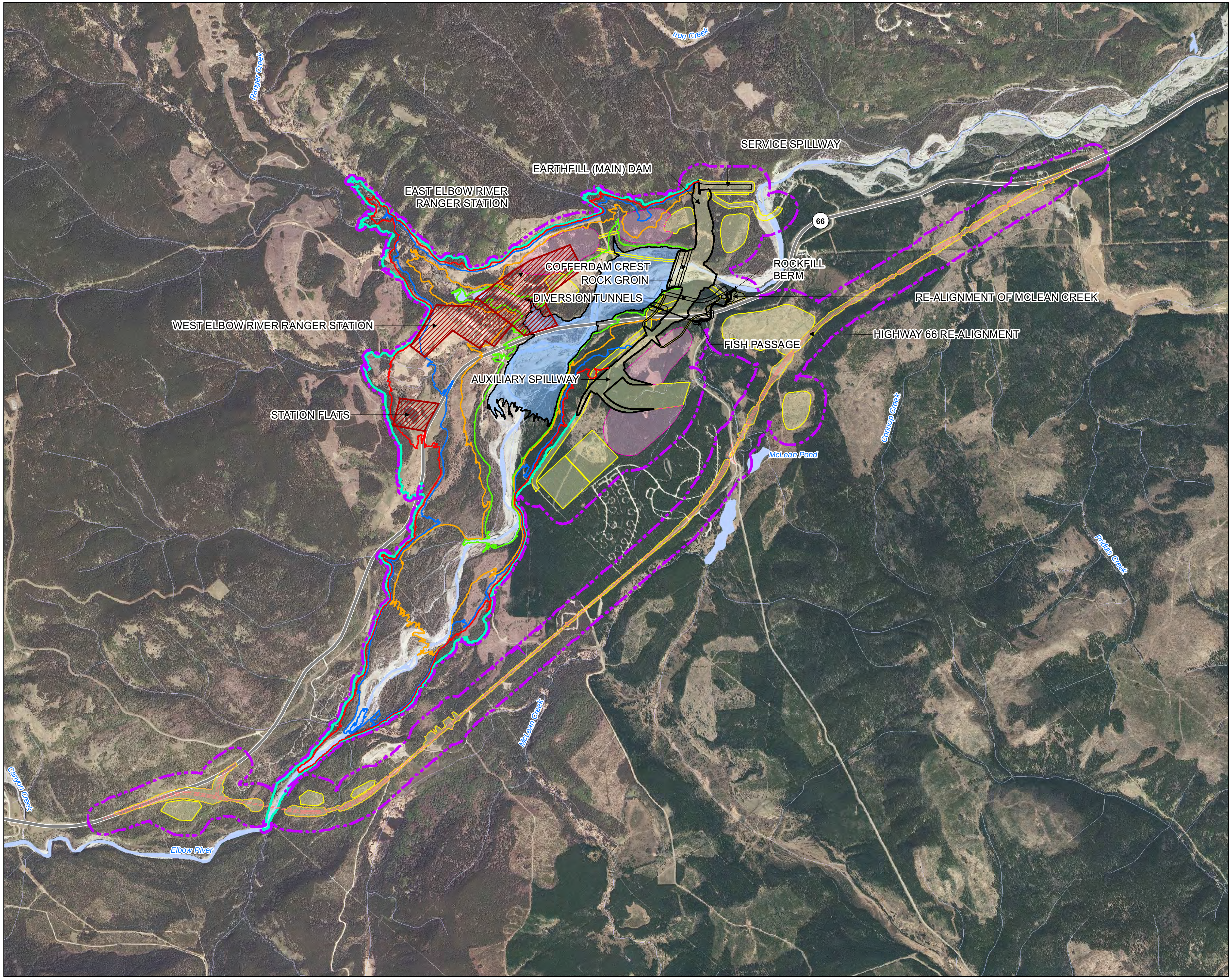
Table 1 Design Criteria for the Elbow River Dam at McLean Creek Option

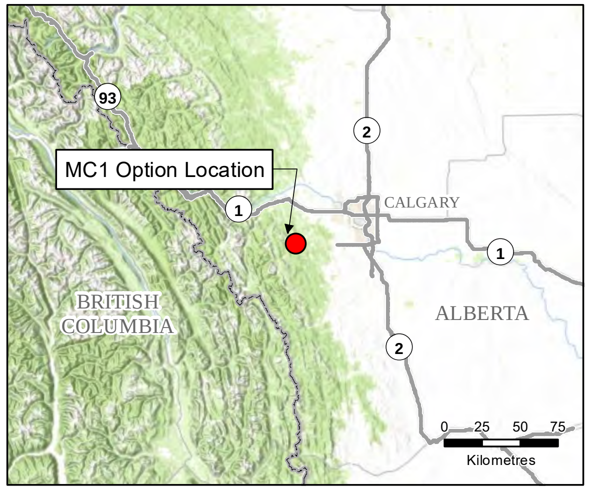
	Permanent Pond	20-year Flood Event	100-year Flood Event	June 2013 Flood	500-year Flood Event	Probable Maximum Flood
Peak reservoir inflow rate (m^3/s)	13.4	440	930	1,240	1,984	2,770
Diversion tunnels peak discharge rate (m^3/s)	13.4	220	220	220	810	1,000
Service spillway peak discharge rate (m^3/s)	0	0	0	0	0	600
Auxiliary spillway peak discharge rate (m^3/s)	0	0	0	0	0	1,000
Maximum reservoir water surface elevation (metres)	1,395	1,403.8	1,419.5	1,424.1	1,424.4	1,428.1
Maximum total contained water volume (million m^3)	3.5	12.3	51.0	71.5	73.0	93.0

Sources of materials and aggregate for the construction of the MC1 Option (e.g., dam embankment) have been identified along with stockpile and spoil locations. Material required for construction would be sourced from borrow areas located in the general vicinity of the MC1 Option components. The layout of the MC1 Option is shown in (Figure 2).

Elbow River at McLean Creek Dam (MC1)

Option Area





Legend

- MC1 Option Area
- MC1 Option Dam
- Highway 66 Re-alignment
- Probable Maximum Flood (PMF) Level
- 2013 Flood Event (1424.1 m)
- 1:100 Flood Event
- 1:20 Flood Event
- 1:50 Flood Event
- Borrow Area
- Laydown Area/Disturbed Area
- Permanent Pond
- Existing Park Infrastructure to be Removed
- Highway
- Watercourse
- Waterbody

Notes

1. All locations and features should be considered approximate and are to be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of Alberta, 2017
- Preferred Road Option and Disturbed Areas: Opus International Consultants Limited, 2017
- Dam Details: Hatch Ltd., 2017
- Aerial Imagery: SPOT 1.5 m, 2016
- Inset Basemap: ESRI Topographic Basemap

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Calgary 3TM

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HEMMERA

Alberta Transportation

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The MC1 Option construction schedule outlines a four-year construction phase. Many of the main Option components and relocation of infrastructure and facilities would be constructed and completed within the first two years.

The dam would pass flows during normal operations. During a flood event, the dam would retain flood waters and regulate downstream flows.

CONTAMINATED SITES ASSESSMENT

In support of MC1 Option planning, a Phase II Environmental Site Assessment was conducted, focused at the Elbow Valley Ranger Station (EVRS) and other potentially contaminated areas. Soil analytical results indicated elevated metals and dissolved metals concentrations as well as toluene, polycyclic aromatic hydrocarbons, several nutrients above background levels, and nitrite concentrations greater than guideline values. A cost was assigned to each potential environmental liability item that was identified during the Phase II Environmental Site Assessment. These values were aggregated to produce a total cost for remediating and managing environmental liabilities identified for each site.

ASSESSMENT METHODOLOGY

The Environmental Impact Assessment screening methodology follows recommended guidelines and legislated requirements, pursuant to the EPEA and CEAA 2012. The MC1 Option assessment considers three development scenarios: Baseline Case, Application Case, and Planned Development Case.

The purpose of this Environmental Impact Screening Report was to identify the key potential environmental effects of the MC1 Option and the associated mitigation measures necessary to reduce, eliminate, or compensate for those predicted effects. Baseline data collected were focused on acquiring sufficient data to identify these key effects and mitigation measures. For many Valued Components (VCs), baseline descriptions rely on previous studies and available literature, including:

- Environmental Overview of the Conceptual Elbow River Dam at McLean Creek (AMEC 2015)
- Site C Clean Energy Project Environmental Impact Statement (BC Hydro 2013)
- Cougar Creek Debris Flood Retention Structure Environmental Impact Assessment (Town of Canmore 2016)
- Environmental Impact Assessment – Glacier Power Ltd. Dunvegan Hydroelectric Project (Jacques Witford 2006)
- South Saskatchewan Regional Plan 2014-2024 (Government of Alberta 2017a)
- Water quality monitoring data from Glenmore Reservoir (Government of Alberta 2017b)
- Elbow River Basin Water Management Plan (Elbow River Watershed Partnership 2009))
- Natural Regions and Subregions of Alberta (NRC 2006)

A full description of the appropriateness of publicly available data for the assessment of each VC is included within each relevant section.

The following field studies were conducted (and continue to be conducted) to supplement public and existing data:

- Vegetation and Wetlands surveys – October 2, 2016, June and August 2017
- Wildlife surveys – March, April, May, June, July, and August 2017 (planned September, October, November 2017)
- Fish habitat use and fish habitat – May, June, July, August 2017 and October, November 2016

The following VCs were selected for assessing effects related to the MC1 Option:

- Physical Environment
  - Air Quality
  - Climate and Climate Change
  - Noise
  - Terrain and Soils
  - Groundwater Quantity
  - Groundwater Quality
  - Fluvial Geomorphology
  - Surface Water Quality
  - Drinking Water Quality
- Biophysical Environment
  - Vegetation
  - Wetlands
  - Grizzly Bear
  - Ungulates
  - Bats
  - Breeding Birds
  - Raptors and Owls
  - Harlequin Duck
  - Piscivorous Birds
  - Amphibians and Reptiles
  - Fish and Fish Habitat

- Human Environment
  - Land Use and Management
  - Socioeconomic Resources
  - Public Health and Safety.

ATMOSPHERIC ENVIRONMENT

MC1 is located within a humid continental climate zone, typified by large seasonal temperature differences with warm, humid summers and cold (sometimes severely cold) winters. There is an average of 440 millimetres of rainfall annually. The highest rainfall amounts occur between May and September. An average of 240 centimetres of snow is received annually, with greatest monthly snowfall amounts occurring from October to November and from March to April.

Overall, existing air quality is considered good. The existing atmospheric environment is primarily affected by industrial and agricultural activity in the area, vehicle traffic along Highway 66, and residential areas of Bragg Creek and Redwood Meadows.

The assessment of Atmospheric Environment largely relies on information regarding equipment and key construction activities that was used to support the air and noise assessments conducted for the Site C Clean Energy Project, as the project components and sources of air and noise emissions for the Site C project are similar to those expected for the MC1 Option.

Key findings of the assessment include the following:

- Activities for the MC1 Option would result in increased emissions and ambient concentrations of criteria air contaminants (CACs). Exceedances of relevant ambient air quality criteria may occur during the Construction phase.
- Activities for the MC1 Option would result in increased emissions of greenhouse gases (GHGs), primarily during the Construction phase. Total GHG emissions would be greater than federal and provincial reporting thresholds, but would likely be small relative to existing provincial and national emissions.
- Activities for the MC1 Option would result in increased noise levels primarily during the Construction phase.

Mitigation measures that would be implemented to address potential effects on air quality and noise include regular inspection of vehicles and equipment, selection of an asphalt plant, management of open burning, clearing of loose sediment on reservoir banks, reduction of exposure to elevated ambient concentrations of CACs, and development and implementation of fugitive dust management and noise management measures.

Exceedances of ambient air quality criteria may occur during the Construction phase at the McLean Creek Campground, Easter Seals Camp Horizon, and Paddy's Flat Campground. To reduce exposure to potential air quality effects, the McLean Creek Campground, Easter Seals Camp Horizon, and Paddy's Flat Campground would likely need to be closed during Construction. Gooseberry Campground may also be closed at night during the peak construction period to prevent sleep disturbance to campers.

After the implementation of mitigation measures, adverse residual effects would be likely for increased emissions and ambient concentrations of CACs, increased emissions of GHGs, and increased noise levels during both the Construction and the Operation and Maintenance phases. Due to the predicted effectiveness of mitigation measures, however, these residual effects would likely be non-substantive.

TERRAIN AND SOILS

MC1 is located within the Montane Natural Subregion of the Rocky Mountain Natural Region, which is characterized by mountains and foothills separated by deep glacial valleys. The surficial geology is typical of the location, with glacial and fluvial deposits being common. The glacial till deposits have been dissected by the Elbow River and tributaries. Generally, the recent fluvial deposits along the Elbow River are bounded by glaciofluvial terraces, in turn bounded by morainal and glaciolacustrine deposits over bedrock and glaciofluvial deposits. Colluvial deposits overlying bedrock are present, and bedrock outcrops tend to occur on the steepest slopes where river incision has exposed rock faces. There are also areas of organic and lacustrine terrain units. The dominant soil orders are Luvisols, Brunisols, and Regosols.

Key findings of the assessment include the following:

- Approximately 165 ha of soil would be temporarily disturbed and 161 ha would be covered by permanent infrastructure during Construction.
- Changes in soil quality could occur where in situ soils likely would be disturbed by MC1 activities; in soils that are salvaged and stockpiled for reclamation; or indirectly through proximity to construction or excavation areas.
- A change in topography during would occur in areas of substantial earth-moving activities (i.e., four borrow areas and the dam).
- Potentially unstable slopes located within or at the edge of the reservoir may be destabilized by changes in groundwater gradients caused by impoundment of water in the reservoir. Approximately 8% of the reservoir was mapped as having a moderate or high likelihood of landslide initiation following reservoir filling or rapid drawdown.
- Inundation in the reservoir may cause additional effects including sedimentation and changes in soil quality.

Mitigation measures proposed to address potential effects to terrain and soils include soil salvage, reclamation and revegetation of disturbed soils, and monitoring and maintenance for post-flood events. Additionally, an Erosion and Sediment Control Plan would be implemented.

After the implementation of mitigation measures, adverse residual effects to terrain and soils would be likely, including a change in soil quantity, a change in topography, a decrease in slope stability in areas of the reservoir, and effects due to inundation and sediment deposition in a flood event. These residual effects would largely be limited in spatial extent to the MC1 Option footprint, and in some cases, would reverse over time; therefore, all residual effects to Terrain and Soils would likely be non-substantive.

HYDROGEOLOGY

The Elbow River aquifer was formed by river deposition comprising high-permeability fluvial deposits, and is hydraulically connected to the Elbow River such that groundwater flows to the river during periods of low flow, and river water recharges the aquifer during times of high river or flood flow. Groundwater quality is generally excellent with concentrations of total dissolved solids typically in the 200 milligrams per litre (mg/L) to 300 mg/L range. There are approximately 10 supply wells in the reservoir boundary. Most wells are owned by AEP, and a small number of private recreational facilities. Most of the wells are classified for domestic use.

Key findings of the assessment are summarized below.

- Groundwater Quantity:
  - Diversion of groundwater may be required to allow safe excavation of granular material during construction.
  - Removal of the sand and gravel aquifer materials in the bed of the Elbow Creek and replacement with impervious fill material (and grout curtain) would cut off groundwater flow through the aquifers.
  - All supply wells within the flood footprint would be vulnerable to damage from floodwaters.
  - Land saturation in proximity to the permanent pond would result in a permanent increase in groundwater quantity, and may result in a temporary increase in groundwater quantity beneath the full flood footprint.
- Groundwater Quality:
  - Clearing of vegetation and topsoil during construction may affect groundwater quality without appropriate handling practices.
  - Groundwater supply wells within the flood footprint are vulnerable to damage from floodwaters. There is risk of contamination entering aquifers under high-flow conditions through supply wells that have not been identified and wells that have not been properly decommissioned.

Mitigation measures proposed to reduce or eliminate potential effects to Groundwater Quantity and Groundwater Quality include decommissioning groundwater supply wells within the reservoir, maintaining surface flows downstream of the dam, and developing and implementing measures for soil salvage and reclamation and revegetation. These measures would fully mitigate potential effects to Groundwater Quality.

After the implementation of mitigation measures, residual effects to Groundwater Quantity would likely include the following: an adverse residual effect is predicted for reduced groundwater quantity downgradient of the dam embankment; and a positive residual effect is predicted for increased groundwater quantity in proximity of the permanent pond and the flood footprint. The adverse effect to downgradient flow would be highly localized in extent because the point-source flow from the diversion tunnel would likely spread out within the alluvial aquifer, and other surface and groundwater inputs would likely re-establish normal flow patterns and surface water / groundwater interaction within several kilometres. Thus, this adverse residual effect would likely be non-substantive.

FLUVIAL GEOMORPHOLOGY

The Elbow River is a low-order braided system in the vicinity of MC1. This channel pattern is characterized by frequent unvegetated mid-channel bars that divide the channel into multiple flow paths (channels). Braiding generally occurs in relatively steep environments with high sediment supply, and is commonly observed in unconfined sections of mountain streams, particularly downstream of glaciated terrain. The Elbow River exhibits a braided pattern in unconfined reaches, and a single-thread (single channel) pattern where the river is confined by less erodible channel banks (e.g., bedrock).

Key findings of the assessment including the following:

- Sediment retention in the permanent pond following impoundment of the Elbow River would occur at the upstream end of the permanent pond due to the associated decrease in water velocity. Sediment would likely accumulate at the upstream end of the reservoir at an average rate of 19,400 tonnes to 77,000 tonnes annually.
- The MC1 Option would result in both a decrease in downstream peak flows and a decrease in the sediment supply, which may result in channel degradation, channel narrowing, coarsening of bed material, pattern simplification, and aggradation at tributary junctions downstream of MC1 to the intake of the Glenmore Reservoir.

Mitigation measures include maintaining flow competence (i.e., allowing flows that exceed the threshold for flow entrainment) and sediment augmentation downstream of MC1.

After the implementation of mitigation measures, adverse residual effects to Fluvial Geomorphology would remain for sediment retention in the reservoir, and changes to channel morphology. The residual effect to sediment retention in the reservoir would likely be non-substantive primarily due to the localized nature of the effect. The residual effect to changes to channel morphology would likely be a substantive effect because the effect would extend to the Glenmore Reservoir, would be irreversible, and would result in a moderate degree of change in channel morphology in the affected area.

WATER QUALITY

The Elbow River near Bragg Creek shows chemical attributes of a highly productive system that would be expected to support a diverse food web for fish and other aquatic organisms. The river is turbid, particularly during the spring and summer snowmelt periods, which infers rapid weathering of parent materials upstream of sampling sites. The occurrence of pathogens indicates upstream contamination from uncontained seepage of untreated wastewater. Total and methylated mercury levels are also high. Nitrogen-to-phosphorus ratios indicate potential phosphorus deficiency of algal growth, which means that any addition of phosphorus could greatly increase algal growth rates and biomass. Multiple water licences for surface water diversion, including drinking water, also exist between MC1 and the Glenmore Reservoir.

Key findings of the assessment include the following:

- Surface Water Quality for Aquatic Organisms and Drinking Water Quality:
    - Activities such as ground disturbance, blasting, use of heavy equipment, and operation of the reservoir could lead to turbidity in exceedance of relevant guidelines.
    - Removal of fuel storage tanks and fuelling stations and chemical and soil waste removal at the EVRS and other provincial park infrastructure could cause chemical leaching in the soil and into the Elbow River and tributary flow into the Elbow River. Handling of these materials during the reclamation process, including runoff from temporary stockpiles or soil inundation during reclamation, could result in potential exceedances of relevant guidelines.
    - Nutrient loading could arise from the decomposition of vegetation and organic material following flooding of soil for the permanent pond, which could ultimately result in increased algal growth and biomass. This in turn could decrease dissolved oxygen and create conditions favourable for methylmercury formation. Nutrient inputs can also favour cyanobacteria, which can produce microcystins that are harmful if ingested.
- Drinking Water Quality:
    - Activities associated with the MC1 Option could lead to an increase in dissolved organic matter, which may interact with chlorine or ozone disinfectants in any downstream water intakes to form disinfectant byproducts. Chloramines, trihalomethanes, chlorate, and dichlorophenol exemplify disinfection byproducts that can impart unpleasant taste and odour to water, and some may be carcinogenic at high concentrations.
    - Pathogens may be introduced into the Elbow River during the decommissioning of the EVRS and other park infrastructure as contaminated soils from septic fields and waste treatment facilities are removed.

Mitigation measures proposed to reduce or eliminate potential effects to Surface Water Quality for Aquatic Organisms and Drinking Water Quality include fully decommissioning and reclaiming the EVRS and Stations Flats day use area, and removing all vegetation and topsoil within the permanent pond area. Additionally, measures would be developed and implemented to manage for chemical contaminants, cementitious materials, wastewater containment, and blast management. An Erosion and Sediment Control Plan would also be implemented.

After the implementation of mitigation measures, an adverse residual effect would likely remain for both VCs due to increased algal biomass. The removal of vegetation and topsoil around the permanent pond prior to inundation would significantly reduce the release of nutrients into the permanent pond, but it is unlikely that all organic material and soil could be removed during this process. This residual effect would likely be more pronounced in winter when the water residence time in the reservoir is greatest; however, although this residual effect would likely be more pronounced immediately after construction, it would also diminish over time as nutrient availability decreases. Dilution during snow melt would also facilitate nutrient flushing and reduce long-term downstream effects. The residual effect would likely be non-substantive.

VEGETATION AND WETLANDS

The location of the MC1 Option within the Montane Subregion of the Rocky Mountain Natural Region of Alberta comprises typical vegetation including a mix of grasslands and deciduous-coniferous forests on southern and western aspects, and predominantly coniferous forests on northern aspects and at higher elevations. Vegetation communities in the general MC1 Option area are characterized as mixed wood over-storey dominated by lodgepole pine (*Pinus contorta*), aspen (*Populus tremuloides*), Douglas fir (*Pseudotsuga menziesii*), and white spruce (*Picea glauca*). The understories are dominated by Canada buffaloberry (*Shepherdia canadensis*), bearberry (*Arcostaphylos uva-ursi*), hairy wild rye (*Leymus innovatus*), and pine reed grass (*Calamagrostis rubescens*), along with a number of forbs. Wetlands are sparse within the Montane Subregion; typically, they are rich, often calcareous fens and marshes.

More than 400 tracked plant species have been recorded within the Montane Subregion, two of which are listed in Schedule 1 of the *Species at Risk Act*, SC 2002 c. 29 (SARA): the western blue flag (*Iris missouriensis*), and the Haller's apple moss (*Bartramia halleriana*).

Key findings of the assessment include the following:

- Approximately 265 ha of vegetation communities (including wetlands) would be temporarily or permanently disturbed by the MC1 Option; the remaining 61 ha is categorized as anthropogenic. Permanent direct and induced MC1-effects to vegetation communities would likely be approximately 203 ha. Vegetation communities would be affected by clearing activities, changes to the hydrological regime, or indirect effects from dust and silt, traffic, and road maintenance activities (e.g., road salt) or the introduction of invasive species.
- Approximately 23 ha of wetland would be directly affected by the MC1 Option, and an additional 70 ha would be temporarily affected. These wetlands would be affected due to clearing activities, changes to the hydrological regime, temporary flooding, or deposition of fill.
- Three tracked species – Palmate germanderwort (*Riccardia palmata*), glaucus-headed earthwort (*Scapania glaucocephala*), and ragged-leaf liverwort (*Lophozia incisa*) – were identified during baseline studies, with palmate germanderwort and glaucus-headed earthwort located within the Option footprint. These species, and others not yet identified, may be affected due to direct removal, hydrological regime changes, and introduction of invasive species.

Mitigation measures proposed to reduce or eliminate potential effects to Vegetation and Wetlands include measures for reclamation and revegetation, riparian vegetation management, sensitive plant surveys, dust controls, and an invasive plant program. Additionally, an Erosion and Sediment Control Plan would be implemented, and AT would be required to follow the standard avoidance, minimization, and compensation measures described in the new Alberta Wetland Policy. Under this policy, a compensation payment would be made to Ducks Unlimited Canada to implement projects that benefit wetlands within the Saskatchewan River Watershed.

After the implementation of mitigation measures, two adverse residual effects are predicted for Vegetation: a change in vegetated area, and a loss of biodiversity diversity. Additionally, adverse residual effects for Wetlands are predicted to include a change in wetland area and function, and a change in species diversity. While all residual effects would be localized to the MC1 Option area, the changes would be irreversible. Although compensation would be made for wetland loss, these measures would not offset interim and long-term loss to wetland area and function within the MC1 LAA. This residual effect is considered substantive. As well, the loss of biodiversity due to the loss of tracked plant species is considered substantive.

WILDLIFE AND WILDLIFE HABITAT

The region around MC1 is productive for wildlife associated with lodgepole pine, mixed wood forests, and streams including: mammals such as grizzly bear (*Ursus arctos*), moose (*Alces alces*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and several species of bats; birds such as common raven (*Corvus corax*), black-billed magpie (*Pica hudsonia*), Bohemian waxwing (*Bombycilla garrulus*), mountain chickadee (*Poecile gambeli*), boreal chickadee (*P. hudsonicus*), and American dipper (*Cinclus mexicanus*); and amphibians such as wood frog (*Lithobates sylvaticus*), western toad (*Anaxyrus boreas*), and common garter snake (*Thamnophis sirtalis*).

Multiple wildlife species of conservation concern are known to occur or are thought to occur in the Option area, including the little brown bat (*Myotis lucifugus*) and Northern myotis (*M. septentionalis*), which are both listed on schedule 1 of SARA as endangered. Common nighthawk (*Chordeiles minor*) and olive-sided flycatcher (*Contopus cooperi*) are listed on schedule 1 of SARA as threatened. Horned grebe (*Podiceps auritus*) and Western toad are both listed on schedule 1 of SARA as special concern. Grizzly bear is listed as endangered under the provincial *Wildlife Act*. Many other wildlife species are listed provincially as sensitive, including harlequin duck (*Histrionicus histrionicus*), sharp-tailed grouse (*Tympanuchus phasianellus*), Columbia spotted frog (*Rana luteiventris*), and long-toed salamander (*Ambystoma macrodactylum*).

Key findings of the assessment include the following:

- Grizzly Bear:
  - The location of the MC1 Option is in Bear Management Area 5; the Option footprint overlaps both the Recovery and Support Zones in Area 5. Vehicle collision mortality is the one of the leading causes of mortality for grizzly bears in Area 5. Use of the realigned Highway 66 would likely continue to be a source of mortality for grizzly bear, as well as effect movement patterns for grizzly bear.
  - The MC1 Option would result in habitat loss for grizzly bear. Core security, foraging, and potentially denning habitat availability would be adversely affected. Change in habitat may also occur as a result of sensory disturbance (i.e., noise associated with construction activity), which can result in reduced habitat suitability.
- Ungulates:
  - The MC1 Option is located in a Key Wildlife Biodiversity Zone, established to protect habitats that support wintering ungulates and biodiversity. The MC1 Option would result in habitat loss for ungulates. Winter foraging habitat availability would be reduced due to vegetation clearing and construction of permanent infrastructure required for the Option.
  - Changes to linear disturbance densities could alter predator-prey dynamics by increasing the likelihood of encounters with predators such as wolves.
- Bats:
  - The removal of forest habitat, particularly mature to old forest, could adversely affect the availability of roost sites for bats (used during late spring, summer, and fall). Vegetation clearing may directly or indirectly cause mortality to bats, as tree removal may destroy occupied roosts or remove suitable habitat for bats.
  - Forage availability for bats would likely be improved with the creation of a permanent pond that provides habitat for insects.
- Birds – Breeding Birds, Raptors and Owls, Harlequin Duck, Piscivorous Birds:
  - Change in habitat associated with vegetation clearing and sensory disturbances would include loss of breeding, foraging, and brood habitat for birds. Clearing in the footprint of the permanent pond would create nesting habitat for ground-nesting species that (e.g., Canada goose (*Branta canadensis*), killdeer (*Charadrius vociferous*), and common nighthawk). Creation of the permanent pond would create foraging habitat for piscivorous birds.
  - Option activities would create a risk of direct mortality for birds.
- Amphibians and Reptiles:
  - Grubbing and clearing activities would alter or remove terrestrial habitats used by amphibians and reptiles for foraging, and potentially alter or remove habitat features used for overwintering requisites.
  - Option activities may also cause direct mortality for amphibians and reptiles. In addition, vehicle use of the re-aligned portions of Highway 66 could result in vehicle collision mortality for amphibians and reptiles, due to the highway's proximity to wetland habitats.

- MC1 could create breeding habitat for western toad and other amphibian species through the creation of the permanent pond, if shallow margins are present, as well as in the borrow areas, which may create low wetland habitats that could be used by amphibians for breeding.

Mitigation measures proposed to reduce or eliminate potential effects to Wildlife and Wildlife Habitat include footprint reductions and access considerations during detailed design, timing considerations, pre-construction surveys for raptor nests and sensitive features, wildlife passage structures for the realigned section of Highway 66, and measures to reduce wildlife-human interactions. Additionally, an Erosion and Sediment Control Plan would be implemented.

After the implementation of mitigation measures, adverse residual effects to Wildlife and Wildlife Habitat would remain due to a change in habitat for all VCs. Positive effects to a change in habitat would also be likely; for example, the creation of the permanent pond could provide habitat for bats, piscivorous birds, and amphibians. Adverse residual effects to a change in movement would remain for Grizzly Bear, Ungulates, and Amphibians and Reptiles. A residual effect on change in mortality risk would remain for Grizzly Bear, Ungulates, Bats, Breeding Birds, Raptors and Owls, and Amphibians and Reptiles. All residual effects to Wildlife and Wildlife Habitat VCs are likely to be non-substantive.

FISH AND FISH HABITAT

The Elbow River watershed supports several fish species of management concern, including bull trout (*Salvelinus confluentus*); brook trout (*S. fontinalis*); rainbow trout (*Oncorhynchus mykiss*); cutthroat trout (*O. clarkii*; introduced); brown trout (*Salmo trutta*; introduced); mountain whitefish (*Prosopium williamsoni*); northern pike (*Esox lucius*); and burbot (*Lota lota)*. Other species known to occur in the Elbow River watershed include brook stickleback (*Culaea inconstans*); lake chub (*Couesius plumbeus)*; trout-perch (*Percopsis omiscomaycus*); pearl dace (*Margariscus margarita*); longnose dace (*Rhinichthus cataractae*); fathead minnow (*Pimephales promelas*); longnose sucker (*Catostomus catostomus*); and white sucker (*C. commersoni*).

Of the fish species that are known to occur in the Elbow River and tributaries around MC1, bull trout is the only species of conservation concern that could reasonably occur. The Option area lies entirely within the range of the Upper Elbow River population, which is listed as being of High Risk of extirpation given that it comprises between 50 and 250 adults. The species' Saskatchewan-Nelson Rivers populations (which encompasses the Upper Elbow River population) are listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada. Although the species is currently not listed under SARA Schedule 1, the Government of Canada has recently consulted with the public as part of their determination as to whether to list the species under SARA. Provincially, bull trout are listed as Sensitive to human activities or natural events.

Key findings of the assessment include the following:

- The construction of the Option components including the earth fill dam, rock groin, and cofferdam would result in a direct and permanent loss of fish habitat.
- Alteration of habitat would likely result during episodic changes in water levels in the reservoir which would reduce the consistency and suitability of habitat, as well as temporarily influence habitat composition.
- The creation of the permanent pond would considerably alter the physical, chemical, and ecological characteristics of the area immediately upstream from the dam. Some new wintering habitat may result from the creation of the permanent pond, and coarse substrate deposition at the upstream end of the permanent pond may enhance foraging or spawning habitat, representing potential positive effects.
- Some mortality of fish passing through the diversion tunnels during construction would likely occur.
- The fish community assemblage could be altered in the permanent pond. Conditions would favour species more adept at adapting to altered environments and ecosystems more representative of lacustrine conditions.

Mitigation measures proposed to reduce or eliminate potential effects to Fish and Fish Habitat include inclusion of a fish passage structure in the dam; consideration of habitat avoidance measures during detailed design; fish habitat restoration, enhancement, and compensatory offset programs; and measures for management of fish health, blasting, invasive species and fish diseases, and riparian vegetation. Flow through the diversion tunnels and fish passage structure would be managed to maintain instream flow needs. Tunnels would be designed to reduce fish entrainment. An Erosion and Sediment Control Plan would also be implemented.

With the implementation of mitigation measures, adverse residual effects to Fish and Fish Habitat are predicted to remain for permanent alteration and destruction of fish habitat, effects on fish mortality and productivity, effect on migration and movement, and effect on fish assemblage due to habitat change. With the exception of effects to fish mortality and productivity, these residual effects are not expected to result in population-level effects, and would therefore be non-substantive. However, the potential residual effect on fish mortality and productivity is considered substantive for bull trout, as mortality from fish passing through the diversion tunnels during construction would likely be unavoidable. Any mortality to bull trout would have population level effects due to the small size of the Upper Elbow River population.

LAND USE AND MANAGEMENT

MC1 would be situated on Crown land within the provincial Green Zone. Land use management direction in Kananaskis Country is provided at a strategic level in the South Saskatchewan Regional Plan, pursuant to the *Alberta Land Stewardship Act,* SA 2009, c. A-26.8. The South Saskatchewan Regional Plan provides direction to activities on Crown lands, through existing legislation (e.g., the *Public Lands Act*, RSA 2000, c.

P-40; the *Forests Act,* RSA 2000, c.F-22; provincial park legislation, sub-regional plans). The park system in the region includes provincial parks, provincial recreation areas (PRAs), wildland provincial parks, and an ecological reserve. The Option area is situated in a predominantly recreational area that is considered one of the most heavily used single access points to Kananaskis Country. The Elbow River valley experiences the highest levels of recreational use within Kananaskis County, supported by proximity to Calgary, and its accessible roads, facilities, and trail systems. An extensive network of trails throughout the valley on the north side of the Elbow River are used year-round for mountain biking, skiing, snowshoeing, hiking, and horse riding.

Current land and resource uses include forestry, agriculture (i.e., cattle grazing), recreation, hunting and fishing, trapping, oil and gas development activities, and sand and gravel quarrying. Existing infrastructure within the MC1 Option area includes the EVRS complex and firefighting base camp. The EVRS is located on the north side of Highway 66 along both sides of Ranger Creek, and serves staff from Alberta Forestry Protection Services, Alberta Parks and Recreation, and Alberta Fish and Wildlife. Other physical infrastructure in the Option area includes four PRAs, Highway 66, electrical transmission lines owned by Fortis Alberta, one pipeline owned by Atco Gas and Pipelines Ltd, an access road owned by Husky Oil Corporation, two abandoned wellsites owned by Shell Canada, and a non-motorized trail network on the north side of the Elbow River.

Key findings of the assessment include the following:

- Construction of MC1 would result in a permanent loss of portions of McLean Creek PRA and Elbow River PRA, including campsites and day use areas. A portion of the McLean Creek campground would be permanently closed and relocated. River Cove Group Campground and Station Flats day use area in the Elbow River PRA are within the reservoir, and would be permanently closed and relocated for public safety reasons.
- Paddy’s Flat campground and McLean Creek campground would be closed for the duration of Construction, due to noise and air quality concerns related to the MC1 Option, and would be fully accessible once construction is complete.
- Changes to resource and commercial use resulting from construction activities would affect lands used for resource activities. Reservoir operation would displace grazing allotments and grazing leases within the reservoir.

Mitigation measures proposed to reduce or eliminate potential effects to Land Use and Management include identifying alternative areas to offset loss of protected areas; retaining or reconstructing access to affected recreation areas; redirecting recreational users to other recreational use areas; creation of a recreation site associated with the permanent pond; communication of construction schedule and road closures; development of a traffic accommodation strategies; compensation for grazing allotment holders and registered fur management area holders; developing and implementing a plan for infrastructure relocation.

With the implementation of mitigation measures, adverse residual effects to Land Use and Management are predicted to remain for changes to protected areas, changes to resource and commercial users, changes to recreational use, change in the quality of the recreational experience, and disruption of infrastructure. With the exception of the change to recreational use, all residual effects are likely to be non-substantive as mitigation measures are likely to be highly effective at reducing or eliminating the predicted residual effects. However, the change to recreational use would include extensive closures of popular trails, changes to fishing opportunities, and loss of popular campgrounds and day use areas. Due to the permanent changes that would occur in the Elbow River Valley on PRAs and other unprotected recreational use areas, in the context of the high level of intensity of recreational use that the LAA currently receives, the effect on recreational use is likely to be substantive.

SOCIO-ECONOMIC RESOURCES

Alberta's provincial economy has led Canada in economic growth during the past 20 years, despite the acknowledgement of recession in 2015. Currently, Alberta's oil and gas sector accounts for 19% of its gross domestic product (GDP), with other non-energy sectors, such as construction, finance and real estate, and business and commercial services growing significantly over the last three decades. For 2016 – 2017, Alberta's provincial revenue is projected to be $41.4 billion, 3.7% lower than forecasted in 2015 – 2016.

Key findings of the assessment include the following:

- Positive effects would occur for provincial and regional economies. The effect on the regional economy, and to a lesser extent, the provincial economy would be an increase in GDP, labour income, and employment. Option CAPEX would generate direct and indirect effects of $238,226,000 in GDP, $162,040,00 in labour income, and 2,700 jobs (FTE) over the four-year Construction phase.
- Positive effects would occur to the labour force, primarily during construction. MC1 would require a construction workforce for an approximate four-year Construction period, ranging from 100 to 150 workers and increasing to 200 at peak construction periods. Much of the force would be sourced from Calgary and adjacent areas.
- A positive effect would also occur due to contracting and procurement opportunities.
- An adverse effect to economic activities of resource-dependent businesses and industry would occur, primarily on lands and uses displaced by MC1, although campground operators and other resource users may experience economic loss.
- A positive effect to regional economic conditions would result in changes to regional businesses from the construction workforce spending earnings on goods and services, thereby redistributing employment income in the region and contributing to induced employment and GDP.
- Worker demand may create a shortage of local accommodation.

Mitigation measures proposed to reduce or eliminate potential effects to Socio-economic Resources include mitigation for loss of economic opportunity such as identifying alternative areas to offset loss of protected areas, and retaining or reconstructing access to affected recreation areas; and establishment of a work camp during construction.

Positive residual effects to Socio-economic Resources are predicted to remain for changes to provincial and regional economies, change in labour force, change in contracting and procurement opportunities, and change to regional economic conditions. The change to provincial and regional economies is likely to be a substantive positive residual effect due to the high magnitude of the change. All other positive residual effects are likely to be non-substantive, as they are likely to be more moderate (i.e. limited) in magnitude.

With the implementation of mitigation measures, adverse residual effects to Socio-economic Resources are predicted to remain for change in economic activities of resource-dependent businesses and industry, and change in availability of accommodation. These adverse residual effects are likely to be non-substantive due to the effectiveness of mitigation measures to reduce the magnitude of the residual effect, and that the most employees are assumed to be based in Calgary or other regional communities and would not require local accommodation.

PUBLIC HEALTH AND SAFETY

Health services in Bragg Creek (and by association Redwood Meadows) are provided by a clinic that operates under Mountain Woods Health Services in association with the Calgary Rural Primary Care Network. Health services on the Tsuut'ina Nation are provided by the Tsuut'ina Clinic, which is supported by the Calgary West Rural Primary Care Network.

There is currently no significant infrastructure in place to protect communities downstream of the MC1 Option from flooding, although flood reduction measures are currently being planned in high risk communities. Flooding is classified as an extreme weather event that is exacerbated by climate change. As such, these events are likely to increase in the future both in frequency and magnitude.

Key findings of the assessment include the following:

- Construction activities associated with the MC1 Option would result in an increase in CAC concentrations and short-term air concentrations of fine particulate matter ($PM_{2.5}$) and nitrogen dioxide would exceed health-based exposure limits. Health effects would likely be reversible.
- In a flood event, once flood waters have receded from the banks of the reservoir after a flood event, dust emissions from wind erosion of reservoir banks could result in increased $PM_{2.5}$ concentrations. Health effects likely would be reversible assuming acute exposure duration.
- The MC1 Option would have a positive effect on regional health services as a result of flood reduction, removing health care demands and improving overall public safety associated with emergency preparedness and emergency response during flood conditions. Flood reduction would result in numerous benefits to health and regional health services before, during, and after a flood event. This would be positive in terms of public health and safety.

Mitigation measures would include public access restrictions, a traffic accommodation strategy, an alternative base for regional emergency response services, and emergency preparedness and emergency response measures.

A positive residual effects to Public Health and Safety is predicted to remain for emergency preparedness/ response during a flood event. The flood protection provided by MC1 Option would improve overall public health and safety and emergency preparedness / emergency response during flood conditions, and is likely to be a substantive effect.

PLANNED DEVELOPMENT CASE

All predicted substantive adverse residual effects were carried forward for consideration in the Planned Development Case (i.e., the environmental conditions that may occur as a result of the interaction of MC1 with other existing and planned projects and activities that can be reasonably expected to occur). The Planned Development Case was evaluated through the completion of a cumulative effects assessment (AEP 2013), which examines how the substantive adverse effects of the MC1 Option may interact spatially and temporally with the residual effects of other past, present, or future projects.

The predicted substantive adverse residual effects considered in the Planned Development Case were:

- Fluvial Geomorphology: changes to channel morphology
- Vegetation and Wetlands: reduction in biodiversity due to loss of tracked plant species
- Wetlands: reduction in wetland area and function
- Fish and Fish Habitat: increased risk of fish mortality and reduced productivity for bull trout
- Land and Resource Use: reduction to recreational use

These predicted substantive adverse residual effects were screened for potential interactions against past, current, and reasonably foreseeable future major projects (i.e., valued at $5 million or greater), as well as smaller projects and activities such as pipelines and super pipes, transmission lines, roads, wells, and grazing. Interactions were evaluated to determine the potential for a potentially substantive cumulative effect. Although interactions between MC1-specific adverse residual effects were identified, these interactions are unlikely to result in substantive adverse cumulative effects, assuming all projects and activities are constructed and operated according to applicable guidelines and best management practices. Thus, no potential for substantive cumulative effects was identified.

EFFECTS ASSESSMENT SUMMARY

The results of the effects assessment, indicates that five VCs are likely to experience residual adverse effects that are considered to be substantive, as a result of construction and operation of the Option:

- Fluvial Geomorphology: changes to channel morphology
- Vegetation and Wetlands: reduction in biodiversity due to loss of tracked plant species
- Wetlands: reduction in wetland area and function
- Fish and Fish Habitat: increased risk of fish mortality and reduced productivity for bull trout
- Land and Resource Use: reduction to recreational use

Additionally, the Option would be likely to have the following positive substantive residual effects:

- Socio-economic Resources: an increase in provincial and regional economies
- Health and Safety: improved emergency preparedness / response and reduced health and safety risk during a flood event

All substantive adverse residual effects were brought forward into the Planned Development Case, and screened against past, present, and reasonably foreseeable projects and activities to determine if a substantive adverse cumulative effect could occur. No potential for substantive cumulative effects was identified.

Effects of the Environment on the Option

Beaver Flats Landslide Complex

The Beaver Flats Landslide Complex, located approximately 8 km upstream of the eastern most extent of the reservoir and 12 km upstream of the MC1 dam site, is thought to be two distinct rock slides. Because the deposit of two rock avalanches is visible on both sides of the Elbow River, it is assumed that historic slide events dammed the Elbow River and led to outbreak floods.

The Beaver Flats Landslide Complex is regarded as most likely to interrupt flows in the Elbow River given. A preliminary analysis of this Landslide Complex suggests a failure frequency of up to approximately 1 in 3,000. Based on historic failures, a potential failure of this complex may create a dam approximately 57 m high, with a peak flow from dam breach estimated to range from 4,300 m^3/s to 42,000 m^3/s. This outburst would substantially exceed the peak flow estimate for hydrological floods (i.e., 2,770 m^3/s for the PMF). This preliminary analysis implies a substantially higher frequency and magnitude of a landslide outburst flood than the PMF.

MC1 may provide a level of protection to the downstream environment from a landslide dam outbreak flood, as the modelled landslide dam outbreak flood could be contained by MC1, assuming a total reservoir storage volume of 93 million m^3, of which approximately 88 million m^3 would be available for flood storage between the permanent pond and the maximum reservoir level. These preliminary conclusions would require examination through field work and landslide runout modelling.

Accidents and Malfunctions

Earthworks Failure of the Main Dam

Several scenarios, including an earthquake or seismic event piping (seepage causing internal erosion of the dam) through the earth fill dam or its foundation and overtopping during the PMF, could result in a failure of the main dam. Such a failure, if it were to occur during or immediately following a major flood event, would result in the release of a substantial volume of water (up to 93 million m^3) downstream, and a consequent increase in peak flow for a short period of time as this pulse of water moves downstream.

A failure of the main dam would have major effects to the downstream environment. Bank erosion and substantial scouring of the streambed would occur in the immediate vicinity of failure. Failure of the earth fill dam would release earth and debris into the Elbow River, and would result in the rapid drawdown of the reservoir water, which could result in landslides. The high energy of flows through a breach in the dam would result in scouring of the stream channel, and consequently would increase the concentration of suspended solids in downstream waters. The pulse of water and subsequent high sediment loads would affect fish and fish habitat in downstream watercourses. Wildlife within the flooded area could be injured or killed by the force of the flood wave or impingement against obstacles, or could be drowned. Vegetation and ecological communities may be affected by direct damage or loss of vegetation on the flood's flow path due to scouring, or may be smothered by sediment.

A failure of the main dam would adversely affect land and resource use due to its effects on fish, wildlife, and vegetation, as described above, as well as effects on agriculture, livestock, and forestry. Other effects would likely include damages to community infrastructure such as roads, highways, trails, and transmission lines; the Bragg Creek and Redwood Meadows communities; outdoor recreation and tourism; and visual and aesthetic resources of the river valley downstream. Residences and recreational areas could be inundated by waters released through a breach in the dam.

The consequence classification rating for the MC1 dam would be extreme due to the downstream population at risk; therefore, the MC1 Option would be designed to the PMF. Safety design considerations include construction of a well-founded and continuous slurry wall to prevent piping failures, and activation of the service spillway. The main dam would be monitored, and in the event of a trigger indicating dam instability or failure, emergency response measures would be triggered. A failure of the dam is considered a rare event. Due to the risk of human fatalities, the consequence of a dam failure is severe. On this basis, the risk associated with failure of the dam is high.

In the event of a failure of the main dam, an evacuation would be undertaken immediately to protect the safety of employees, site personnel, and the public. Monitoring and assessment programs would be initiated to identify any residual effects in the receiving biophysical and human environment.

Earthworks Failure of the Cofferdam

As with the main dam, scenarios such as an earthquake, seismic event, or piping through the dam or its foundation could result in failure of the structure during the Construction phase. Such a failure would result in the release of a large volume of water and material into the downstream environment.

The potential effect of a failure of the cofferdam would be similar to those associated with failure of the main dam, but of a lower scale and magnitude given the substantially lower volume of water that would be retained by the cofferdam when compared to the main dam.

Best practices recommend cofferdams are designed to handle 1:20-year flood event plus 1 m of freeboard. The MC1 cofferdam would be designed to handle a 1:50-year flood event plus 3 m to 5 m of freeboard. Emergency response measures would be the similar to those for the main dam.

The likelihood of failure of the cofferdam is considered rare. Since the maximum storage capacity of the cofferdam is less than half of that of the main dam, the potential effects associated with the failure of the upstream cofferdam would be similar to those described for the main dam, but would be lower in severity and geographic extent. Due to the risk of human fatalities, the consequence of a dam failure is still considered to be severe. On this basis, the risk associated with a failure of the cofferdam is high.

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3. Deltares Reports

Deltares

Enabling Delta Life

Alberta Environment and Parks
Resilience and Mitigation
Attn. Mr. A. Wilson
4th Floor, 9920 - 108 Street
EDMONTON, AB T5K 2M4
Canada

Date	Our reference	Number of pages
7 October 2015	1220924-001-BGS-0003-c	1
From	**Direct line**	**E-mail**
Hans van Duijne	+31(0)88335 7776	hans.vanduijne@deltares.nl

Subject
Review of two flood mitigation projects: Bragg Creek / Springbank off-stream flood storage and McLean Creek flood storage

Dear Mr Wilson, Hi, Andrew,

Attached you find the letter-report on the Review of two flood mitigation projects: Bragg Creek / Springbank off-stream flood storage and McLean Creek flood storage. Our additional considerations are mentioned in this report.

We trust this review serves you in the decision making process.

Yours sincerely,

ing. J.D.G. van Duijne
international project manager

Enclosures
1

Deltares

Enabling Delta Life

Alberta Environment and Parks
Resilience and Mitigation
4th Floor, 9920 – 108 Street
Edmonton, AB T5K 2M4

Date	Our reference	Number of pages
October 7, 2015	1220924-001-BGS-0001-lk	8
From	**Direct line**	**E-mail**
Hans van Duijne	+31(0)88335 7776	hans.vanduijne@deltares.nl

Subject
Review of two flood mitigation projects: Bragg Creek / Springbank off-stream flood storage and McLean Creek flood storage

ISSUE:
The southern part of the Province of Alberta suffered from severe flood in June 2013. The flood resulted in loss of life, considerable damage to houses and public infrastructure, and social disruption. Possible flood mitigation projects have been identified to lower the flood risk. The present summary reviews two flood mitigation projects proposed for the Elbow River, namely the Bragg Creek / Springbank off-stream flood storage (SR1) and the McLean Creek flood storage (MC1). Both projects aim at the storage of flood water and thus reducing the peak river discharge through Calgary.

We conclude that, based on the current design concepts, both storage sites can provide the **required storage** for the 1:200 event used as design flood. As with all detention measures, the effect of storage heavily depends on the expected range in possible flood hydrographs, accurate forecasts and quick response in the operation of the gates. Both schemes would be best positioned as a part of an overall plan for water management within the watershed.
We estimate that MC1 and SR1 would achieve a similar reduction in flood risk once built. SR1 has a lower risk of catastrophic structure failure during construction than MC1. MC1 has a small advantage for the Hamlet of Bragg Creek because no additional measures are required to protect the hamlet. But since the proposal for SR1 also includes flood protection measures to be taken specifically for Bragg Creek, this difference is small.

Without additional information on **sediment transport**, it is difficult to express a well substantiated preference for either of the two projects from this point of view. However, given the fact that MC1 will trap all bed-material load, one might argue that MC1 is likely to have more impact on sediment transport. This would imply that SR1 could be preferred from this point of view. This needs to be verified by sediment transport studies. The impact of SR1 to the natural flow of the Elbow is smaller than MC1. **From an environmental point of view, SR1 leaves the river as a more natural system.**

SUMMARY:
The following table is a summary of our assessment of the two projects:

Subject		Comments	Recommende
Efficacy	Storage	Both storage facilities have sufficient storage capacity for 1:200 return period and can offer the same level of protection.	SR1/MC1
	Sedimentation	Both storage facilities are susceptible to sedimentation and need regular and timely maintenance; however SR1 is less sensitive	SR1
	Water Management	Both schemes provide similar value in terms of water management It is expected that SR1 is more sensitive for differences in flood hydrograph or inaccurate forecasts than MC1. The catchment area for SR 1 is much larger and located well downstream of MC1. The effect of storage at the MC1 site on the discharge in Calgary may, however, also depend on the runoff that is generated downstream of the proposed location. This seems to be less of a problem for the SR1 location. SR 1 is closer to the operational response teams (response time shorter), is easier accessible (more than one access route) and is less vulnerable to damage of these access roads during extreme weather conditions	SR1/MC1
	Climate Change	Both facilities can be adapted to climate change	SR1/MC1

Cost Benefit	Construction	SR1 can be built off stream and is less dependent on (extreme) seasonal influences in river discharges, which might influence construction time outs. Both SR1 and MC1 have similar impact on existing infrastructure (road reallocation) and reconstruction of existing infrastructure. The total cost estimate for SR1 include protection for Bragg Creek and Redwood Meadows. The use for SR1 during flooding can(is to) be compensated for the damage to the owners after use. The option enables the current land owners to retain ownership and be compensated post flood events. Overall SR1 is less costly according to the consultants' reports. As the economic benefits are the same, the benefit/cost ratio is higher for SR1.	SR1
	Operational	Both storage facilities need a fast response to their operation; this is a critical issue, especially at SR1.	SR1/MC1
Risks		Timing: SR1 can be constructed one year quicker. Regulatory risk: It is expected that the regulatory process would be significantly longer for MC1 than SR1 due to the need for environmental mitigation and First Nations consultation. Construction: MC1 has potential for catastrophic failure during construction. Cost: the construction location has a higher risk of cost escalation due to topography.	SR1
Environmental Impacts		MC1 has detrimental effects to the environmental impact on spawning grounds and wild life trekking. SR1 is pasture land and its use does not change except during high river discharges.	SR1
Social impacts	Landownership	Affected residents are not in favour of SR1. MC1 is located on Crown land. There would be significant impact to First Nations traditional uses and recreational users of the MC1 area if MC1 went forward. Environmental NGO's are opposing the MC1 option, as MC1 is affects the natural system more than SR1.	SR1/MC1
Overall		Between the two schemes, SR1 is recommended	SR1

ADDITIONAL CONSIDERATIONS:
The province should continue to pursue the multiple layers approach to flood mitigation as outlined in previous work on Room for the River, structural mitigation is only one element. Programs like wetland restoration, flood way regulations and removal of obstructions should continue. Temporary storage of water in detention areas is not a very robust measure, in the sense that it is effective up to a certain design condition, but when it is overcharged its effect is reduced to nil. And, moreover, it is very sensitive to 'sound operation and fast response time'. When floods up to the size of the June 2013 flood would be avoided, but anything above would not be reduced in size, the awareness of the people in the floodplain will further decline, making them (and society at large) even more vulnerable.
Other considerations in relation to adopting Room-for-the-River principles were reported by Frans Klijn (memo October 29, 2014). Increasing the discharge capacity of rivers usually results in less sudden responses in terms of water level rise, less sudden flooding, and lesser flooding depths than embankments or detention in reservoirs.

BACKGROUND:
McLean Creek flood storage (MC1)
The Elbow River Dam at McLean Creak (MC1) site is located in the Green Zone on Crown Land approximately 10 km upstream of the hamlet of Bragg Creek, and immediately upstream of the confluence of McLean Creek with the Elbow River.

As described by AMEC (2014a), this project involves building an earth-fill dam across the main stem of the Elbow River. The proposed earth-fill dam (main embankment) traverses a river gorge, which is approximately 110 m wide at the base and is steep walled for a height of about 28 m (maximum height 50m). The dam includes a combined concrete outlet/service spillway structure for discharging normal and flood flows, and includes an auxiliary earth cut channel spillway to protect the dam from extreme floods up to the Probable Maximum Flood (PMF) event. The permanent outlet/service spillway is a gated conduit structure with its intake invert located about 21 m above the valley bottom. The concrete gates would typically be left in a wide-open position thereby allowing free passage of river water with minimum rise of the reservoir level during normal flow conditions (i.e., non-flood). The gates would be strategically closed during flood events thereby holding back a significant portion of the flow in reservoir storage. The concrete structure also serves as an emergency spillway designed to let above-design floods pass, thereby protecting the dam from potential overtopping or overloading and associated catastrophic failure.

The conceptual design includes a small permanent pool in the valley bottom, permanently containing approximately 4,000 dam^3 of water as dead storage. This storage should prevent incoming larger bottom sediment from plugging the intake area. There is no low level outlet to release the dead storage. Additional water could be contained above the dead storage El. 1,398.0 m (i.e., multi-use storage) by regulating the permanent outlet gates. The potential benefit and/or need for multi-use storage at this site has not yet been reported.

The dam site and reservoir area are shown in Figure 1.

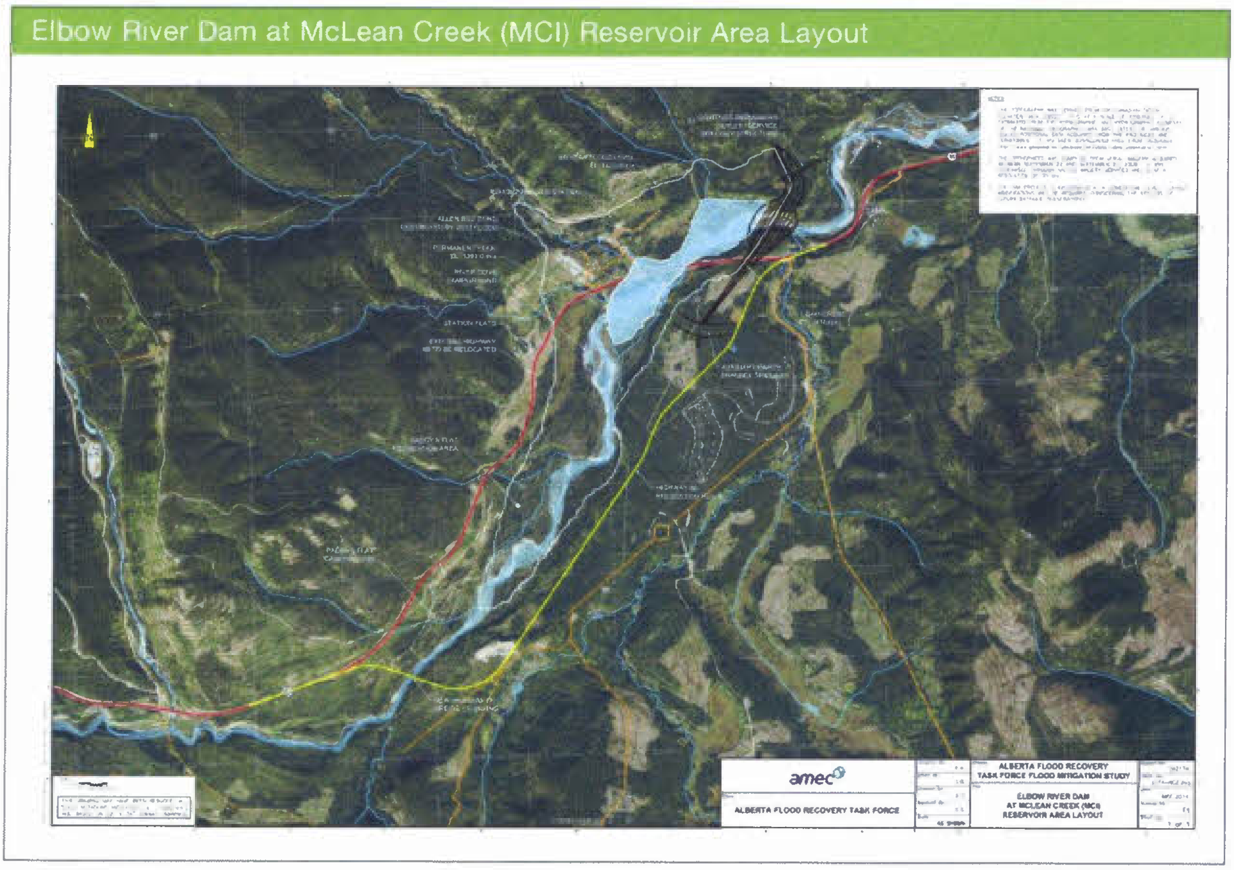

Figure 1 *L ocation and reservoir area of the Elbow River Dam at McLean Creak (MC1)*

Springbank off-stream flood storage (SR1)

The Springbank off-stream storage (SR1) site is located just west of Calgary approximately 18.5 km upstream of the Glenmore Reservoir in a relatively undeveloped farmland and ranchland valley. According to the concept prepared by AMEC (2014b), the SR1 concept involves diverting extreme flood flow from the Elbow River into an off-stream storage reservoir where it would be temporarily contained and later released back into the Elbow River after the flood peak has passed.

The project consists of:
1 a diversion structure constructed across the Elbow River;
2 a diversion channel excavated through the adjacent uplands to transport flood water into an off-stream storage reservoir; and
3 an earth-fill dam to temporarily contain the diverted flood water and a low level outlet structure incorporated into the dam to later release the stored water back into the Elbow River after the flood peak has passed.

The diversion structure would consist of a concrete overflow weir section crossing the Elbow River, a gated concrete sluiceway/fishway located on the left valley abutment with its invert at the river thalweg level, and another gated diversion outlet structure located in the left valley abutment immediately upstream of the sluiceway.
The diversion weir component of the diversion structure is a 100 m long concrete structure with an ogee crest shape and a hydraulic jump stilling basin This structure serves to reduce approach velocities and increase the river water level to facilitate diversion through the outlet structure into the diversion channel.
The outlet structure invert level would be located approximately 1.5 m above the river thalweg in order to prevent that larger bottom sediment enters the diversion channel.

The diversion channel was originally designed to convey a peak diversion flow of 300 m^3/s[1] from the Elbow River into the off-stream storage reservoir. The channel is designed with a 24 m bottom width three horizontal to one vertical side slopes and a 3.6 m water depth.

A 3 km long earth-fill storage dam, having a maximum height of 24 m, is required to contain the diverted flood water. The dam system will include a gated low-level outlet structure. The structure will include a 1.5 m wide by 1.8 m high concrete conduit through the dam, including a gatewell tower located near the dam centerline. This structure will be used to release stored water back into the river after the flood has passed.

It should be acknowledged that detailed engineering design has not occurred for either scheme and both are subject to refinement.

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[1] *In the Stantec adjusted design (April 2015) this seems to be removed, only a 40 m wide spillway/sluicegate in the river bed is assumed. Also Stantec adjusted the diversion channel capacity to 600 m^3/s, with design 6.4 m water depth. Also the storage dam is a bit higher and a few 100 m downstream. Same intake location from the river, and same outlet structure at the dam*

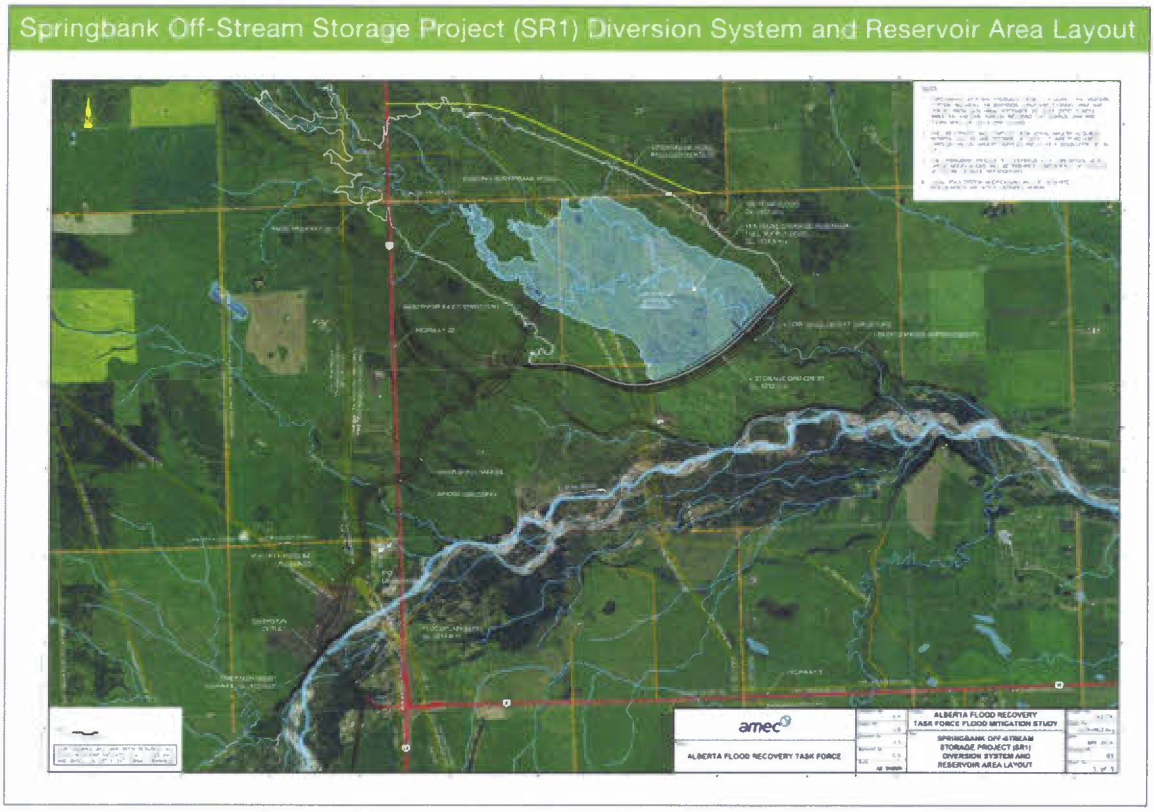

Figure 2 Location and reservoir area of the Springbank off-stream storage project (SR1)

DECISION CONSIDERATIONS:

Storage:
We conclude that, depending on the design, both storage sites can provide the required storage volumes. As with all detention measures, in-stream or off-stream, the effect of storage heavily depends on the expected range in possible flood hydrographs, accurate forecasts and quick operation of the gates. It is expected that SR1 is more sensitive for differences in flood hydrograph or inaccurate forecasts than MC1. However, the effect of storage at the MC1 site on the discharge in Calgary will also depend on the runoff that is generated downstream of the proposed location. This is likely to be less of a problem at the SR1 location.

Risk:
We think that MC1 and SR1 would achieve a similar reduction in flood risk once built. SR1 has a lower risk of cost escalation, regulatory risk leading to extended timing, and catastrophic structure failure during construction than MC1.

Cost estimate:

Item	Cost	
	MC1	SR1
Total 1:200 year protection	$343,581,000	$263,668,000

SR1 is cheaper (± 20 - 25%) than MC1 and therefore results in a higher benefit/cost ratio. It is recommended to consider compensating the damage after use instead of buying all of the reservoir land at SR1, if possible. Depending on the frequency of use and the extent of the damage, this might be more cost effective and supports future agricultural use. It is also recommended to explore possibilities for future modifications in reservoir design to cope with increased floods.
MC1 has a small advantage in that no additional measures are required to protect Bragg Creek and Redwood Meadows. But since SR1 costs also include flood protection for Bragg Creek and Redwood Meadows, this difference is small.

Erosion and sedimentation:
Without additional information on sediment transport, it is not possible to express a well substantiated preference for either of the two measures from this point of view. However, as MC1 will probably trap more bed-material load, it is likely that MC1 will have more impact on sediment transport at large. This would imply that SR1 could be preferred from this point of view.

Environmental Impact:
Based on the reports completed to date, environmental impacts (in terms of impact on endangered species) are less for SR1 than for MC1.

Timeliness of construction:
According to the reports, construction of SR1 will require at least 1 year, but a 2 to 3 year schedule is preferred. Construction of MC1 will require a minimum of two calendar years, but a 3-year process is preferred (AMEC, 2014a).This implies that construction time could be one year shorter for SR1 than for MC1. These construction times do not account for unforeseen issues during construction (eg. floods). They also do not address possible differences in the time required for regulatory and environmental review requirements, which are expected to be longer at MC1.

Alberta Environment and Parks

Recommendations on the Elbow River major infrastructure decisions

October 2015

Alberta Government

SUMMARY

In June 2015, Alberta Environment and Parks commissioned the Dutch research foundation Deltares to review the original infrastructure proposal reports and a subsequent benefit/cost study for flood mitigation work on the Elbow River and provide a recommendation on which project to take forward to construction-ready status.

The Deltares (2015) report recommends moving forward with project design and Environmental Impact Assessment for the Springbank Off-stream Reservoir (SR1) in combination with local mitigation for Bragg Creek and Redwood Meadows because of lower environmental effects, lower cost and less risk during construction when compared to the McLean Creek Dam (MC1).

Deltares' view on protecting communities against flooding over the long term highlights the government's approach to multiple mitigation elements. This includes the importance of being prepared for a range of flood hydrographs. Building infrastructure must be considered a complement to the multiple other facets of mitigation.

The assessment that follows is focused on MC1 and SR1 in combination with upstream mitigation. The scale of these projects offers a substantial reduction in risk and is being designed to the 2013 scale event.

VALUES AT RISK

- The IBI/Golder Calgary benefit/cost study of 2015 suggests that there is up to $942 million at risk on the Elbow River during a 1:200 event.

PROJECT EFFECTIVENESS

- SR1 is more effective than MC1 because it is further downstream and has a larger catchment area. It can respond to rainstorms occurring over a significantly larger area than MC1 by also managing water entering the Elbow River downstream of MC1.
- SR1 is significantly less affected by sedimentation. The amount of large sediment that the Elbow River carried in 2013 is a key factor in supporting off-stream storage.
- MC1 is on-stream, closer to the mountains, and is more likely to trap rocks and trees, putting the structure and its operations at risk.
- Through the design of the SR1 diversion structure, it is possible to look at ways to reduce the impact of sediment on the dam itself.
- SR1 is closer to Calgary and is more accessible. This means that dam operations are more robust, as emergency access to the dam is less likely to be hampered by damage to access roads.

ENVIRONMENTAL IMPACTS

- The environmental reviews undertaken have consistently described the MC1 proposal as fundamentally more ecologically sensitive to disturbance than SR1.
- The Elbow Valley is home to a number of species at risk or concern, including grizzly bears, harlequin ducks, bull trout, westslope cutthroat trout, and wolverine.
- Construction of MC1 would permanently alter fish habitat and interfere with fish spawning.
- MC1 would require the removal of trees and vegetation from the reservoir area, and would irreparably alter the habitat for wildlife and fish population.
- Deltares notes that “From an environmental point of view, SR1 leaves the river as a more natural system.”[1]
- Since SR1 is an off-stream project, less in-stream work will be required during its construction.

CONSTRUCTION AND OPERATION RISKS

- Deltares indicates that fewer construction risks makes SR1 the preferred project.[2]
- SR1 is less subject to the risks of flooding and the consequent threat of catastrophic failure during construction when compared to MC1, which involves building a dam in the river itself. Further, should MC1 fail during construction, the communities of Bragg Creek and Redwood Meadows would be subject to severe damage from debris from the partially built dam.
- SR1 is estimated to require less time to build than MC1 because it is less subject to construction windows required by environmental concerns.
- MC1 is an on-stream dam and would be constrained by construction windows which limit when work can happen in the river.
- There is a greater risk of cost increases associated with MC1 because of the complex engineering required, the on-stream nature of the dam, the comparatively limited access to the site, and the more difficult geology.
- The approval process for MC1 has a higher risk of delays to address mitigation of environmental impacts, and it is possible that the project could not receive approval at all.
- The MC1 site is less accessible and more remote than the SR1 site making on-site response to emergencies more challenging.
- Potential debris flows during a flood are more likely at MC1 and could threaten the structure.

SOCIAL AND RECREATIONAL VALUE

- MC1 would have a direct negative impact on the recreational and social values of the region.
- AMEC notes that "current users appear to place a high social value on the area in its present state".[3]
- The area is the single access point for one of the most heavily used recreational areas in Kananaskis Country with an estimated half a million visitors annually.
- This area includes the primary access to the McLean Creek Off-Highway Vehicle Zone, Moose Mountain Downhill Biking and secondary access to the West Bragg Creek trails, the Elbow River camping and trailhead facilities, and numerous sight-seeing and day use facilities such as "Elbow Falls".
- Other outdoor recreational opportunities and experiences include cross-country skiing, snowshoeing, hiking, camping, equestrian riding, off-highway vehicle (OHV) use, backpacking, rafting, fishing, hunting, canoeing, kayaking, and paddle boarding.
- The recreation sites and parks in the Elbow Valley that are directly affected by the MC1 proposal are:
    - Gooseberry Public Recreation Area (PRA), including the campground (83 sites) and Elbow Visitor Centre;
    - McLean Creek PRA and OHV Zone, including day use, campground (170 sites), and concession;
    - Elbow River PRA, including Allen Bill day use, River Cove Group Camp, Paddy's Flats Campground (98 sites) and Group Camp, Station Flats Staging Area, and Elbow Ranger Station.
- There were 17 special events permitted in the Elbow Valley parks this year from May 1, 2015 to October 15, 2015.
- SR1 affects grazing areas and ranch lands for a small number of Albertans. This will have an impact as these are legacy ranching families with a strong stewardship ethic.

COMMERCIAL AND TOURISM VALUES

- From commercial and tourism valuation perspective, SR1 is the preferred project.
- The McLean Creek access point is one of the main arteries into the recreational area.
- In 2014, there were 107 Commercial Guiding and Outfitting Permits representing over 40 different commercial companies involved in over 20 different activities.

CONSTRUCTION COST ESTIMATES

- SR1 is the preferred project because it is less expensive and therefore has a more favourable benefit/cost ratio.
- The cost referred to in the Deltares report says it includes funding for mitigation in Bragg Creek and Redwood Meadows, but it doesn't include the latest cost estimates required to provide the necessary level of flood protection.
- The actual amount for the project (earmarked for SR1 plus upstream mitigation) is $297 million. This figure remains cheaper than MC1 and provides protection against the same level of cost damage. Therefore, SR1 still provides the better benefit/cost ratio.
- The initial cost estimates are susceptible to change but the cost-escalation risk for MC1 is higher than for SR1.
- Deltares recommended that compensating landowners after flood events should be considered because it could be less costly than buying the land.

CONSTRUCTION TIMELINES

- It is expected that SR1 will take less time to construct than MC1.
- AMEC notes that "Special measures would be required for winter construction, including heating and hoarding for concrete, and continuous 24-hour per day earthfill operations" should rapid, year-round construction proceed. Such measures would also affect the cost of construction.[4]
- An additional concern with respect to the construction time of the MC1 project is the uncertainty around identified zones of "moderate and high archaeological potential". Projects unable to avoid damage to historical resources require an "extended regulatory timeline … including restrictions on winter fieldwork".[5]
- Approval for environmental impacts will likely take longer for MC1 than SR1.
- With reference to MC1, AMEC notes that "The EIA process (preparation and review), combined with the NRCB process … could take between 2 to 5+ years for these types of projects. Some projects have taken longer."[6] Note that this time would be in addition to the time required for construction.

CONCLUSION

- Deltares agreed with previous assessments that SR1, combined with local mitigation at Bragg Creek and Redwood Meadows, was less expensive, more environmentally-friendly, could be delivered on a shorter timeline, and presented less risk during construction than MC1.

- There is also a clear recognition that SR1 would capture a storm surge that entered a much wider area of the basin, offering better protection for the City of Calgary over the long term.
- The off-stream design for SR1 better handles sedimentation and is more cost effective.
- The complexity and remote location of MC1 comes with an inherently higher risk of escalating construction costs. Deltares highlighted the potential risk of a major flood event during the construction phase.
- Overall, the assessment and scoring for SR1 are considerably more favourable than for the proposed MC1. When social and recreation values enter into the equation the evidence is overwhelmingly in favour of the social good created by the SR1 project from a cost, environmental, and risk basis.

REFERENCES

1. *Review of Bragg Creek / Springbank Off-stream Storage and McLean Creek Flood Storage*, Deltares (p.1, 2015)
2. *Review of Bragg Creek / Springbank Off-stream Storage and McLean Creek Flood Storage*, Deltares (p.3, 2015)
3. *Environmental Overview of McLean Creek Dry Dam*, AMEC (p.ii, 2015)
4. *Southern Alberta Flood Recovery Task Force Flood Mitigation Measures for the Bow River, Elbow River and Oldman River Basins*, AMEC (Appendix F, p.25, 2014)
5. *Environmental Overview of McLean Creek Dry Dam,* AMEC (p.ii, 2015)
6. *Environmental Overview of McLean Creek Dry Dam,* AMEC(p.156, 2015)

4. AT ECO Plan Framework

The City of Calgary • Alberta Transportation • The City of Edmonton

Environmental Construction Operations (ECO) Plan Framework

2017 EDITION

In partnership with

Calgary

Alberta Government

Edmonton

PUBLISHING INFORMATION

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ADDITIONAL COPIES:	To download a free electronic copy: Alberta Transportation www.transportation.alberta.ca The City of Calgary www.calgary.ca The City of Edmonton www.edmonton.ca

Table of Contents

Environmental Construction Operations (ECO) Plan Checklist

Project Name: ______________________________

Contractor's On-Site Representative(s) (Name & Company): ______________________________

ECO Plan submitted to (Name & Jurisdiction): ______________________________

Note: All checklist items are required in the ECO Plan. Explain any deficiencies in the comments section on page b.
Ensure that this three-page checklist is signed and submitted with the ECO Plan.

ECO Plan Framework Step	Content Requirements	YES	NO	N/A
STEP 1: Project Description				
1.1 Project Overview	Briefly describe the construction project and its location.	☐	☐	☐
1.2 Site Activities	Detail the scope of work. List all construction and demolition activities and specify the main equipment that will be used during those activities.	☐	☐	☐
1.3 Project Schedule	Provide a project schedule that includes scheduled shut-downs and restricted work periods due to environmental requirements.	☐	☐	☐
STEP 2: Project Setting & Site Drawing(s)				
2.1 Site Characteristics	Describe the existing condition of the project site.	☐	☐	☐
2.2 Environmental Sensitivities	Describe site-specific sensitive features that could be impacted by the Contractor's activities.	☐	☐	☐
2.3 Site Drawing(s)	Provide site drawing(s) that detail the site location, set-up and layout; erosion and sediment controls; and, environmental sensitivities.	☐	☐	☐
STEP 3: Potential Environmental Impacts & Controls				
3.1 Permits, Approvals, Authorizations & Notifications	Append copies of all project permits, approvals, authorizations and notifications (and their associated applications, when referenced in the approval) to the ECO Plan, and list their file names, numbers and environmental conditions and/or restrictions in a table like Table 3-1.	☐	☐	☐
3.2 Regulatory Compliance	Describe specific regulatory requirements (additional to those listed in Step 3.1) as well as corporate policy and/or program requirements that directly impact or restrict the construction project.	☐	☐	☐
3.3 Potential Environmental Impacts & Mitigation Strategies	Identify all potential project-specific environmental issues and impacts.	☐	☐	☐
	Describe procedures, controls or best management practices (BMPs) that will be used to prevent or reduce adverse environmental impacts.	☐	☐	☐
3.4 Erosion & Sediment Control	Provide project-specific, jurisdiction-appropriate erosion and sediment controls.	☐	☐	☐
3.5 Municipal Tree Protection	Provide project-specific, jurisdiction-appropriate municipal tree protection measures.	☐	☐	☐

ECO Plan Framework Step	Content Requirements	YES	NO	N/A
STEP 4: Hazardous Materials & Waste Management				
4.1 Hazardous Materials	List every hazardous material to be used or stored on site by the Contractor and all sub-contractors, and provide appropriate handling, containment, storage and disposal methods.	☐	☐	☐
4.2 Waste Management	List all anticipated hazardous and non-hazardous waste materials along with proper handling and disposal methods. Provide all additional jurisdiction-specific handling procedures.	☐ ☐	☐ ☐	☐ ☐
STEP 5: ECO Plan Implementation				
5.1 On-Site Representative	Provide name(s) and contact details for the Contractor's On-Site Representative(s).	☐	☐	☐
5.2 Training & Communication	Detail the procedures that will be used to train staff and sub-contractors in their ECO Plan responsibilities.	☐	☐	☐
5.3 Monitoring & Reporting	Describe monitoring and inspection procedures that suit the nature and scale of the project and meet regulatory and contractual requirements.	☐	☐	☐
5.4 Documentation	Describe the environmental information and ECO Plan records that will be kept in up-to-date hard copies on the project site.	☐	☐	☐
5.5 ECO Plan Update	Provide ECO Plan review and update procedures. Append a current ECO Plan Revision Summary table (e.g., Table 5-3) to all updated ECO Plans.	☐ ☐	☐ ☐	☐ ☐
STEP 6: Environmental Emergency Procedures				
6.1 Environmental Emergency Prevention & Response	Identify potential incidents that may impact the environment, and provide appropriate prevention and response procedures. In addition, provide an environmental emergency response contact list.	☐	☐	☐

Comments ***(include relevant special provisions and/or conditions for the project, and explain any deficiencies in the ECO Plan):***

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Contractor Responsibilities

All Contractors need to be aware of their responsibilities for protecting the environment. The Contractor is responsible, either by its own actions or through its sub-contractors, for providing the resources needed to develop and implement the ECO Plan. The Contractor is responsible for ensuring sub-contractors understand their roles and responsibilities, and operate in compliance with the ECO Plan.

Contractors must refer to the terms and conditions contained in applicable contractual and regulatory documents to be fully aware of their responsibilities. In general, Contractors must:

a)	Identify the potential environmental issues and develop environmental mitigation measures to prevent or minimize environmental impacts.
b)	Identify and acknowledge permits, approvals, authorizations, notifications, guidelines, standards, policies and programs applicable to the project.
c)	Prepare and update the ECO Plan in accordance with this ECO Plan Framework.
d)	Submit copies of the ECO Plan and all other required documentation to the consultant for Alberta Transportation projects or The City Project Manager for municipal projects.
e)	Revise the ECO Plan as required based on reviewer (i.e., The City of Calgary, The City of Edmonton or the consultant for Alberta Transportation projects) comments.
f)	Identify an on-site individual to be the Contractor's On-Site Representative to maintain environmental controls and address any environmental issues or questions that arise. The Contractor must identify this individual within the ECO Plan (see page a of the ECO Plan Checklist and Step 5.1) and at the pre-construction meeting.
g)	Train staff and sub-contractors so they can identify, address and report potential environmental problems.
h)	Review the ECO Plan requirements at orientation meetings, the pre-construction meeting, tailgate meetings, etc.
i)	Implement and maintain environmental mitigation measures in accordance with the ECO Plan.
j)	Correct and record any deficiencies in a timely and appropriate manner.
k)	Take corrective action (e.g., shut down work) when it is recognized that an impact to the environment may occur or has occurred.
l)	Ensure that all sub-contractors comply with the ECO Plan.
m)	Sufficiently monitor the work site to ensure that the ECO Plan is effective for all conditions, including inclement weather and shut-down periods. Document all monitoring efforts.

This ECO Plan is complete to the best of our abilities. The undersigned acknowledges and accepts the responsibilities detailed herein.

Contractor Principal-in-Charge Signature	Name (please print)	Date

Introduction

The Environmental Construction Operations (ECO) Plan Framework guides the development of ECO Plans for Alberta Transportation, The City of Calgary and The City of Edmonton. ECO Plans ensure the following:

- environmental considerations are integrated into project decision making
- the project is compliant with applicable regulations, bylaws and guidelines
- all parties demonstrate environmental commitment, both in writing and in action, to their stakeholders and the public

ECO Plan Definition

An ECO Plan is a project-specific plan that identifies and mitigates the potential environmental impacts of construction. Contractors are responsible for developing and implementing ECO Plans for their projects. ECO Plans cover the following topics:

- project setting, activities and schedule
- applicable permits, approvals and regulations
- potential environmental impacts and controls
- hazardous materials and waste management
- ECO Plan implementation procedures
- environmental emergency response procedures

DEFINITION: Environmental Construction Operations (ECO) Plan
An ECO Plan is a Contractor's plan to identify and mitigate the environmental impacts that may result from their activities.

ECO Plan Process

It is the Contractor's responsibility to develop and implement an ECO Plan. ECO Plans may be required by Alberta Transportation, The City of Edmonton or The City of Calgary in the contract/tender documents.

Project-specific ECO Plans must follow this Framework, and adopt the headings and structure provided here. The ECO Plan checklist (pages a-c) must be completed and included with the ECO Plan; it should be used to ensure that the ECO Plan is complete. The ECO Plan Checklist must identify an On-Site Representative and be signed by the Contractor Principal-in-Charge.

The ECO Plan must include a completed ECO Plan checklist. This checklist must identify an On-Site Representative and be signed by the Contractor Principal-in-Charge.

Contractors must submit their ECO Plans to the appropriate jurisdiction at least 14 days prior to the scheduled start of construction. The reviewer will evaluate the ECO Plan, and one of the following will result:

1. **Acceptance** — If the ECO Plan is accepted to the mutual satisfaction of the Contractor and the reviewer (i.e., reviewers include The City of Calgary, The City of Edmonton or the consultant for Alberta Transportation projects), the Contractor will be advised in writing that the ECO Plan is complete.

2. **Follow-up or Revision** — If the reviewer identifies deficiencies or has questions, they will follow up with the Contractor. Incomplete ECO Plans will be returned to the Contractor for revision. ECO Plans must be completed to the mutual satisfaction of all parties. All changes to the ECO Plan must be documented (see Step 5.5; include a revision summary table such as Table 5-3) and copies of the updated ECO Plan forwarded to the reviewer and other parties, as applicable.

No work may begin until all parties have agreed to the ECO Plan.

The Contractor must submit the ECO Plan to the appropriate jurisdiction at least fourteen (14) days prior to the scheduled start of construction.

No work may begin until all parties have agreed to the ECO Plan.

ECO Plan Instructions

This Framework provides instructions for developing ECO Plans for Alberta Transportation, The City of Edmonton and The City of Calgary. All ECO Plans must follow this Framework, and adopt the headings and structure provided here.

ECO Plans must present organized, summarized information. When a document is well organized, the information is easy to use. All parties must use and understand the ECO Plan to successfully identify and mitigate the potential environmental impacts of the project.

The following sections describe the six components of an ECO Plan.

***This document guides project-specific ECO Plan development.
Boxes (like this one) are located at the start of each section, and contain specific summaries of what is required in that section.***

ECO Plan Template

The goal of Alberta Transportation, The City of Edmonton and The City of Calgary is to have quality, organized ECO Plans that describe the project, its potential effects and its mitigation and control measures. These ECO Plans are easily reviewed, understood and implemented by all parties. Unfortunately, many poor quality or incomplete ECO Plans are submitted, placing substantial burdens on the review process.

To address this challenge, Alberta Transportation, The City of Edmonton and The City of Calgary are developing a new, standardized format for ECO Plans. They have produced a draft ECO Plan template; this draft is available for use on a trial basis in the 2017 calendar year (ECO Plan Template; Internet Explorer required). The Province and Cities encourage all Contractors developing ECO Plans to try the template and submit feedback to ECOPlan@calgary.ca.

Step 1 Project Description

STEP 1		
	1.1 Project Overview	Briefly describe the construction project and its location.
	1.2 Site Activities	Detail the scope of work. List all construction and demolition activities and specify the main equipment that will be used during those activities.
	1.3 Project Schedule	Provide a construction project schedule that includes scheduled shut-downs and restricted work periods due to environmental requirements.

1.1 Project Overview

Briefly describe the construction project and its location.

In this section, briefly describe the nature and location of the construction project. The project description must include the following:

- type of project
- name and location of the project (including legal land description and municipal address, if applicable)
- site size
- details of the main components of the project, including any permanent and temporary structures

1.2 Site Activities

Provide a detailed scope of work. List the construction and demolition activities that will occur during the project and specify the main equipment that will be used during those activities.

In this section, provide the scope of work and list all construction and demolition activities (e.g., earthworks, surfacing, saw cutting, stream crossings) that will occur during the project. It is particularly important for the ECO Plan to describe specific on-site construction activities that could result in environmental impacts.

Construction projects use many different types of equipment. The Contractor will provide a project-specific list of the equipment that will be used during the construction and demolition activities. Some examples of equipment that could be included are as follows:

- General construction and demolition (e.g., personal hand tools, pumps, generators)
- Trucking and hauling (e.g., pickup trucks, delivery trucks, pump trucks)
- Earthmoving (e.g., excavators, graders, loaders, backhoes, bobcats, dump trucks)
- Lifting and material handling (e.g., mobile cranes, man lifts)
- Paving and compacting (e.g., asphalt pavers, drum compactors)
- Concrete handling (e.g., saw cutting equipment, concrete trucks)
- Drilling and trenching (e.g., directional drills, trenchers, hydrovac trucks)

1.3 Project Schedule

Provide a construction project schedule that includes scheduled shut-downs and restricted work periods due to environmental requirements.

The ECO Plan will include a project schedule that presents the sequence and timing of construction activities. It will identify any time-sensitive environmental considerations, including scheduled shut-downs and restricted work periods. For example, in-stream work may be restricted to the times outlined within federal and provincial regulatory approvals.

Step 2 Project Setting & Site Drawing(s)

STEP 2		
	2.1 Site Characteristics	Describe the existing condition of the project site.
	2.2 Environmental Sensitivities	Describe the site-specific or protected features that could be impacted by the Contractor's activities.
	2.3 Site Drawing(s)	Provide site drawing(s) that illustrate the site location; site set-up and layout; jurisdiction-appropriate erosion and sediment controls; and, environmental sensitivities.

2.1 Site Characteristics

Describe the existing condition of the project site.

In this section, describe the project site's topography, drainage and storm water infrastructure. It is helpful to include site photographs in this section.

2.2 Environmental Sensitivities

Describe site-specific sensitive or protected features that could be impacted by the Contractor's activities.

The Contractor must pre-screen the project site for environmental sensitivities and concerns. To pre-screen the site, review the contract documents and all applicable environmental information and reports, such as the following:

- Biophysical Impact Assessment
- Environmental Evaluation
- Historical Resources Impact Assessment
- Phase I and/or II Environmental Site Assessment
- Risk Management Plan

In this section, describe the sensitive or protected features that could be impacted by the Contractor's activities. This description must include source references, be specific to the project site, and highlight features that require protection such as:

- wildlife and wildlife habitat (consider both terrestrial and aquatic animals)
- waterbodies (e.g., wetlands, streams, creeks)
- vegetation (e.g., trees, rare plants, noxious weeds)
- archaeological, paleontological and/or other historical resources
- parks, protected areas and other designated lands
- site contamination and/or underground infrastructure (e.g., monitoring wells, pipelines)

Show all environmental sensitivities and protected features on the site drawing(s) (see Step 2.3).

2.3 Site Drawing(s)

Provide one or more site drawing(s).

In this section, provide site drawing(s) of appropriate scale showing:

- project location
- site set-up and layout
- erosion and sediment controls (as appropriate for the jurisdiction; see Step 3.4 and Table 3-4 for more details)
- environmental sensitivities (see Steps 2.2, 3.1–3.3 and 3.5 for more details)

The site drawing should contain standard map features (e.g., north arrow, scale, legend) and be at an appropriate scale to show the location of the project components and activities relative to existing features. Table 2-1 summarizes some additional details that may be relevant to include on the site drawing(s).

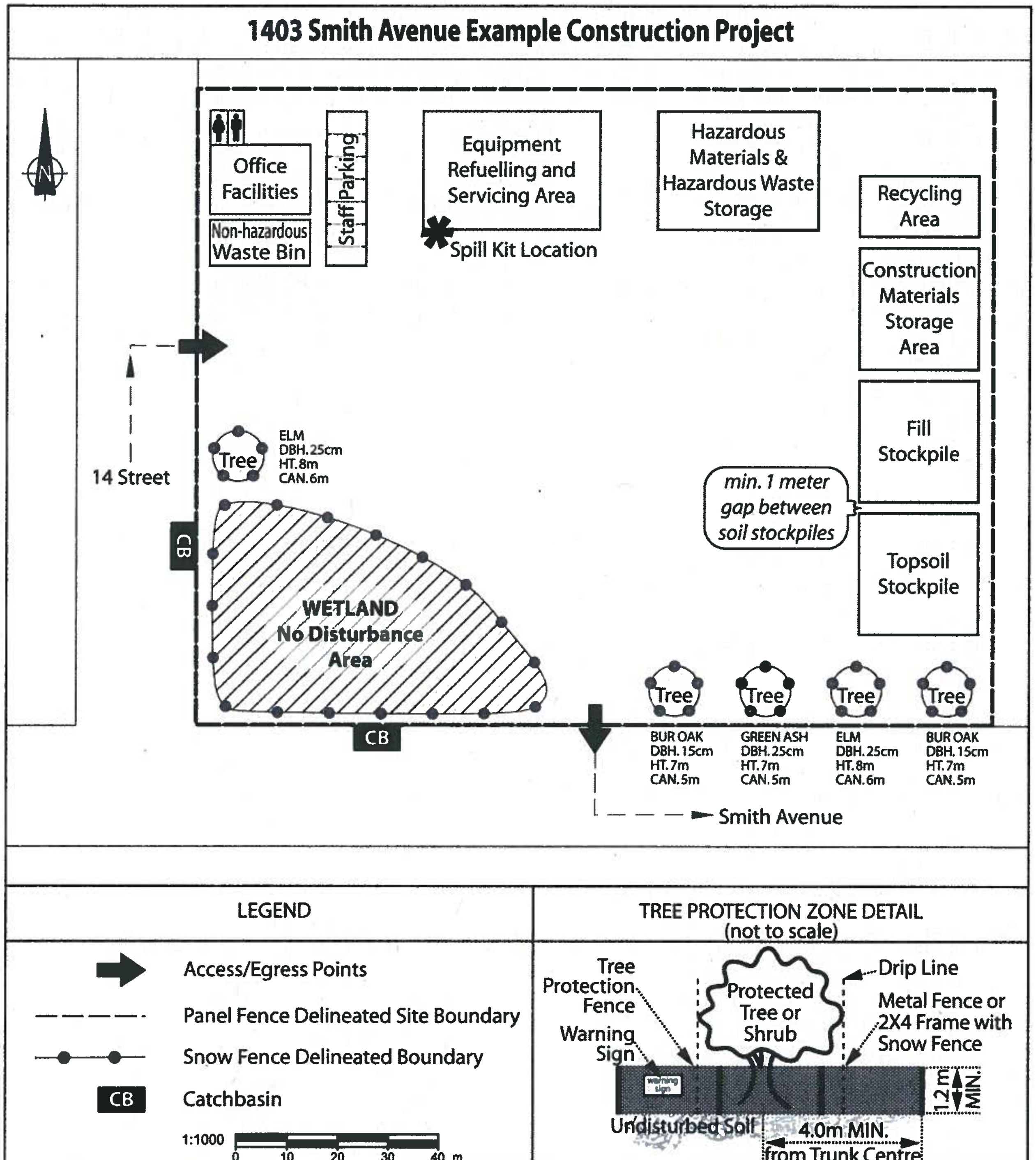
Table 2-1 Example: Potential Details to include on the Site Drawing(s)

Site Location	Site Set-up and Layout	Erosion and Sediment Controls	Environmental Sensitivities
• Site location (e.g., municipal address; legal land description) • Site size • Project boundaries • Municipal boundaries, historic sites, protected areas (e.g., parks), federal land • Linear and other transportation components (e.g., railways, roads)	• Access/egress points • Traffic routes • Temporary parking • Office • Toilets • Staging areas • Borrow areas • Stockpile locations • Refuelling areas • Recycling areas • Spill kits • Hazardous materials storage • Hazardous and non-hazardous waste storage	• Project-specific erosion and sediment controls as appropriate for the jurisdiction (see Step 3.4 and Table 3-4 for more details) • Storm water infrastructure	• Environmentally sensitive areas (e.g., wildlife and wildlife habitat; waterbodies such as wetlands, streams and creeks; vegetation such as trees and rare plants) • Buffers around sensitive areas • Trees to be protected (and the specific tree protection measures as appropriate for the jurisdiction; see Step 3.5 and Table 3-5 for more details) • Storm water discharge points • Monitoring wells • Contamination

Annotated photographs can be included in this section. Super-imposing construction site set-up and operational details on aerial photographs of appropriate scale and nature is particularly informative.

See the sample site drawing on the following page.

Sample Site Drawing



NOTE

1. A minimum 1 meter gap shall be maintained between soil stockpiles unless a larger gap is specified in legislation that applies to your site.

Step 3 Potential Environmental Impacts & Controls

STEP 3		
	3.1 Permits, Approvals, Authorizations & Notifications	Compile the file name, number and environmental conditions and/or restrictions of all required project permits, approvals, authorizations and notifications. Append copies of all project permits, approvals, authorizations and notifications (and their applications, when referenced in the approval) to the ECO Plan.
	3.2 Regulatory Compliance	Describe regulatory, corporate policy and program requirements (additional to those listed in Step 3.1) that directly impact or restrict the construction project.
	3.3 Potential Environmental Impacts & Mitigation Strategies	Describe the potential environmental issues and impacts that may result from the construction activities. Provide procedures, controls or best management practices (BMPs) to prevent or reduce adverse impacts on the environment.
	3.4 Erosion & Sediment Control	Provide project-specific, jurisdiction-appropriate erosion and sediment controls.
	3.5 Municipal Tree Protection	Provide project-specific, jurisdiction-appropriate municipal tree protection measures.

3.1 Permits, Approvals, Authorizations & Notifications

In this section, list the file name and number of all required project permits, approvals, authorizations and notifications. Compile all of the environmental conditions and restrictions prescribed by regulatory agencies in those documents into a summary table.

Append copies of all project permits, approvals, authorizations and notifications (and the associated permit applications, when referenced in the approval) to the ECO Plan.

Provide the file number and title of all required project permits, approvals, authorizations and notifications and compile the environmental conditions and/or restrictions prescribed in those documents into a summary table (e.g., Table 3-1). If the approval references the permit application, also include the environmental conditions and/or restrictions described in that application in the summary table.

Append copies of all project permits, approvals, authorizations and notifications (as well as the associated permit applications, when relevant) to the ECO Plan.

The tender package will include many of the approvals. These approvals, along with any additional approvals needed for the project, must be identified in this section of the ECO Plan.

The Contractor, their staff and all sub-contractors must understand the current environmental legislation that governs their project as well as the environmental conditions and/or restrictions prescribed in permit conditions, approvals, authorizations and notifications.

Retain copies of project permits, approvals, authorizations and notifications (as well as the permit applications, when relevant) on site during all activities. Regulators may make site visits and inspections prior to, during and following construction.

Table 3-1 Example: Project Permits, Approvals, Authorizations & Notifications

Example Project Permit, Approval, Authorization or Notification File Number and Title	Construction Activity	Example Environmental Conditions and/or Mitigation Measure(s) *(as detailed in the permit, approval, authorization or notification OR its application)*
Fisheries & Oceans Canada Authorization CA-10-1249 Watercourse Crossings and Replacements — Tributary to Elbow River — Calgary	All	No in-stream work occurs May 1–July 15 and Sept 16–April 5
		Operate machinery on land in a manner that minimizes disturbance to the bed and banks of the watercourse
	Isolation and dewatering	Remove fish from the work area prior to dewatering and release alive immediately into a downstream staging area
	etc.	etc.
Alberta Environment & Parks Authorization 37/801 to Construct the Access Road Tie-in to the Canal Pathway with the WHS Right-of-Way	All	Within the canal ROW, minimize disturbance; no equipment is allowed outside the prescribed work area.
		Surface disturbance within the Department's canal ROW is permitted only during dry and/or frozen ground conditions.
		etc.
Notification under the Code of Practice for Watercourse Crossings (City of Calgary file number 2017WAXP712)	Post-Construction	The crossing site will be inspected at least once a year, during the snow-free season.
		A qualified aquatic environment specialist will design and conduct all monitoring.
		etc.
City of Calgary Drainage Permit HPZ0079	Site dewatering	The Permit Holder will notify The City of Calgary and all other required agencies if the results of water quality tests exceed specified limits.
		etc.

3.2 Regulatory Compliance

Describe specific regulatory requirements (additional to those covered in Step 3.1) as well as corporate policy and/or program requirements that directly impact or restrict the construction project.

The Contractor, their staff and all sub-contractors must understand and comply with all applicable regulatory requirements. In this section, describe specific regulatory requirements (other than permits, approvals, authorizations and notifications) as well as corporate policy and/or program requirements that directly impact or restrict this particular construction project (e.g., Table 3-2).

Table 3-2 Example: Project Regulatory Requirements (other than permits, approvals, authorizations and notifications)

Legislation	Construction Activity	Environmental Conditions
***Migratory Birds Convention Act* and its regulations**	All	Avoid engaging in potentially destructive or disruptive activities in key sensitive periods and locations, in order to reduce the risk of affecting migratory birds, their nests or eggs. Key sensitive periods include breeding and nesting (generally mid-March to late August in most parts of Canada), spring migration and fall migration. To determine the requirements for a specific project, consult with the Canadian Wildlife Service and provincial wildlife agencies.
		etc.
Alberta *Weed Control Act* and its regulations	All	A person shall control noxious weeds and destroy prohibited noxious weeds that are on land the person owns or occupies.
		Subject to the regulations, a person shall not use or move anything that, if used or moved, might spread a noxious weed or prohibited noxious weed.
		etc.
City of Calgary Community Standards Bylaw 5M2004		A Person shall not engage in any activity that is likely to allow smoke, dust or other airborne matter ... to escape the Premises without taking reasonable precautions to ensure that the smoke, dust or other airborne matter does not escape the Premises.
		etc.
City of Edmonton Corporate Tree Management Policy C456A	All	Contractors are responsible for the regular watering and maintenance of City trees while enclosed by tree protection hoarding.
		All equipment, soil, building materials and other debris shall be kept outside of the tree protection hoarding.
		etc.

3.3 Potential Environmental Impacts & Mitigation Strategies

In this section, describe the potential environmental issues and impacts that may result from the construction activities. Then summarize the procedures, controls and best management practices (BMPs) that this project will use to prevent or reduce adverse impacts on the environment.

An environmental impact is any change to the environment (positive or negative) resulting from the construction activities. For the purposes of the ECO Plan, negative impacts are the primary concern.

The Contractor should focus on the environmental impacts over which they have reasonable control. These potential issues and impacts will form the basis of the project-specific ECO Plan.

The review process for potential issues and impacts should consider normal operating conditions; shut-down and start-up conditions; and, any reasonably foreseeable emergency or abnormal situations. Further, ensure the review considers:

- potential releases of emissions to air (e.g., dust)
- potential releases to land (e.g., spills), surface water and groundwater
- potential to harm habitat or regulated species
- noise and light issues
- site waste management

Taking into account the environmental sensitivities, construction activities and regulatory requirements discussed in the previous sections, as well as any new sensitivities described in this section, provide a comprehensive summary of all the procedures, controls or best management practices that will be used to prevent or reduce adverse impacts on the environment.

Mitigation measures must be developed based on the Contractor's own site information, with reference to the consultant's Risk Assessment (for Alberta Transportation projects), and any relevant conditions contained within permits, approvals, authorizations and/or notifications. Include mitigation measures contained in the contract, including Standard General Conditions or Standard Specifications as applicable. Table 3-3 provides one method of summarizing potential environmental impacts and mitigation measures.

Table 3-3 Example: Potential Environmental Impacts and Mitigation Measures

Construction Activity	Potential Environmental Impact(s)	Environmental Mitigation Measure(s)
Earthworks	Erosion and compaction of soils Transport of sediment and associated contaminants by water and wind Sedimentation in infrastructure and waterbodies Loss of vegetation Damage to trees	Minimize the area of exposed soil by phasing stripping and grading work and/or ensuring timely implementation of suitable temporary or permanent soil stabilization measures Implement, inspect and maintain erosion and sediment controls Ensure traffic travels along pre-defined routes and within the confines of the working easements Install fencing around the drip lines of trees to protect the trees from vehicles and equipment
Refuelling and servicing of equipment	Hydrocarbon spills	Ensure spill kits are on all vehicles and workers are trained in their use Designate refuelling areas appropriate distances from waterbodies
Ground Disturbance	Unexpected discovery of historic contamination	Ensure that workers are trained to recognize the signs of possible contamination (e.g., drums and containers; stained or discoloured earth in contrast with adjoining soil) and immediately report them to the appropriate regulatory authorities
In-stream activity	Release of hydraulic fluid	Machinery for in-stream use will utilize vegetable-based hydraulic oil
Site Maintenance	Disturbance of vegetation Establishment of weed species	Equipment moving from areas with non-native species onto natural areas must be clean and free of weeds Weed control will occur during active construction Disturbed areas will be immediately re-seeded and/or re-vegetated with approved species

3.4 Erosion & Sediment Control

Provide project-specific erosion and sediment controls that are appropriate for the jurisdiction.

Alberta Transportation, and The Cities of Calgary and Edmonton require Erosion and Sediment Control Reports and Drawings on construction projects; however, each jurisdiction has its own specific requirements (see Table 3-4).

Erosion and sedimentation are significant environmental concerns on construction projects. The Contractor must implement, inspect and maintain appropriate erosion and sediment control measures for the contract term.

Table 3-4 Erosion and Sediment Control Requirements by Jurisdiction

Alberta Transportation and The City of Edmonton Requirements
In the ECO Plan, descriptions and drawings of erosion and sediment control are required. Items that should be in the ECO Plan include but are not limited to: • Text demonstrating the use of appropriate methods and materials and a corresponding drawing indicating the locations of erosion and sediment control near waterbodies. Erosion and sediment control measures should be included on the site drawing (Step 2.3). • Documentation that shall be utilized by appointed staff for the monitoring of sediment and erosion control for the project site. The Contractor must ensure erosion and sediment control devices are in place and maintained during the contract term. For Alberta Transportation projects refer to the *Alberta Transportation Erosion and Sediment Control Manual* (available at www.transportation.alberta.ca). For City of Edmonton projects, refer to *The City of Edmonton Erosion and Sedimentation Control Guidelines* (available at www.edmonton.ca) for specific guidance.
The City of Calgary Requirements
City of Calgary projects that require an ECO Plan also require a separate Erosion and Sediment Control Report and/or Drawing(s) to be developed. The documents are to be reviewed, signed and stamped by a professional with experience in the design and implementation of erosion and sediment control who is a professional engineer (P.Eng.), professional licensee (P.L.(Eng.)) or professional agrologist (P.Ag.), or who holds a designation as a Certified Professional in Erosion and Sediment Control. In the ECO Plan, indicate whether an Erosion and Sediment Control Report and/or Drawing was developed for the project. Include a complete citation for all Reports and Drawings submitted (i.e., Author, Full Title, Publication Date, Date submitted to The City of Calgary, the Business Unit [and contact person] that the Report and/or Drawing was submitted to, and the mode used to transmit the documents [e.g., email, fax, registered mail]). The ECO Plan and the separate Erosion and Sediment Control Report and/or Drawing(s) must be submitted together to The City of Calgary Project Manager. The City of Calgary Environmental & Safety Management will review the ECO Plan, and The City of Calgary Water Resources will review the Erosion and Sediment Control Report and/or Drawing(s). For more information on submission requirements, refer to the current edition of *The City of Calgary Guidelines for Erosion and Sediment Control* (available at www.calgary.ca) or contact The City of Calgary Water Resources — Erosion and Sediment Control by phone at 3-1-1 (local Calgary calls only) or (403) 268-CITY (for callers outside Calgary). The ECO Plan does not replace an Erosion and Sediment Control Report and/or Drawing(s).

3.5 Municipal Tree Protection

Provide project-specific municipal tree protection measures that are appropriate for the jurisdiction.

Construction work on, near or crossing City property can damage City-owned trees. Ninety-nine percent of a tree's roots are found within one meter of the soil surface and processes like moving heavy equipment near trees, changing the soil structure, paving over roots, breaking branches, scraping bark and excavating in the root zone can damage and even kill trees.

The Cities of Calgary and Edmonton both have municipal tree protection standards for construction projects; Table 3-5 summarizes their specific requirements.

Tree Protection Plans outline how construction work will be accomplished while protecting public trees. Tree Protection Plans are required for any development involving the following: excavation, storage of construction materials, or access routes for people and/or equipment within a certain distance of a City-owned tree. The Contractor must develop Tree Protection Plans, when needed, for their projects, and ensure that tree protection measures are in place and maintained during the contract term.

Please note that Tree Protection Plans are intended to protect only the trees themselves; trees with specific wildlife values (e.g., nesting or fledging birds, riparian habitat) may have additional regulatory requirements that apply to the project.

Table 3-5 Tree Protection Requirements by Municipal Jurisdiction

The City of Edmonton Requirements
Prior to the start of construction, City of Edmonton urban foresters must be notified of any construction work planned within five meters of a City-owned tree. City of Edmonton tree protection is mandated by the Corporate Tree Management Policy C456A and the Community Standards Bylaw 14600.
In the ECO Plan, include a copy of the Tree Protection Plan developed for the project and summarize the required tree protection measures. The location of all City trees and associated tree protection measures should be included on the ECO Plan site drawing (Step 2.3).
The City of Edmonton urban foresters will work with you to develop tree protection solutions and to reduce potential damage costs to your project. For more information or to inquire about tree ownership, call 3-1-1 (in Edmonton) or (780) 442-5311 (outside Edmonton), or email citytrees@edmonton.ca.

Table 3-5 Tree Protection Requirements by Jurisdiction (*cont'd*)

The City of Calgary Requirements
City of Calgary projects require a *Tree Protection Plan* and a *Tree Protection Plan Agreement* when construction or construction-related activities are to occur within six meters of a public tree. Public trees, including trees growing in parks, natural areas, boulevards and road right-of-ways, are City of Calgary property. The protection of public trees is mandated by municipal bylaws, including the Tree Protection Bylaw 23M2002 and the Street Bylaw 20M88. In the ECO Plan, indicate whether a Tree Protection Plan is required for the project and summarize the required tree protection measures. Please submit a copy of all Tree Protection Plan(s) and Agreement(s) required by the project and the ECO Plan together to The City of Calgary Project Manager. The City of Calgary Environmental & Safety Management will review the ECO Plan, and The City of Calgary Parks — Urban Forestry will review the Tree Protection Plan(s) and Agreement(s). Note that the location of all City trees and associated tree protection measures should be included on the ECO Plan site drawing (Step 2.3). For more information on Tree Protection Plans or to inquire about tree ownership, contact The City of Calgary Parks — Urban Forestry by phone at 3-1-1 (local Calgary calls only) or (403) 268-CITY (for callers outside Calgary). The ECO Plan does not replace a Tree Protection Plan.

Step 4 Hazardous Materials & Waste Management

STEP 4		
	4.1 Hazardous Materials	List every hazardous material to be used or stored on site by the Contractor and all sub-contractors. Describe specific handling, containment, storage and disposal methods for each hazardous material.
	4.2 Waste Management	List all anticipated hazardous and non-hazardous waste materials along with proper handling and disposal methods. As well, provide all additional jurisdiction-specific handling procedures.

4.1 Hazardous Materials

List every hazardous material to be used or stored on site by the Contractor and all sub-contractors. Describe specific handling, containment, storage and disposal methods for each hazardous material.

Hazardous materials are commonly used on construction sites. In this section, consider all the hazardous materials that will be used in the construction project and by the construction equipment (see Step 1.2). For example, be sure to include hazardous materials that will be required for equipment cleaning, maintenance and operations (e.g., diesel, propane, oil, lubricant, hydraulic fluid, antifreeze) as well as materials required for the project itself (e.g., caulking, paint, solvent, glue, pesticide).

The ECO Plan must identify every hazardous material to be used or stored on site by the Contractor and all sub-contractors, along with material-specific handling, containment, storage and disposal procedures (see example Table 4-1). These procedures must comply with all regulatory requirements; for example, materials must be stored specific distances back from waterbodies and storm sewers. The storage location(s) of hazardous materials must also be marked on the site drawing (Step 2.3).

The Contractor must keep all hazardous waste disposal receipts and manifests and maintain copies on site. The Cities of Edmonton and Calgary have additional hazardous waste management requirements; these are presented in Step 4.2.

Table 4-1 Example: Hazardous Materials and Associated Handling Procedures

Hazardous Material	User	Storage Location	Containment	Handling Procedure	Reuse, Recycling and/or Disposal Method
Diesel	Contractor, sub-contractor	Refuelling station (see Site Drawing, Step 2.3)	Double-walled fuel tank located on impervious tray with capacity to hold 110% of stored liquid volume. Concrete barriers, fire extinguisher and no smoking sign erected.	On-site fuelling will follow best management practice XYZ described in Step 3.3 and provided in Appendix A.	Fuel tank will be reused on subsequent projects.
Lubricating Oil	Contractor	Storage locker in laydown area (see Site Drawing, Step 2.3)	Fire-proof containment locker. All lubricating oil packaging clearly labelled with Contractor's name.	When lubricating oil is used, Contractor will provide secondary containment with capacity to hold 110% of stored liquid volume.	Storage locker(s) will be reused on subsequent projects.

4.2 Waste Management

List all anticipated hazardous and non-hazardous waste materials along with proper handling and disposal methods. Provide all additional jurisdiction-specific handling procedures.

Construction projects generate waste materials; these materials fall into two broad categories, as follows:

- waste generated as part of the contract deliverable (e.g., concrete and wood demolition waste)
- waste generated by the Contactor's activities, such as oil filters, oils, plastic, cardboard, paints, solvents, spill clean-up materials and sewage

The ECO Plan must identify every hazardous and non-hazardous waste product to be produced by the project, and specify its appropriate handling and disposal procedure (see example Table 4-2). These procedures must comply with applicable regulatory requirements. The Contractor must keep all hazardous and non-hazardous waste disposal receipts and manifests. All waste storage locations must be shown on the site drawing (Step 2.3).

Contractors shall reuse or recycle their hazardous and non-hazardous waste materials when possible. The Cities of Calgary and Edmonton have specific additional landfill diversion and recycling requirements (see Table 4-3, next page). When evaluating recycling options, contractors may wish to consult Alberta's Recycling Hotline (www.recyclinghotline.ca; 1-800-463-6326); this tool allows users to match a wide range of waste materials with suitable local recycling depots.

Table 4-2 Example: Waste Material Handling and Disposal Procedures

Waste Material	Handling Procedure	Reuse, Recycling and/or Disposal Method
Non-Hazardous Waste Materials		
Concrete	Break up and put in concrete bin	Recycle (*provide Recycling Company name & location*)
Wood	Stack reusable boards next to supply of new form boards for reuse; recycle clean unusable forms in wood recycling bin	Scraps used for formwork, remaining recycled (*provide Recycling Company name & location*)
Road Asphalt	Truck directly to vendor as asphalt is stripped/removed	Recycle (*provide Recycling Company name & location*)
Drywall	Truck directly to vendor as drywall is removed	Recycle (*provide Recycling Company name & location*)
Paper & Cardboard	Bundle (if needed) and put in covered paper and cardboard recycling bins	Minimize on-site paper use; when needed, print double-sided and black & white (if possible); then Recycle (*provide Recycling Company names & locations*)
Clear Plastic Film	Bundle and put in covered plastic bin	Recycle (*provide Recycling Company name & location*)
Hazardous Waste Materials		
Epoxy	Stockpiled separately	Container returned to distributor
Concrete washout	All washout contained in a designated lined area or in a self-contained concrete washout system	Recycle (*provide Recycling Company name*)

The Cities of Calgary and Edmonton both have additional waste management requirements for construction projects. These are detailed in Table 4-3.

Table 4-3 Waste Management Requirements by Municipal Jurisdiction

The City of Edmonton Requirements
When working for The City of Edmonton, hazardous waste handling procedures must be included in the ECO Plan. Hazardous waste manifest or recycle dockets must be completed and appropriate copies maintained on site or by the generator when disposing hazardous waste or hazardous recyclables. The Contractor must identify all waste streams and disposal methods (i.e., diverted from the landfill, recycled or land-filled). Contractors shall document / recycle / divert materials as per their contractual agreement. Table 4-2 provides an example of how to summarize the project's waste management.
The City of Calgary Requirements
When working for The City of Calgary, the Contractor must identify how waste will be reduced and diverted from the landfill or recycled. At a minimum, the Contractor will recycle cardboard, paper, recyclable wood, drywall, asphalt (both road asphalt and asphalt shingles), concrete, brick and masonry block, scrap metals and clear plastic film (polyethylene) *or* provide written justification for not diverting any of these waste streams. Table 4-2 provides an example of how to summarize this component of project waste management. The City of Calgary is tracking its quantities of re-used, recycled and landfilled waste associated with capital construction projects. The City of Calgary requests that contractors use form TS 5377 (Construction Waste Diversion & Disposal Report; Internet Explorer required) to summarize their waste disposal and diversion activities. Contractors are also required to retain and submit copies of all waste disposal and diversion records (e.g., bills of lading, waybills, weigh slips, waste manifests, tipping receipts, waste disposal receipts) for materials disposed and those recycled or reused. Completed Form TS 5377 together with all associated waste disposal and diversion receipts must be submitted within two weeks of disposal or diversion to the following email: ECOPlan.waste@calgary.ca.

Step 5 ECO Plan Implementation

STEP 5		
	5.1 On-Site Representative	Provide the name(s) and contact details for the Contractor's On-Site Representative(s).
	5.2 Training & Communication	Detail the procedures that will be used to train staff and sub-contractors in their ECO Plan responsibilities.
	5.3 Monitoring & Reporting	Describe monitoring and inspection procedures that suit the nature and scale of the project and meet regulatory and contractual requirements.
	5.4 Documentation	Describe the environmental information and ECO Plan records that will be kept in up-to-date hard copies on the project site.
	5.5 ECO Plan Update	Provide ECO Plan review and update procedures. Append a current ECO Plan Revision Summary table (e.g., Table 5-3) to all updated ECO Plans.

5.1 Contractor's On-Site Representative

Provide the name(s) and contact details for the Contractor's On-Site Representative(s).

The Contractor must identify an on-site individual to be their On-Site Representative; this individual is responsible for maintaining the environmental controls and addressing any environmental issues or questions that arise. The Contractor must identify their On-Site Representative on the ECO Plan Checklist and at the pre-construction meeting.

In this section, provide the name(s) and full contact details for the Contractor's On-Site Representative.

5.2 Training & Communication

Detail the procedures that will be used to train staff and sub-contractors in their ECO Plan responsibilities.

The Contractor must ensure that their workers are aware of applicable environmental legislation and project-specific requirements before construction starts. Anyone on a construction site could negatively impact the environment. To ensure environmental protection, it is essential to train all staff (including sub-contractors) in their specific environmental responsibilities.

ECO Plans must be included as a topic in site orientations, pre-construction meetings and regular site meetings. Minutes of these meetings must be retained and available upon request. Topics for training and awareness sessions may include (but are not limited to) those listed in Table 5-1.

Table 5-1 Potential Topics for ECO Plan Training and Awareness Sessions

ECO Plan Training and Awareness — Potential Topics
ECO Plan Content & On-site Location
ECO Plan Team Roles & Responsibilities
Locations of Environmental Restrictions (e.g., wetlands, rare plants, bird nests, riparian areas)
Requirements of Project Permits, Approvals, Authorizations & Notifications
Regulatory, Policy & Program Compliance Measures
Potential Environmental Impacts, Mitigation Measures & Best Management Practices
Erosion & Sediment Control
Municipal Tree Protection
Hazardous Materials & Waste Management
Monitoring & Reporting Procedures
Environmental Emergency Response Procedures (including locations of spill kits, contact information, etc.)

5.3 Monitoring & Reporting

Provide monitoring and inspection procedures that suit the nature and scale of the project, and that satisfy regulatory and contractual requirements.

The Contractor will develop monitoring and inspection procedures that satisfy the contract terms and conditions and all regulatory requirements. The monitoring and inspection procedures must also be appropriate for the nature and scale of the project, as well as the site characteristics, work activities and potential environmental risks associated with the project.

The Contractor is responsible for understanding and complying with the reporting requirements, and ensuring that all of the environmental controls are working.

The Contractor must include the following project-specific information in this section:

- locations and items to be inspected
- monitoring frequency
- monitoring during scheduled shut-downs
- reporting requirements related to permits, approvals, authorizations and notifications

Deficiencies identified during monitoring activities must be immediately addressed.

5.4 Documentation

Describe the environmental information and ECO Plan records that will be kept in up-to-date hard copies on the project site. These documents must always be available for inspection or review.

A master hard copy of documents relating to the ECO Plan and the project's environmental activities must be retained at the construction site and available for inspection at all times. These documents must be kept current and be available to all personnel. Table 5-2 provides a non-comprehensive list of the types of documents that should be maintained as up-to-date hard copies on the project site.

Table 5-2 Example Types of Documentation to be Retained on the Project Site in Hard Copy

Example — Hard Copy Documentation to be Retained on the Project Site
Current ECO Plan
Current Erosion and Sediment Control Report and/or Drawing(s)
Current Municipal Tree Protection Plan
Regulatory Permits, Approvals, Authorizations and/or Notifications, as well as their applications when relevant (often the application forms part of the approval)
Record of Environmental Incidents (e.g., spill and release records)
Hazardous Materials Inventory
Hazardous and Non-Hazardous Waste Materials Inventory
Completed Environmental Monitoring Records
Site Orientation, Tailgate Meeting and Project Progress Minutes
Construction Equipment Inspection Logs (to ensure that the equipment is inspected before coming on site be certain that the equipment is, for example, weed-free and/or leak-free)
Fuelling Logs
Relevant Memos Relating to Environmental Matters

5.5 ECO Plan Update

In this section, provide ECO Plan review and update procedures; include a list of people who will be contacted when the ECO Plan changes.

If an update to the ECO Plan is required, attach a completed revision summary table (such as Table 5-3) to all subsequent versions of the document.

In this section, provide ECO Plan update procedures; include a circulation list for updated ECO Plans. ECO Plan updates are generally required in two circumstances:

- when an ECO Plan is deficient and returned to the Contractor for revision prior to the start of construction
- when the project, its site conditions and/or its activities change in a way not anticipated in the original ECO Plan

If an ECO Plan is determined to be deficient at the review stage, the Contractor must modify and complete it to the mutual satisfaction of all parties. No work may begin until all parties have agreed to the ECO Plan.

ECO Plans must be updated when the project, its site conditions and/or its activities change in a way not anticipated in the original document. ECO Plans must provide details to continually meet environmental requirements and proactively protect the environment. For example, in the case of an unplanned winter shut-down, the ECO Plan must be revised to include the procedures and environmental protection measures required for the shut-down period.

Once the ECO Plan is updated, the Contractor is responsible for notifying (as appropriate) Alberta Transportation, The City of Calgary and/or The City of Edmonton of the changes prior to implementation. The Contractor shall communicate the changes to employees and relevant sub-contractors, and provide the necessary training before implementing the changes. Modifications to the ECO Plan must provide an equal or better level of avoidance or mitigation.

All changes to the ECO Plan must be documented (include a revision summary table such as Table 5-3). Clearly summarize what the changes are and where they are located in the document, referencing applicable sections, pages, drawings and/or table numbers. This revision summary table should be located at the front of the revised ECO Plan (just after the cover page). Forward the revised ECO Plan to the reviewer (i.e., The City of Calgary, The City of Edmonton or the consultant for Alberta Transportation projects) and other applicable parties.

Table 5-3 Example: ECO Plan Revision Summary Table

Date	ECO Plan Section	Specific Document Reference (Page #, Drawing # or Table #)	Description of Change
25 Jun 2017	2.2	Page 4	Modify Step 2.2 to add "Environmental Site Information Reports (i.e., Phase II ESA, remediation reports)" to the list of documents to be reviewed.
	2.3	Drawing 2-3	Add Spill Kit location to Site Drawing 2-3.
	5.3	Page 25	Modify Table 5-16 to add "Fisheries and Oceans Canada" to the list of regulatory agencies that will be contacted.
28 Aug 2017	6.1	Page 32	In paragraph 5, change the words, "investigate the release", to the words "review details of the release".

Step 6 Environmental Emergency Procedures

STEP 6	6.1 Environmental Emergency Prevention & Response	Identify potential incidents that may impact the environment and provide appropriate prevention and emergency response procedures. Provide a current emergency contact list and describe where it will be posted on site.

6.1 Environmental Emergency Prevention & Response

In this section, identify project-related potential incidents that may impact the environment, and provide details or copies of prevention and emergency response procedures. In addition, provide a current emergency contact list and describe where it will be posted on site.

The ECO Plan must identify potential project-related incidents that may impact the environment. These incidents could be the result of natural events, accidents, human error or improper work practices.

Examples of potential incidents include:

- contaminant spills and releases to land, water and air from fuels, oils, lubricants and chemicals
- discovery of historic contamination
- erosion events of land (e.g., water, wind), watercourses (e.g., bank erosion, flooding), berms and coffer dams

The ECO Plan must provide emergency procedures to prevent and respond to potential incidents that may impact the environment. The emergency response procedures must include:

- training provisions to make Contractor staff and sub-contractors aware of their responsibilities during emergency situations
- a list of equipment and materials available on site including their specific location

- initial response to an emergency, describing the steps to be taken and equipment to be used
- immediate reporting of environmental incidents to appropriate authorities
- post-emergency review, follow-up and improvement of procedures as needed

The Contractor is responsible to ensure that each emergency response procedure reflects the current, specific requirements of the relevant jurisdiction.

At a minimum, each ECO Plan must include contamination discovery and release reporting emergency response procedures. As a City of Edmonton, Alberta Transportation and/or City of Calgary Contractor, you have specific responsibilities associated with the reporting, prevention, control and clean up of spills or releases that you may cause or discover. The immediate reporting of environmental releases and spills is a requirement of provincial and federal environmental legislation.

The ECO Plan must include a current emergency contact list and describe where it will be posted on site. This list must include names and contact details for key personnel and applicable regulatory agencies.

5. AT Environmental Management System

Transportation

ENVIRONMENTAL MANAGEMENT SYSTEM MANUAL (v.14)

Executive Summary

Alberta Transportation's Environmental Management System ("EMS") is an organizational approach to environmental management with the goal of making environmental considerations part of daily activities. The EMS applies to Alberta Transportation employees identified herein, and consultants and contractors contracted by Alberta Transportation (collectively "Service Providers") to build and maintain the province's transportation and water infrastructure facilities.

EMS Chapters

Chapter 1: Introduction to the Environmental Management System – Chapter 1 describes the elements of an EMS, explains the application of the EMS, and sets out the purposes of the EMS Manual.

Chapter 2: Roles and Responsibilities – Roles and responsibilities under the EMS are identified for all levels of personnel (Alberta Transportation employees and Service Providers).

Chapter 3: Regulatory Requirements – Chapter 3 summarizes the federal, provincial and municipal regulatory requirements and current regulatory trends that relate to Alberta Transportation's key environmental activities.

Chapter 4: Environmental Practices and Procedures – This chapter is a reference to all existing departmental environmental practices and procedures, contained in various specifications, tender documents, special provisions, manuals, standards, best management practices and guidelines, and those developed under the EMS.

Chapter 5: Spill Release Reporting Procedures – This chapter outlines release reporting requirements and procedures that apply to all Alberta Transportation staff and Service Providers. The procedures ensure consideration of the environmental effects resulting from accidental releases and that there will be an appropriate reporting response to environmental incidents. The procedures address the release of hazardous materials and sediment under the federal Fisheries Act, the Transportation of Dangerous Goods Act and the Alberta Environmental Protection and Enhancement Act.

Chapter 6: Noncompliance and Corrective and Preventive Action – This chapter describes Alberta Transportation's procedures for investigating and correcting non-conformances, and for preventing the re-occurrence of non-conformances. Non-conformances are activities and/or incidents that do not conform to identified requirements. These requirements include specifications, legislation, regulations and contracts, to name a few.

Chapter 7: Inspection and Monitoring – This chapter outlines Alberta Transportation’s processes for inspection and monitoring of the key characteristics of the Department’s environmental activities. This includes tracking of Alberta Transportation’s environmental liabilities, regulatory monitoring, site inspections, and the monitoring of EMS objectives and targets. These activities allow Alberta Transportation to establish its due diligence and evaluate its environmental performance on an annual basis.

Chapter 8: Communication – Chapter 8 describes Alberta Transportation's approach to the ongoing management of comments and information requests from internal and external stakeholders.

Chapter 9: Environmental Training – Chapter 9 outlines the environmental awareness training required to support the EMS.

Chapter 10 - Environmental Audit Program – This chapter identifies the key components and responsibilities associated with Alberta Transportation's audit program and management reviews.

1.0 Introduction to the Environmental Management System

1.1 APPLICATION OF THE EMS

1.1.1 Alberta Transportation

Highway and Water Infrastructure

The EMS is intended to manage the environmental impacts related to Alberta Transportation's core activities related to the design, construction, operations, maintenance and decommissioning of the provincial highway network and water infrastructure.

The following offices and divisions within Alberta Transportation provide support as required:

Offices:

- Minister
- Deputy Minister
- Assistant Deputy Ministers

Divisions:

- Delivery Services
- Transportation Services
- Corporate Strategies & Services

Detailed descriptions of the offices and divisions as well as the organization chart for the Alberta Transportation is located on the Department website.

Environmental Working Group

The Environmental Working Group (EWG) provides support to Environmental Services by ensuring the implementation of the EMS effectively and consistently. The members of the EWG identify environmental issues and provide advice and recommendations to upper management. EWG members also review proposed changes to the EMS and identify the need for further improvements.

1.2 BACKGROUND

Alberta Transportation has responsibility for the Province's extensive transportation network and water management infrastructure, including, but not limited to, highways, bridges, culverts, tunnels, ferries, dams, reservoirs and canals. Alberta Transportation has a business goal of providing safe, efficient and sustainable transportation and water management infrastructure through effective planning, design, construction, rehabilitation, operation, maintenance and decommissioning.

Alberta Transportation is committed to meeting this goal in a manner that minimizes impacts on the environment, including the land, water and air, and human health. It has enhanced its ability to meet this commitment by developing an Environmental Management System (EMS) for its transportation and water management infrastructure projects and activities.

An EMS is an organized and formal approach to managing environmental issues with the goal of making environmental considerations part of daily activities. At its core, the purpose of the EMS is to identify and responsibly manage the potential environmental impacts of Alberta Transportation's activities and projects.

Alberta Transportation’s EMS is designed to accomplish the following:

- Integrate consideration of environmental impacts into the Department's decision-making processes
- Extend environmental considerations into policies, procedures and practices
- Prevent the occurrence of environmental incidents at the outset
- Establish the Department’s due diligence in the event that an incident does occur
- Establish a means of monitoring the Department's environmental performance

1.3 The EMS Manual

The EMS Manual is intended to identify the policies, procedures and practices that make up Alberta Transportation's EMS. The EMS Manual does the following:

- ✓ Outlines the roles and responsibilities of all personnel under the EMS
- ✓ Identifies the Alberta Transportation's key regulatory environmental responsibilities
- ✓ Provides details of procedures and practices designed to manage Alberta Transportation's potential environmental impacts
- ✓ Sets out the Alberta Transportation's communications approach and procedures
- ✓ Outlines the training required to maintain and potentially improve the Alberta Transportation's environmental performance.
- ✓ Provides information regarding EMS documentation and document control systems
- ✓ Outlines the process for inspection and monitoring of the key characteristics of Alberta Transportation's environmental activities
- ✓ Describes procedures for investigating, correcting and preventing re-occurrence of non-conformances
- ✓ Outlines Alberta Transportation's environmental audit program

Official Manual Version

The official version of the Manual is the electronic version located on Alberta Transportation's web site. If your document is a printed copy it is uncontrolled and may not be the current version. Check the Department's web site for the current, official version.

Maintenance

Environmental Services is responsible for maintaining the EMS Manual and issuing revisions as required. The EMS Manual is reviewed and updated on an annual basis.

Consultants and Contractors

Alberta Transportation out-sources the design, construction, rehabilitation, maintenance, and decommissioning of transportation and water infrastructure projects to private sector consultants and contractors (collectively, "Service Providers"). The EMS applies to the work of all Service Providers (individuals and companies) who build and maintain the Alberta Transportation's transportation and water infrastructure facilities. As the Alberta Transportation's representatives on site, Service Providers play an integral role in helping the Department fulfill its commitment to environmental protection. Alberta Transportation continues to work with the consulting and contracting sectors to develop sound policies and procedures to meet the EMS requirements and overall environmental management goals.

The specific EMS roles and responsibilities of Alberta Transportation's offices and divisions, and Service Providers are detailed in Chapter 2.0 of the Manual.

All Alberta Transportation employees and Service Providers should regularly review the EMS Manual. Alberta Transportation employees, Service Providers, and other stakeholders are asked to bring any suggestions regarding the EMS Manual to the attention of Environmental Services.

2.0 EMS Roles and Responsibilities

2.1 INTRODUCTION

Alberta Transportation recognizes that its primary activities can result in lasting changes to the environment. Alberta Transportation believes in identifying and managing its environmental issues in a pro-active and responsive manner. This includes taking environmental issues into account throughout the entire lifecycle of a project. This way, Alberta Transportation hopes to reduce its negative environmental impacts, while maximizing positive environmental effects. Proper planning and investment in the early stages of project development can result not only in environmental benefits, but also economic and social benefits for all Albertans.

2.2 PRIMARY ROLES AND RESPONSIBILITIES UNDER THE EMS

The EMS identifies the roles and responsibilities for all levels of personnel under the EMS. This ensures that all personnel involved in environmental activities have a clear understanding of their roles and responsibilities.

Table 2.1 sets out the primary roles and responsibilities for environmental activities and the EMS. In addition to the information set out below, specific roles and responsibilities are set out in procedures and practices throughout the EMS Manual. Personnel are expected to review and become familiar with all of their responsibilities under the EMS.

TABLE 2.1: EMS ROLES AND RESPONSIBILITIES

TITLE/POSITION	ROLES AND RESPONSIBILITIES
Minister	• Review and provide direction to the Deputy Minister on environmental matters to ensure consistency with other government and departmental polices and initiatives. • Coordinate with other government Departments on environmental issues, and any other issues related to the Department's EMS and overall environmental management. • Receive and review environmental information from the Deputy Minister.
Deputy Minister & Executive Committee	• Incorporate into budgetary planning the allocation of resources to address the Department's EMS requirements. • Approve allocation of resources. • Receive and review environmental information from the Assistant Deputy Ministers and provide to the Minister as required. • Receive information and direction from the Minister and disseminate to the Department as appropriate.
Assistant Deputy	• Make recommendations to the Deputy Minister and Executive

TITLE/POSITION	ROLES AND RESPONSIBILITIES
Ministers & Divisional Executive	Committee on the resources required to address the Department's environmental interests. • Integrate environmental planning into the Department's business planning processes. • Receive and review environmental information from Environmental Services. • Provide direction to the relevant Divisions of the Department on environmental matters. • Provide long-term direction to the Environmental Services on environmental matters.
Environmental Working Group	• Identify environmental issues related to the Department’s activities. • Provide expertise regarding the EMS to their respective functional units. • Provide expertise regarding regulatory requirements to their respective units. • Manage environmental programs in their functional units. • Review proposed changes to the EMS and identify the need for further improvements. • Be a champion for environmental excellence. • Provide support, direction and advice to Environmental Services on matters related to the EMS and other environmental matters affecting the Department.
Environmental Services	• Continuously improve and maintain the EMS for the Department's environmental activities. • Identify and advise Divisional Executive on resource requirements for the Department's EMS. • Deliver EMS awareness programs, as required, to ensure Department staff and Service Providers continue to meet the Department's requirements under the EMS. • Conduct annual reviews of the EMS and issue EMS revisions as changing circumstances require. • Commission, receive and review audit results and other environmental data required to monitor and evaluate the Department's environmental performance, and ensure appropriate follow up. • Report audit findings and environmental performance issues to Divisional Executive. • Provide environmental information, direction and advice as requested by Divisional Executive or by Department employees. • Undertake liaison with regulatory agencies to address compliance and consistency issues.
Regional Environmental	• Provide leadership and direction with respect to environmental

TITLE/POSITION	ROLES AND RESPONSIBILITIES
Coordinators (REC)	stewardship. • Monitor, track and identify departmental or regional environmental performance issues. • Ensure measures are in place for compliance with regulatory requirements and the EMS. • Report to Environmental Services on regional or departmental environmental issues and incidents that have been identified by Service Providers or by Department employees and ensure proper follow-up.
Alberta Transportation Employees	• Ensure measures are in place for compliance with regulatory requirements and the EMS. • Report to Environmental Services or RECs on local or regional environmental issues that have been identified by Service Providers or other Department employees and ensure proper follow-up. • Report to Project Sponsors or RECs on local or regional environmental incidents that have been identified and ensure the proper reporting to external stakeholders (e.g. regulatory authorities, adjacent landowners, etc.) as required. • Incorporate training requirements to meet regulatory requirements and the EMS into individual learning plans, and complete the required training. • Provide feedback regarding the EMS, documentation, procedures and practices (as per the EMS Communications Procedure) to ensure that the Department continuously improves its ability to limit and manage the environmental impacts associated with its activities.
Service Providers	• Ensure measures are in place for compliance with regulatory requirements and the EMS. • Identify environmental incidents, report these to the Department and to external stakeholders (e.g. regulatory authorities, adjacent landowners, etc.) as required, and undertake appropriate incident response and follow up. • Identify environmental issues/concerns and report these to the Project Sponsor/Administrator. • Possess the appropriate knowledge and expertise to meet environmental responsibilities (regulatory requirements, EMS responsibilities, etc.). • Provide feedback regarding the EMS, documentation, procedures and practices to ensure that the Department continuously improves its ability to limit and manage the environmental impacts associated with its activities.

3.0 Regulatory Requirements

3.1 INTRODUCTION

This chapter provides an initial reference regarding the primary statutes, regulations, bylaws, codes of practice, standards and guidelines that relate to the Department's key environmental impacts and affect the Department's activities. It also identifies the proposed regulatory changes related to the Department's environmental impacts.

This chapter does not include a detailed summary of the environmental compliance requirements contained in specific regulatory authorizations, approvals, licences or permits (collectively, "Regulatory Instruments"), as there are numerous Regulatory Instruments issued for Department projects that come into force and expire at various times, depending upon the activity in question. A summary of the Department's Regulatory Instruments could not accurately capture all of the variations and permutations. Service Providers are to keep copies of all Regulatory Instruments for each Department project/activity, and the original copies are to be submitted to the Department. Department employees and Service Providers working on Department projects are expected to be familiar with, and comply with, the Regulatory Instruments that have been issued for the project activity. Mechanisms designed to aid in identifying and obtaining regulatory approvals are available in the Appendices.

3.1.1 Authorizations Required

It is important to recognize that the required authorizations (i.e. approval, permit, licence, etc.) must be obtained prior to commencing the activity. Failure to have the proper authorization in hand prior to commencing the activity could result in contravention of legislation and enforcement measures being imposed. This applies to all legislation under which authorizations are needed for a given activity, for example: *Fisheries Act*, *Navigation Protection Act*, *Environmental Protection and Enhancement Act*, *Water Act*, etc.

3.2 ENVIRONMENTAL LEGISLATION LISTS

The following lists identify the PRIMARY acts that may apply to the environmental impacts resulting from the Department's activities, products and services. The lists are NOT exhaustive and legal advice must be sought to ensure all relevant legislation has been identified when a specific regulatory issue arises.

Appendix 4 identifies the Department's key activities and the corresponding regulatory requirement(s) that relates to those activities. The table provides a quick cross-reference for regulatory requirements related to specific environmental activities.

The Environmental Section updates this chapter on an annual basis. The currency of the legislation listed is identified at the top of each list. Unless otherwise noted, the legislation listed is as amended to the currency date.

3.2.1 Federal Legislation List (current to October 2017)

- *Canada Water Act,* R.S.C. 1985, c. C-11
- *Canada National Parks Act*, S.C. 2000, c. 32
- *Canada Wildlife Act*, R.S.C. 1985, c. W-9
- *Canadian Environmental Assessment Act, 2012*, S.C. 2012, c. 19
- *Canadian Environmental Protection Act, 1999*, S.C. 1999, c. 33
- *Environmental Enforcement Act* (received Royal Assent on June 18, 2009; not all provisions are currently in force)
- *Environmental Violations Administrative Monetary Penalties Act*, SC 2009, c 14, s 126
- *Environmental Violations Administrative Monetary Penalties Regulations,* SOR/2017-109
- *Fisheries Act*, R.S.C. 1985, c. F-14
- *Forestry Act*, R.S.C. 1985, c. F-30
- *Migratory Birds Convention Act, 1994,* S.C. 1994, c. 22
- *Navigation Protection Act*, R.S.C. 1985, c. N-22
- *Species At Risk Act, 2002, c. 29*
- *Transportation of Dangerous Goods Act, 1992*, S.C. 1992, c. 34

3.2.2 Provincial Legislation List (current to October 2017)

- *Alberta Land Stewardship Act*, S.A. 2009, c. A-26.8
- *Climate Change and Emissions Management Act,* S.A. 2003, c. C-16.7
- *Dangerous Goods Transportation and Handling Act*, R.S.A. 2000, c. D-4
- *Environmental Protection and Enhancement Act*, R.S.A. 2000, c. E-12
- *Forest and Prairie Protection Act*, R.S.A. 2000, c. F-19
- *Government Organization Act*, R.S.A. 2000, c. G-10
- *Historical Resources Act*, R.S.A. 2000, c. H-9
- *Natural Resources Conservation Board Act*, R.S.A. 2000, c. N-3
- *Provincial Parks Act*, R.S.A. 2000, c. P-35
- *Public Highways Development Act*, R.S.A. 2000, c. P-38
- *Public Lands Act*, R.S.A. 2000, c. P-40
- *Responsible Energy Development Act*, SA 2012, c R-17.3
- *Soil Conservation Act,* R.S.A. 2000, c. S-15
- *Special Areas Act*, R.S.A. 2000, c. S-16
- *Water Act*, R.S.A. 2000, c. W-3
- *Weed Control Act*, S.A. 2008, c. W-5.1
- *Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Act*, R.S.A. 2000, c. W-9
- *Wildlife Act*, R.S.A. 2000, c. W-10

3.2.3 Municipal Legislation List (current to October 2017)

- *City of Edmonton, By-law No. 14600*, *Community Standards Bylaw* (Consolidated on July 16, 2014)
- *City of Edmonton, By-law No. 5590,Traffic Bylaw* (consolidated on July 3, 2013)
- *City of Edmonton, By-law No. 12846, Regulation at Work and Equipment Installation on City Lands Bylaw* (consolidated on November 12, 2002)
- *City of Edmonton, By-law No. 13777, Waste Management Bylaw* (consolidated on May 14, 2014)
- *City of Calgary, Community Standards Bylaw No. 5M2004 being a Bylaw of the City of Calgary to Regulate Neighborhood Nuisance, Safety and Liveability Issues* (last amended on September 22, 2014)
- *City of Calgary, Bylaw No. 41M2002 being a Bylaw of the City of Calgary to Control and Regulate Parking within the City*
- *City of Calgary, Bylaw No. 14M2012 Being a Bylaw of the City of Calgary to Regulate Wastewater*
- *City of Calgary, Bylaw No. 60M90 Being a Bylaw of the City of Calgary respecting Truck Routes* (last amended on April 28, 2014)
- *City of Calgary, Bylaw No. 20M2001, Being a Bylaw of the City of Calgary to Regulate and Manage Waste*

> In order to keep the regulatory documentation brief and focused only on the Department's primary impacts, not all legislation listed above as potentially applicable has been summarized in detail in the regulatory summaries that follow. Further, even the more detailed summaries are provided as a general orientation to the regulatory requirements and focus only on those requirements that were thought by the reviewer to be of the greatest interest to the Department. Accordingly, the summaries are not exhaustive, nor are they intended to be relied upon to determine particular compliance requirements in any given case. Specific legal and regulatory compliance advice must be sought to assess compliance requirements in individual cases.

3.3 PRIMARY FEDERAL LEGISLATIVE REQUIREMENTS

3.3.1 Canada Water Act

Aspects of managing water resources in Canada fall under both federal and provincial jurisdiction. The *Canada Water Act* aims to provide for the coordinated management of Canada's water resources through programs relating to the conservation, development and utilization of those water resources. The *Canada Water Act* provides an enabling framework for collaboration among the federal, provincial and territorial governments in matters relating to water resources. Joint projects involve the regulation, apportionment, monitoring or surveying of water resources, and the planning and implementation of programs relating to the conservation, development and utilization of water resources. Pursuant to section 5 of the *Act*, the Minister must enter into an agreement with a provincial government, subject to the approval of the Governor in Council, to design projects for the efficient conservation, development and utilization of Canada's water resources.

Further, as is discussed in part 3.3.6 of this Manual, the *Environmental Violations Administrative Monetary Penalties Regulations*, which came into force on June 2, 2017, implement an Administrative Monetary Penalties regime for six federally-administered environmental acts, including for violations under the *Canada Water Act*.This Act should be consulted whenever federal, inter-jurisdictional, or international waters, as defined in the Act, are implicated, or when there is potential for the pollution of any waters in areas designated under the Act. Of further note, inspectors are authorized under the Act to conduct searches of any area, place, premises, vessel or vehicle, other than a private dwelling-place, with or without a warrant, depending on the circumstances. The owner or the person in charge of the area must provide the inspector with all reasonable assistance to enable them to carry out their duties and function under the Act. The obstruction or hindrance of an inspector is prohibited by the Act.

3.3.2 Canada National Parks Act

The *Canada National Parks Act* aims to maintain and protect the national parks of Canada through the protection of natural resources and natural processes. Pursuant to the Act, the Minister is responsible for the administration, management and control of national parks, including public lands. As such, the Minister must enter into an agreement authorizing the use of lands in a national park.

3.3.3 Canada Wildlife Act

The *Canada Wildlife Act* is a protective statute that allows for the creation, management and protection of wildlife areas for wildlife research activities and conservation. In this regard, the Minister must issue a permit authorizing the use of any federal wildlife area that has been identified for research and conservation purposes. This Act should be considered if public lands, as defined below, or wildlife are implicated.

The purpose of wildlife areas is to preserve habitats that are critical to migratory birds and other wildlife species, particularly those that are at risk. The *Wildlife Area Regulations* prohibit all activities that could be harmful to species and to their habitat, unless a permit is issued indicating the permitted activity. Activities such as hiking, canoeing, photography and bird watching can be carried out without a permit in most areas. The Regulations also designate and establish National Wildlife Areas, which are identified in Schedule I of the regulations. The regulations prohibit certain activities in National Wildlife Areas, unless the Minister of the Environment has issued a permit or posted a public notice at the entrance to the wildlife area or on its boundary or in a local newspaper authorizing the activity.

The *Canada Wildlife Act* is binding on the federal government and the provinces. Public lands are defined in the Act as lands belonging to the federal government and lands that the federal government has power to dispose of, subject to the terms of any agreement between the Government of Canada and the government of the province in which the lands are situated, and includes any waters on or flowing through the lands and the natural resources of the lands.

Contravention of sections 11(6), 11.91(1) or any provisions of the Regulations is an offence under the Act. The aim of these provisions is the prevention of unlawful possession of wildlife protected under the Act as well as ensuring the wildlife officers are able to carry out their duties and functions.

There were some significant additions made to the offence and penalty provisions of this Act, which was last amended in July 2017. The amendments, being the addition of sections 13.01-13.13, broaden the scope of what contraventions of the Act are to be considered offences for the purpose of apportioning liability, and levying the penalties of imprisonment, a fine, or both. The amendments also capture the contravening behavior of small revenue corporations under the Act, and provide detailed guidance for sentencing under the offence provisions.

3.3.4 Canadian Environmental Assessment Act, 2012

Purpose and Scope

The *Canadian Environmental Assessment Act, 2012* ("CEAA, 2012") is administered by the Canadian Environmental Assessment Agency ("Agency"). CEAA, 2012 and regulations passed under that statute set out the responsibilities and procedures for conducting environmental assessments ("EA") in relation to certain projects.

Under CEAA 2012, only those projects designated by regulation or Ministerial Order (Designated Projects), or those projects for which a responsible authority identified in section 15 has a decision to make in relation to, require an EA. CEAA 2012 considers changes to the environment only within those areas of federal jurisdiction: Aboriginal peoples, fish and fish habitat (*Fisheries Act*), aquatic species (*Species at Risk Act*), and migratory birds (*Migratory Birds Convention Act, 1994*). EAs for Designated Projects may be conducted by bodies other than the Agency, if the Minister of the Environment authorizes an equivalent assessment to be conducted by a responsible federal authority (e.g. National Energy Board, or the Canadian Nuclear Safety Commission), provincial government agency, foreign government, or other approved authority. The Minister of the Environment may designate a project not on the Designated Projects list and may refer an EA to a review panel if the Minister considers it to be in the public interest.

Projects on federal lands require a federal authority to make a determination with respect to potential adverse environmental effects that may result. The project cannot be carried out unless:

- the authority determines that it is not likely to cause significant adverse environmental effects, or

- the federal authority determines that the carrying out of the project is likely to cause significant adverse environmental effects and the Governor in Council decides that those effects are justified in the circumstances (s. 67).

Regulations

The *Regulations Designating Physical Activities*, prescribe physical activities and classes of projects for which a federal EA is required because they may cause significant adverse environmental effects or generate considerable public concern. Examples of transportation and water management related activities that require EAs include:

- The expansion of an existing dam or dyke that would result in an increase in the surface area of the existing reservoir of 50 per cent or more and an increase of 1 500 ha or more in the annual mean surface area of the existing reservoir
- The construction, operation, decommissioning and abandonment of a new dam or dyke that would result in the creation of a reservoir with a surface area that would exceed the annual mean surface area of a natural water-body by 1500 ha or more
- The construction, operation, decommissioning and abandonment of a new structure for the diversion of 10 000 000 m3/year or more of water from a natural water body into another natural water body
- The expansion of an existing structure for the diversion of water from a natural water body into another natural water body that would result in an increase in diversion capacity of 50 per cent or more and a total diversion capacity of 10 000 000 m3/year or more
- The construction, operation, decommissioning and abandonment of a canal, lock, dam, dyke, reservoir or other structure for the diversion of water, railway line or public highway, aerodrome or runway in a wildlife area or migratory bird sanctuary
- The construction, operation, decommissioning and abandonment of a new:
    - canal or any lock or associated structure to control water levels in the canal
    - lock or associated structure to control water levels in existing navigable waterways
    - railway line that requires a total of 32 km or more of new right of way
    - all-season public highway that will be more than 50 km in length and either will be located on a new right-of-way or will lead to a community that lacks all-season public highway access

- railway line designed for trains that have an average speed of more than 200 km/h
- railway yard with seven or more yard tracks or a total track length of 20 km or more
- aerodrome located within the built-up area of a city or town
- airport
- all-season runway with a length of 1,500 m or more

- The extension of an existing all-season runway by 1,500 m or more

The regulations require that a project description must be submitted to the Agency for Designated Projects in order to determine whether a federal EA is required.

Time Limits

CEAA, 2012 sets the following time limits within which the Minister of Environment must render a decision pertaining to the EAs:

- Upon receipt of the proponent's project description for a Designated Project, the Agency has 45 days to determine if a federal EA is required.
- 365 days for EAs conducted by the Agency
- 24 months if the EA is handled by a review panel or is currently subject to a comprehensive review initiated under the predecessor to CEAA, 2012

However, all time limits are subject to extensions provided by the Minister of Environment or Federal Cabinet, depending on the circumstances. The time limits also apply only to “complete applications” and the clock is halted if further studies or information are required.

Canada-Alberta Agreement

The *Canada-Alberta Agreement for Environmental Assessment Cooperation* was signed in June 1999, and was renewed in 2005 after an interim extension to this Agreement was reached in 2004. Under the Agreement, projects that require a review under both federal and provincial environmental assessment legislation undergo a single cooperative assessment. One government takes the lead in administering the assessment, but both governments are involved. The process ensures a single panel and a single public hearing process for joint assessments.

3.3.5 Canadian Environmental Protection Act, 1999

Purpose and Scope

The *Canadian Environmental Protection Act, 1999* ("CEPA") targets pollution prevention and protection of the environment, human life and health from the risks associated with toxic substances. The goal is the "virtual elimination" of the most persistent toxic substances that remain in the environment for extended periods of time before breaking down.

Toxic Substances and Release Reporting

Part 5 provides the authority to assess substances to determine if they are toxic, and to manage them to prevent pollution that could harm the environment or human health. Under s. 64, a substance is "toxic" if it is entering or may enter the environment in a quantity or concentration or under conditions that:

- have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
- constitute or may constitute a danger to the environment on which life depends; or
- constitute or may constitute a danger in Canada to human life or health.

The Priority Substances List identifies substances to be assessed on a priority basis to determine whether they are toxic. Once a substance is declared toxic, it is placed on the Toxic Substances List, found in Schedule 1 of CEPA. These substances are considered for risk management measures, such as regulations, guidelines, or codes of practice, to control any aspect of their life cycle, from the research and development stage through manufacture, use, storage, transport and disposal. Examples of toxic substances include PCBs, lead, mercury, asbestos, formaldehyde, particulate matter (less than or equal to 10 microns), and road salts.

Under ss. 95 to 99, where a toxic substance is released into the environment, any person who owns or has the charge, management or control of a substance, or causes or contributes to the release or increases the likelihood of the release, must report the release and take measures to prevent the release and remedy/mitigate the effects.

ROAD SALTS

The *Code of Practice for the Environmental Management of Road Salts (the "Code")* was first published on April 3, 2004. Organizations that use more than 500 tonnes of road salts per year and that have vulnerable areas (as defined in the *Code*) should submit a notice of intention to prepare a Salt Management Plan ("SMP"). Implementation of the SMP is recommended to occur in the fiscal year following the preparation of the SMP.

The *Code* indicates that organizations that do not meet the 500 tonnes threshold should consider implementing best management practices that are relevant to their local conditions in order to protect the environment from the negative impacts of road salts.

The SMP is to contain best management practices with the following objectives: salt storage, snow disposal, and salt application. The best management practices set out by the Transportation Association of Canada (“TAC”), as well as any other federal, provincial or municipal maintenance standards, are to be used as guidance in addition to the *Code*.

The elements that should be included in a SMP are set out in the *Code,* and the *Code* also contains environmental impact indicators, guidance for identifying vulnerable areas, and reporting provisions in the three Annexes to the *Code.*

Information required to be reported by an organization to the Minister in the *Code* is to be provided by June 30 of the year an organization becomes subject to the *Code*, and every year thereafter.

The *Code* also recommends that organizations that hire agents or contractors ensure that the agents/contractors comply with any measures in the salt management plan related to their work.

The *Code* is periodically reviewed by the Multi-stakeholder Working Group on Road Salts (the “Working Group”), administered by Environment Canada. Working Group members represent a wide range of stakeholders, including federal, provincial, territorial and municipal governments, environmental organizations, insurance companies and the salt industry.

The primary purpose of the Working Group is to review and comment on materials sent by Environment Canada, share information, transfer technology and ideas, and develop a common approach to addressing environmental issues related to the use of road salts in Canada. The reviews consider implementation of best management practices, such as those found in the TAC *Syntheses of Best Practices*, the progress accomplished towards preventing or reducing the negative impacts of road salts on the Canadian environment and road safety monitoring data. The Working Group also identifies other steps or programs needed to further prevent or reduce negative impacts of road salts on the environment.

In November 2013, the Working Group published a draft document for consultation, the “Performance Indicators and National Targets Code of Practice for the Environmental Management of Road Salts”. Consultations closed on January 24, 2014 and no amendments to the *Code* have been published yet.

Hazardous Waste and Hazardous Recyclables

The *Export and Import of Hazardous Wastes and Hazardous Recyclable Material Regulation* govern the transporting of hazardous wastes and hazardous recyclables coming into, leaving, and in transit through Canada. There are requirements for prior notification and consent of the importing and transit jurisdictions, and tracking the movement of hazardous wastes and hazardous recyclables from the point of origin to the final destination through the use of manifests and certificates of recycling/disposal.

The *Interprovincial Movement of Hazardous Waste Regulations* under CEPA requires a hazardous waste manifest when transporting inter-provincially. These requirements are in addition to those under the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*, which were enacted in 2005.

In summary:

- If a hazardous waste/recyclable is being transported solely within a province, the provincial regulatory requirements apply. Most provinces have adopted the federal *Transportation of Dangerous Goods Act* ("TDGA") and *Transportation of Dangerous Goods Regulations* ("TDGR") provisions.
- If a hazardous waste/recyclable is being transported between provinces within Canada, the *Interprovincial Movement of Hazardous Waste Regulations* apply in addition to the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*. Furthermore, if the waste is a "toxic leachate" or "environmentally hazardous substance" (as defined in the TDGR) that is "destined for disposal", TDGR requirements also apply.
- If a hazardous waste/recyclable is being imported into Canada or exported out of Canada, the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*, and the *PCB Waste Export, 1996 Regulations* apply.

There are proposed *Regulations Amending the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* which would amend the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations to expand the definitions of "hazardous waste" and "hazardous recyclable materials" to capture any waste or material as "hazardous" if:

- they are defined as, or considered to be, hazardous under the legislation of the importing or transit country; or
- their importation is prohibited under the legislation of the importing country; or
- they are one of the "hazardous wastes" or "other wastes" in the Basel Convention and the country of import is a Party to the Basel Convention.

The proposed Regulations Amending the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations would also add new provisions to address shipments of waste or recyclable material, for which consent was provided by the importing country and a permit issued, but that could not be completed as planned.

<u>Offences and Penalties</u>

Under s. 272, in general terms, it is an offence under CEPA to contravene: specified provisions of the Act or the regulations; an obligation or a prohibition arising from the Act or regulations; an order or direction made under the Act; an order, direction, or decision of a court made under the Act; or an agreement respecting environmental protection alternative measures within the meaning of s. 295.

Summary conviction offences for individuals carry a minimum penalty of a $5,000 fine and a maximum penalty of a $600,000 fine and/or imprisonment for not more than six months. Individuals convicted of an indictable offence face a minimum penalty of $15,000 fine and a maximum penalty of a fine $2,000,000 fine and/or imprisonment for not more than three years.

Penalties for corporations vary widely. Penalty amounts depend on the type of offence (*i.e.* summary conviction or indictable), and other factors such as the size of the corporation, enforcement history, etc. Generally, penalties for corporations range between a minimum fine of $25,000 up to a potential maximum fine of $12,000,000.

Minimum fines less than the prescribed amount may be imposed if the court is satisfied that the prescribed amount would cause undue financial hardship (s. 273). Conversely, pursuant to s. 274.1, additional fines may be imposed if the court is satisfied that additional benefit was gained from commission of the offence. The additional fine shall be equal to the court's estimation of the value of the property, benefit or advantage gained.

Enforcement history is an important factor for determining the penalty that individuals and corporations may receive. Generally, lower minimum and maximum penalties are associated with first offences, compared to subsequent offences. If a person either: (i) intentionally or recklessly causes an environmental disaster, or (ii) shows wanton and reckless regard for the lives or safety of other persons and causes a risk of death or harm to another person, he is guilty of an indictable offence under s. 274(1) and is liable to a fine and/or to imprisonment for not more than five years.

The fundamental purpose of sentencing under the Act is stated in s. 287 as being the protection of human and environmental health, and to promote respect of the law protecting the environment and human health. Sanctions under the Act ought to: deter the commission of offences under the Act, denounce unlawful conduct that damages or risks causing damage to the environment or human health, and to reinforce the "polluter pays" principle by ensuring that offenders are held responsible for effective clean-up and environmental restoration. Section 287.1 lists sentencing principles and aggravating factors that ought to be considered when determining appropriate sanctions under the Act.

Where a contravention is committed or continued on more than one day, each day may be considered a separate offence (s. 276). In addition to any penalties imposed, s. 291 provides the court with authority to issue orders with a broad array of implications. Orders imposed by the court under s. 291 may even suspend or cancel permits and authorizations issued to the offender under the Act.

Section 282 indicates in any prosecution of an offence (see exceptions), it is sufficient proof of the offence that an employee or agent of the accused committed it, whether or not the employee or agent is identified or prosecuted for the offence. Due diligence is a defence to most offences under CEPA. Due diligence is established when the accused either: demonstrates that even though the offence has occurred, all reasonable steps were taken prior to the offence in order to prevent it from taking place, or where the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

3.3.6 Environmental Enforcement Act

An Act to amend certain Acts that relate to the environment and to enact provisions respecting the enforcement of certain Acts that relate to the environment, also known as the *Environmental Enforcement Act*, received Royal Assent on June 18, 2009. The provisions of the *Act*, other than clause 127, will come into force on a day or days to be fixed by order of the Governor in Council. Clause 127, which is a coordinating amendment, came into force when the bill received Royal Assent.

The *Environmental Enforcement Act* proposes to amend nine existing environmental statutes administered by Environment Canada and Parks Canada. To date, provisions amending only six statutes have been brought into force (identified with an asterisk in the list below) . All nine affected statutes are:

- *Antarctic Environmental Protection Act**
- *Canada National Marine Conservation Areas Act**
- *Canada National Parks Act**
- *Canada Wildlife Act (amending provisions not yet in force)*
- *Canadian Environmental Protection Act, 1999**
- *International River Improvements Act**
- *Migratory Birds Convention Act, 1994 (amending provisions not yet in force)*
- *Saguenay-St. Lawrence Marine Park Act**
- *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act (amending provisions not yet in force)*

The *Environmental Enforcement Act* also creates an act called the *Environmental Violations Administrative Monetary Penalties Act* ("*EVAMP Act"*), which makes a number of changes to Canada's environmental enforcement scheme, including establishing minimum penalties and increasing maximum penalties for environmental offences enforced through prosecutions; providing for different fine amounts for individuals, corporations and vessels; providing sentencing guidance to courts; and creating administrative monetary penalties for less serious environmental offences.

The administrative penalty regime under the *EVAMP Act* is discussed further below.

<u>Penalties for Environmental Offences</u>

The *Act* provides new minimum penalties, increases maximum penalties, and provides different levels of penalties for different classes of offenders (individuals, small and large corporations, and small and large vessels or ships), as well as for different types of offences (less and more serious offences). Prior to the *Environmental Enforcement Act*, the statutes amended by the bill included no minimum penalties, and maximum penalties varied widely. The following Tables reflect the penalty levels for individuals and corporations under the statutes that may be relevant to Alberta Transportation's activities, which have been or are proposed to be amended by the *Environmental Enforcement Act*:

<table>
<tr><th colspan="4">Table 1 - New Penalty Levels for Individuals and Corporations[1]</th></tr>
<tr><td rowspan="7">More serious offence</td><td rowspan="4">Individual</td><td rowspan="2">Indictment</td><td>Min. $15,000</td></tr>
<tr><td>Max. $1 million (and/or imprisonment)*</td></tr>
<tr><td rowspan="2">Summary conviction</td><td>Min. $5,000</td></tr>
<tr><td>Max. $300,000 (and/or imprisonment)*</td></tr>
<tr><td rowspan="3">Large revenue corporation, or vessel or ship of 7,500 tonnes deadweight or over</td><td rowspan="2">Indictment</td><td>Min. $500,000</td></tr>
<tr><td>Max. $6 million</td></tr>
<tr><td>Summary</td><td>Min. $100,000</td></tr>
</table>

[1] Peggy Becklumb, LEGISinfo Legislative Summary, "Bill C-16: Environmental Enforcement Act" (1 April 2009, revised 19 June 2009), online: <http://www2.parl.gc.ca/Sites/LOP/LEGISINFO/index.asp?Language=E&query=5747&Session=22&List=ls>

		conviction	Max. $4 million
	Small revenue corporation, or vessel or ship of less than 7,500 tonnes deadweight	Indictment	Min. $75,000
			Max. $4 million
		Summary conviction	Min. $25,000
			Max. $2 million
Less serious offence	Individual	Indictment	No minimum
			Max. $100,000
		Summary conviction	No minimum
			Max. $25,000
	Large revenue corporation, or vessel or ship of 7,500 tonnes deadweight or over	Indictment	No minimum
			Max. $500,000
		Summary conviction	No minimum
			Max. $250,000
	Small revenue corporation, or vessel or ship of less than 7,500 tonnes	Indictment	No minimum

	deadweight		Max. $250,000
		Summary conviction	No minimum
			Max. $50,000

Table 2 - Maximum Possible Terms of Imprisonment for Individuals			
Canada Wildlife Act *International River Improvements Act* *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act*	Indictment	First offence	5 years
		Subsequent offence	5 years
	Summary conviction	First offence	6 months
		Subsequent offence	6 months
Canadian Environmental Protection Act, 1999 *Migratory Birds Convention Act, 1994*	Indictment	First offence	3 years
		Subsequent offence	3 years
	Summary conviction	First offence	6 months
		Subsequent offence	6 months

Additional Sentencing Provisions

The *Act* explicitly sets out the purposes to be applied by the courts in sentencing those convicted under the legislation: deterrence, denunciation, and restoration, and/or making the offender pay for clean-up.

The *Act* also sets out aggravating factors a sentencing judge must consider: the damage caused and its extent, the offender's moral blameworthiness, the offender's profit or intended profit in committing the offence, whether the offender was warned not to commit the offence, the offender's history of non-compliance, and the offender's subsequent conduct. A court must give reasons if it decides not to increase a fine when there are aggravating factors.

Moreover, the *Act* adds or amends additional types of orders that a judge may impose for an environmental offence:

- directing the offender to implement an environmental management system, pollution prevention plan or environmental emergency plan;
- directing an offender to pay the Crown an amount for environmental/wildlife conservation or protection;
- directing an offender to compensate any person for the cost of any remedial or preventative action;
- monitoring (or paying for monitoring of) environmental effects of an activity on the resources of a marine conservation area;
- requiring periodic environmental audits;
- requiring an offender to provide information on the offender's activities;
- directing a person to perform community service;
- directing a person to pay an amount to environmental or other groups to assist in their work in the area;
- requiring an offender to pay an amount for research on protection, conservation or restoration; and/or
- directing an offender to pay an amount to an educational institution, including for scholarships for students enrolled in studies related to the environment.

A number of other sentencing provisions are added or amended by the *Act.*

<u>Environmental Protection Compliance Orders</u>

An "environmental protection compliance order" is a tool for dealing with certain suspected environmental contraventions in progress, or anticipated contraventions, discovered during the course of an inspection or search. The *Environmental Enforcement Act* amends the environmental protection compliance order process that was previously found only in the *Canadian Environmental Protection Act, 1999*, and adds that same process to several other Acts. Essentially, an enforcement officer may make an order directing a person to take action, or refrain from doing something, to comply with the *Act*; stop some activity or work for a period; move, unload, or reload a vehicle, vessel or aircraft; and take any other measures an officer considers necessary to facilitate compliance with the order, such as keep records or report periodically to the officer. Failure to comply with an order allows an officer to access a place or property and take measures or do anything reasonable and necessary in the circumstances.

<u>Administrative Penalties under the *EVAMP Act*</u>

The *EVAMP Act* establishes a system of administrative monetary penalties ("AMP") for the enforcement of the nine amended acts, as well as the *Canada Water Act*. The purpose in establishing this system is to provide an alternative to the penal system and to supplement existing measures to enforce environmental Acts (s. 3). Accordingly, proceeding with a matter as a violation under the *EVAMP Act* precludes prosecuting the same matter as an offence under an environmental act, and vice versa (s. 13). The *EVAMP* Act came into force on December 10, 2010.

The *Environmental Violations Administrative Monetary Penalties Regulations* ("AMPs Regulation"), which came into force on June 2, 2017 and were published in the Canada Gazette, Part II on June 14, 2017, complete the Administrative Monetary Penalties ("AMPs") regime by establishing some key details.

The AMPs Regulations designate violations under the following six acts and their associated regulations that may be enforced by means of an AMP:

- *Antarctic Environmental Protection Act;*
- *Canada Wildlife Act;*
- *Canadian Environmental Protection Act*, 1999, Parts 7 and 9 only;
- *International River Improvements Act;*
- *Migratory Birds Convention Act, 1994;* and
- *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act*.

The AMPs Regulations also specify the method used to calculate the amount of an AMP, including baseline penalty amounts for different types of violations and violators, and aggravating factors that, if applicable, increase the amount of the penalty.

The AMPs Regulations do not introduce any new legal obligations, create new prohibitions or limits on conduct, or impose new administrative or compliance costs. AMPs are a new tool to help achieve higher levels of compliance with federal environmental legislation, offering an alternative to the existing penal system and supplementing existing enforcement measures.

3.3.7 Fisheries Act

Purpose and Scope

The *Fisheries Act*, administered by the Department of Fisheries and Oceans ("DFO"), applies to all fishing zones, territorial seas and inland waters of Canada. It is binding on federal, provincial and territorial governments. The Act regulates the protection of fish habitat, pollution prevention, the harvesting of fish, and the safe use of fish.

“Fish” includes all parts of fish, shellfish, crustaceans and marine animals, in all life stages (eggs, sperm, spawn, larvae, spat, juvenile and adult stages) (s. 2). "Fish habitat" is defined as "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" (s. 2).

Significant amendments to the *Fisheries Act* were made in 2012. The amendments were implemented in two phases, the first of which came into force on June 29, 2012. The remaining amendments came into force on November 25th, 2013.[2]

Prohibitions for killing fish by means other than fishing (previously in s. 32) and through the harmful alteration, disruption or destruction of habitat (previously in s. 35) were merged under the new s. 35, which prohibits “serious harm to fish” (as defined under the new s. 2(2)). The serious harm prohibition will apply to three categories of fisheries:

- commercial;
- recreational; and
- Aboriginal.

Serious harm is defined as “the death of fish or any permanent alteration to, or destruction of, fish habitat.” Under the new regime, serious harm to fish will be allowed if authorized by the Minister (or prescribed authority) or if the work is carried out in accordance with activities as permitted under the regulations.

Once it has been determined that a Ministerial power will be exercised the four factors in Section 6 of the *Fisheries Act* must be considered. The four factors in Section 6 are:

a) The contribution of the relevant fish to the ongoing productivity of commercial, recreational or Aboriginal fisheries;

b) Fisheries management objectives;

c) Whether there are measures and standards to avoid, mitigate or offset serious harm to fish that are part of a commercial, recreational or Aboriginal fishery; and

d) The public interest.

Penalties are also proposed to increase. For example, maximum fines for corporations causing serious harm to fish could be as high as $4 million for a first offense, up from the maximum of $300,000 for similar offences under the current provisions.

[2] For a more detailed discussion of the amendments, please refer to: The Fisheries Protection Policy Statement, October 2013.

It is also worth noting that prohibitions against depositing deleterious substances will remain. However, such deposits can be authorized by regulations enacted to provide so.

Fish Passage

The *Fisheries Act* requires the safe passage of fish. Under s. 20(1), where the Minister determines it to be necessary for the public interest, he/she can require the construction of a fish-way or canal to permit the free passage of fish around obstructions across or in any stream. Any projects that have the effect of blocking the stream channel require the construction of a fish-way in a portion of the channel to allow for fish passage. For some projects (such as bridges), a fish-way may be required only during the construction phase; for projects that result in the permanent blockage of streams (such as dams), the fish-way would be a permanent structure requiring ongoing maintenance. A fish guard or screen must be placed at the entrance of water intakes, ditches, channels or canals that are constructed for conducting water from any Canadian fisheries waters for irrigating, manufacturing, power generation or domestic purposes.

Deposit of Deleterious Substances

Section 36(3) prohibits any person from depositing or permitting the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance may enter such water. “Deleterious substance” means any substance that degrades or alters the water and makes it harmful to fish or fish habitat (s. 34(1)). Common types of deleterious substances are: silt, nutrient imbalances, acid rain, toxic contaminants, pesticides, industrial and municipal waste discharges, and other chemical, physical and biological agents.

Section 36(5.1) provides that regulations may be passed allowing the deposit of deleterious substances in certain classes of waters or places, or resulting from certain works undertakings or activities. However, no such regulations are currently in force.

The Act also places a duty on a person to report the deposit of a deleterious substance and to take steps to remedy or mitigate any adverse effects (s. 38(4)).

Offences and Penalties

Table A.1 in Appendix A to the Manual provides a summary of the relevant offences and minimum and maximum penalties under the *Fisheries Act*. In determining if an offence has occurred, fish need not be present in the area at the time of the deposit. The area must only be one that is found to support fish habitat. Where a contravention continues for more than one day, each day may be considered a separate offence (s. 78.1). If any monetary benefit was obtained as a result of the offence, the court can impose a fine equal to the amount of the monetary benefit and this fine can be in excess of the maximums specified (s. 79). Section 79.2 sets out a list of orders that may be imposed by the court in addition to any other penalty. Examples include directing the offender to publish the facts relating to the conviction, perform community service, or pay money to the Minister for the purpose of promoting the proper management, control, conservation and/or protection of fish or fish habitat. The Crown can also sue for costs related to prevention of a deposit of a deleterious substance or any measures to limit or remedy adverse effects that result or are expected to result from the release (s. 42). The parties responsible for such costs include the owner of the substance, a person with charge, management or control of the substance, and any person who contributed to the deposit or potential deposit.

The Act creates liability for employers if an offence is committed by one of their employees or agents, whether or not the employee or agent has been prosecuted or identified, unless the employer shows that it was done without their knowledge or consent (s. 78.3).

Offences under the Act are "strict liability" offences (ss. 40 & 78.6). Due diligence is a defence to strict liability offences and is established by demonstrating that even though the offence has occurred, all reasonable steps were taken prior to the offence in order to prevent it from taking place or that the accused reasonably but mistakenly believed in a set of facts, which if true, would have rendered the activity in question compliant.

<u>Projects Near Water</u>

It is important to note that DFO's Operational Statements are no longer valid as of November 25th, 2013. In place of the Operational Statements DFO has developed a number of guidance documents intended to assist proponents with the implementation of the new requirements of the federal Fisheries Act. These guidance documents identify:

- Types of water bodies where DFO review is not required;
- Those project activities and criteria where DFO review is not required; and
- Measures to avoid causing harm to fish and fish habitat.

It is important to visit the DFO website frequently as additional guidance documents may be posted throughout the year.

3.3.8 Forestry Act

The *Forestry Act* aims to protect the forest resources of Canada, while promoting their efficient use. Pursuant to the Act, the Minister is responsible for the protection, management and utilization of forest resources. The Minister must enter into an agreement before resources can be taken from a forest area. Alternatively, a permit may be issued by a forestry officer, who is appointed by the Minister.

3.3.9 Migratory Birds Convention Act, 1994

<u>Purpose and Scope</u>

The *Migratory Birds Convention Act, 1994* and the *Migratory Birds Regulations* are the result of a Convention signed between the United States and Canada directed at the protection and preservation of migratory birds and migratory bird habitats. The Act protects certain species, controls the harvest of others, and prohibits the commercial sale of all species. It establishes a closed season, with limited exceptions, on the hunting of migratory birds from March 10 to September 1, and prohibits the taking of eggs or nests except for scientific or propagation purposes. The legislation is binding on federal and provincial governments. The Act and Regulations apply to various:

- Migratory game birds, including ducks, geese, swan, cranes, shorebirds and pigeons
- Migratory insectivorous birds, including chickadees, cuckoos, hummingbirds, robins, swallows and woodpeckers
- Other migratory non-game birds, including gulls, herons, loons, and puffins

The complete list of migratory birds to which the Act applies is set out in Article I of the Convention (Schedule to the Act).

<u>Prohibitions</u>

It is prohibited to disturb, destroy or take a nest, egg or nest shelter of a migratory bird or have in one's possession a live migratory bird, carcass, skin, nest or egg of a migratory bird except under authority of a permit (s. 6, Regulations). It is also prohibited to deposit or permit to be deposited oil, oil wastes or any other substances harmful to migratory birds in any waters or any area frequented by migratory birds (s.5.1), and also allows for the authorization of deleterious deposits by the *Canada Shipping Act*, another federal act, or the Minister.

<u>Compliance Orders</u>

Sections 11.21 to 11.30 authorize game officers to issue compliance orders where there are reasonable grounds to believe that the Act and regulations have been, continue to be, or likely will be contravened. The compliance orders may direct persons to take measures consistent with the protection and conservation of migratory birds, their nests, and public safety.

<u>Permits</u>

Schedule II of the Regulations provides for the following permits: migratory game bird hunting; scientific; avicultural; migratory bird damage; airport-kill; taxidermist; and eiderdown. There are no permits, other than scientific permits, for disturbing, destroying, or taking a nest, egg, or nest shelter of a migratory bird, nor for depositing or permitting to be deposited oil, oil wastes or any other substances harmful to migratory birds in any waters or any area frequented by migratory birds. These activities are strictly prohibited by the legislation.

In order to conduct a survey for avian viruses, the Minister of the Environment has temporarily varied application of the Regulation so that a person is permitted to temporarily possess dead migratory birds without a permit to allow for swift delivery of such birds to provincial or territorial authorities for analysis. In all other circumstances, a prohibition against possessing the carcass of a migratory bird remains in effect. This varied application of the Regulation is currently in effect until August 27, 2017.

However, the responsible Minister may refuse to issue a permit, or may cancel a permit, if the applicant or permit holder has been convicted of an offence under the Act (s. 18.22).

<u>Offences and Penalties</u>

Offences and penalties are set out in s. 13 of the Act. There have been significant additions made to this part of the Act, which reflect the penalty provisions in Tables 1 and 2 reproduced in the *Environmental Enforcement Act* section of this Manual. They are substantially similar to those made to the *Canada Wildlife Act*, discussed above, as well as the other pieces of legislation affected by the *EVAMPA* and AMPs Regulation. . Currently, a person who is found to be in contravention of the Act or Regulations is subject to a fine not exceeding $300,000 and/or up to six months in prison on summary conviction for a first offence. For a second or subsequent offence, a person found to be in contravention of the Act or Regulations will be subject to a fine of no more than $600,000 and/or to imprisonment for a term of not more than six months. Under an indictable conviction, a person is subject to a fine not exceeding $1,000,000 and/or up to 3 years in prison for a first offence, and for a second or subsequent offence, to a fine of not more than $2,000,000 and/or to imprisonment for a term of not more than three years.A court can also impose additional orders, such as the performance of community service.

A person or vessel that commits or continues an offence on more than one day is liable to be convicted for a separate offence for each day on which the offence is committed or continued (s. 13.18). If the contravention involves more than one bird harmed, each bird may be considered a separate offence for the purpose of calculating a fine (s. 13.19).

The Minister shall maintain a publically accessible registry containing information about the convictions against corporations under the Act. The registry is intended to encourage compliance with the Act and regulations (s. 18.21).

Due diligence is a defence to strict liability offences, and is established by demonstrating that even though harm to a migratory bird, nest or egg occurred, all reasonable steps have been taken prior to an offence to prevent harm from taking place or when the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

3.3.10 Navigation Protection Act

<u>Purpose and Scope</u>

The *Navigation Protection Act*, formerly called the *Navigable Waters Protection Act*, administered by Transport Canada, applies to navigable waters listed in the schedule at the end of the Act. The purpose of the Act is to protect the public right of navigation in navigable waters. "Navigable water" governed by the Act includes the water bodies listed in the schedule and any canal or other body of water created or altered that is associated with the water bodies listed in the schedule (s. 2). The schedule can be modified through regulations.

The following questions are considered when determining if a waterway is a navigable water under the Act:

- Do the physical characteristics of the waterway support carrying (floating and traversing) a vessel of any size (e.g., canoe/kayak) from one point to another?
- Is there information (i.e., evidence) of current use by the public of the waterway as an aqueous route for navigation purposes either as a self-contained route or as part of a navigation network extending beyond the boundaries of the specific waterway?
- Is there information (i.e., evidence) of historical or past use by the public of the waterway as an aqueous route for navigation purposes either as a self-contained route or as part of a navigation network extending beyond the boundaries of the specific waterway?
- Is there a reasonable likelihood of use by the public as an aqueous highway?

This Act underwent significant amendments in 2014 that affect its scope of application.

There are six waterways in Alberta listed in the schedule that require approval under the Act. These are:

- Peace River
- Athabasca River
- Lake Athabasca
- North Saskatchewan River
- South Saskatchewan River
- Bow River

There are three main categories of works under the Act:

- approved works (s. 6)
- permitted works (s. 9)

- designated works (s. 10)

Approved works are works that are approved by the Minister after being assessed as likely to substantially interfere with navigation. Permitted works are works that may proceed without the Minister's approval, after determination by the Minister that they are not likely to substantially interfere with navigation. Permitted works are deemed compliant with the Act if they meet regulatory requirements and any terms and conditions applied to the project. Designated works are works that may proceed without notice under the Act, as long as they comply with the requirements of the *Minor Works Order* (discussed below). If the waterway is not listed in the schedule, an approval is not required under the Act (s. 10). If the waterway is listed in the schedule, and the work is not listed in the Minor Works Order an approval for the work must be obtained from Transport Canada.

The Act prohibits the building or placing of a work, other than a "designated work", in, on, over, under, through or across navigable waters unless an approval has been issued by the Minister prior to commencement of construction (s. 6). "Work" is defined in s. 2 and includes any structure, device or thing, whether temporary or permanent, that is made by humans. It also includes the dumping of fill or the excavation of materials from the bed of any navigable water. If the Minister considers that two or more works are related, the Minister may deem them to be a single work (s. 5(5)).

Designated works include "minor works" or works that are constructed or placed in, on, over, under, through or across any "minor water" (s. 2). Minor works and minor waters may be designated by Ministerial order pursuant to s. 28(2) of the Act. Section 28(1) of the Act also provides the Minister with broad authority to make regulations respecting the construction, placement, alteration, repair, rebuilding, removal, decommissioning, maintenance, operation, safety or use of works – other than in or over minor waters – and approvals relating to the same.

Minor Works Order

The *Minor Works Order* allows for works to be built if they meet the criteria for the applicable class of works, as well as specific terms and conditions for construction. Works meeting the assessment criteria of the *Minor Works Order* are classed as "designated works" under the Act and may proceed without notice to the Minister as long as they comply with the requirements of the Act and any applicable regulations.

The classes of works established by the *Minor Works Order* are:

- Erosion-Protection Works
- Docks and Boathouses
- Boat Ramps, Slipways and Launch Ramps
- Aerial Cables — Power and Telecommunication

- Submarine Cables — Power and Telecommunication
- Pipelines Buried Under the Bed of Navigable Water
- Pipelines and Power or Communication Cables Attached To Existing Works
- Works within a Boomed-Off Area Upstream or Downstream of an Existing Work For Water Control
- Outfalls and Water Intakes
- Dredging
- Mooring Systems

Offences and Penalties

Failing to receive an approval for a work is not an offence under the Act. However, Transport Canada can order the owner of an unauthorized work to remove or alter it or to refrain from proceeding with construction of the work where the work interferes with navigation (s. 6(1)). The owner of an unauthorized work who fails to remove it can also be ordered to pay for the costs of removing, destroying or disposing of the work (s. 6(3)). Other offences and penalties include throwing or depositing sawdust, edgings, slabs, bark, stone, gravel, earth, cinders, ashes or other material or rubbish that interferes with navigation (ss. 21 & 22) and attract a fine of not more than $5,000.

Offences under the Act are strict liability offences. Due diligence is a defence to strict liability offences and is established by demonstrating that even though the offence has occurred, all reasonable steps were taken prior to the offence to prevent it from taking place, or when the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

The Act also provides for administrative penalties to be issued by Transport Canada if regulations under the Act are contravened (s. 39.1). Maximum administrative penalties for individuals are $5,000 and $40,000 for corporations.

Navigation continues to be protected for waters not listed in the schedule under common law rights, which could be subject to civil court actions if these rights are violated

3.3.11 Species At Risk Act

Purpose and Scope

The purposes of the *Species at Risk Act* (“SARA”) are to prevent Canadian indigenous species, subspecies and distinct populations of wildlife from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species, and to encourage the management of other species to prevent them from becoming at risk. The Act is binding on provincial and federal governments.

“Critical habitat” is defined as habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in a recovery strategy or in an action plan for the species. An “endangered species” is a species that is facing imminent extirpation or extinction, while a “threatened species” is a wildlife species that is likely to become an endangered species if measures are not taken to reverse the factors leading to its extirpation or extinction. "Extirpated species" means a wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.

<u>Species Listing</u>

SARA formally establishes the Committee on the Status of Endangered Wildlife in Canada (“COSEWIC”) as the independent body of experts responsible for assessing and identifying species at risk. COSEWIC can classify a species as extinct, extirpated, endangered, threatened, of special concern, or not currently at risk. COSEWIC's assessments are reported to the Minister of the Environment and to the Canadian Endangered Species Conservation Council, and published in the SARA public registry. The Minister must publish a response within 90 days (s.251(3)). Schedule 1 lists the wildlife species at risk.

<u>Prohibitions</u>

As soon as a species is added to the list, a number of provisions take effect. Under s. 32 it is prohibited to kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, while s. 33 prohibits the destruction of their residences. Sections 32 and 33 apply to species found on federal lands throughout Canada.

Section 34 provides that sections 32 and 33 apply and protect listed aquatic species and species of birds covered by the *Migratory Birds Convention Act, 1994* on both federal and non-federal lands. Non-aquatic listed species and species not covered under the *Migratory Birds Convention Act, 1994*, are not protected by SARA on non-federal lands unless the Governor in Council orders otherwise.

The Minister is required to develop recovery strategies and management plans within specific time periods for all species listed as extirpated, endangered, threatened or of special concern (s. 37 and s. 47). In addition, the Minister must recommend an emergency order to protect a listed species or its habitat if a species faces imminent threats to its survival or recovery (s.80). To the extent possible, recovery strategies, action plans and management plans must be prepared in cooperation with affected provinces, territories, aboriginal organizations, landowners and other affected parties. Under the Act, stewardship is the first response to critical habitat protection.

Permits and Environmental Assessments

Under s. 73, the Minister may enter into an agreement or issue a permit to a person, authorizing the person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or the residences of its individuals if:

- the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
- the activity benefits the species or is required to enhance its chance of survival in the wild; or
- affecting the species is incidental to the carrying out of the activity.

The agreement may be entered into, or the permit issued, only if all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted, all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals, and the activity will not jeopardize the survival or recovery of the species. The agreement or permit must also set out its date of expiry.

Where an environmental assessment for a project is required under a federal statute, including CEAA, 2012, the proponent must notify the Minister if the project is likely to affect a listed wildlife species or its critical habitat (s. 79(1)). If an environmental assessment is required under CEAA, 2012, the authority responsible for making that determination must also notify the Minister of the potential effect on listed species or its habitat (s. 79(1)). The adverse effects must be identified and measures taken to avoid or lessen the effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and actions plans (s. 79(2)).

Offences and Penalties

Under s. 97(1), a person who contravenes sections. 32 or 33 is guilty of an offence punishable on summary conviction and is liable (i) in the case of a corporation to a fine of not more than $300,000, or (ii) in the case of any other person, to a fine of not more than $50,000 or to imprisonment for a term of not more than one year, or to both. For an indictable offence the penalty for a corporation is a fine of not more than $1,000,000, and for an individual a fine of not more than $250,000 or to imprisonment for a term of not more than five years, or to both. For subsequent offences, the penalty is double the amounts set out above (s. 97(3)). A person who commits or continues an offence on more than one day is liable to be convicted for a separate offence for each day on which the offence is committed or continued (s. 97(4)). The court may order the person to pay an additional fine in an amount equal to the court's estimation of the amount of the monetary benefits.

Under s. 99, a person may be charged for an offence committed by an employee or agent.

Under s. 100, due diligence is a defence in a prosecution for an offence. Due diligence is established by demonstrating that even though the offence has occurred, all reasonable steps were taken prior to the offence in order to prevent it from taking place, or that the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

3.3.12 Transportation of Dangerous Goods Act, 1992

Purpose and Scope

The *Transportation of Dangerous Goods Act, 1992* is in place to promote public safety dealing with the transportation of dangerous goods. Both the provinces and territories have memoranda of agreement to work with Transport Canada to enforce transportation on Highways. Transport Canada conducts the enforcement of rail, marine and aviation. In the event of a mishap, the Act assigns roles and responsibilities to shippers, carriers and empowers inspectors to take steps to preserve public safety.

An Act to amend the Transportation of Dangerous Goods Act, 1992 came into force on June 16, 2009. The legislation remains focused on the prevention of incidents during the handling and transportation of dangerous goods. The main amendments to the 1992 Act fall into two categories – safety amendments and new security requirements. The main points are the following:

1) Security

- Requiring security plans and security training;
- Requiring a transportation security clearance for the dangerous goods, including an appeals process;
- Enabling the use of Security Measures and Interim Orders (as in the *Public Safety Act* and 10 other existing Parliament Acts); and
- Enabling regulations to be made to require that dangerous goods are tracked during transport or reported if lost or stolen.

2) Safety

- Reconfirming that the Act is applicable uniformly throughout Canada, including to local works and undertakings (movements of dangerous goods within a province not using a federal carrier/shipper);

- Reinforcing and strengthening Emergency Response Assistance Plan Program – including enabling the use of Emergency Response Assistance Plans to respond to a terrorist release of dangerous goods;
- Enabling inspectors to inspect any place for which a means of containment is being manufactured, repaired or tested (under a warrant if it is a private dwelling);
- Changing the concept of importer so that it is clearer who is the importer in Canada that needs to meet the obligations of the Act; and
- Enabling a shipping record to be used in court as evidence of the presence of a dangerous good in a means of containment.

The *Transportation of Dangerous Goods Regulations* (the "*TDGR*") has been fully adopted in Alberta with some additional provisions included in the provincial regulations. The *TDGR* has been largely adopted by all provinces and territories. The *TDGR* establish the regulatory requirements for handling, offering for transport and transport of dangerous goods by all modes within Canada.

<u>Offences and Penalties</u>

Sections 33(1) and 33(2) provide that every person who contravenes or fails to comply with a provision of the Act, a direction issued under specified provisions of the Act, the regulations, a security measure or an interim order is guilty of an offence punishable on summary conviction and liable to a fine not exceeding $50,000 for a first offence, and not exceeding $100,000 for each subsequent offence. On a conviction for an indictable offence a person is liable to imprisonment for a term not exceeding two years.

Where an offence is committed or continued on more than one day, the person who committed the offence is liable to be convicted for a separate offence for each day on which the offence is committed or continued (s. 36). Before offering for transport or importing any quantity or concentration of dangerous goods prescribed for the purposes of this section, a person shall have an emergency response assistance plan that is approved by the transportation ministry and outlines what is to be done if there is an accident in transporting the dangerous goods (s.7(1)).

The Act creates a duty to report and to respond to accidental releases of dangerous goods. Section 18 indicates that where an accidental release of dangerous goods in excess of a prescribed quantity occurs or is imminent to occur from a means of containment being used to handle or transport dangerous goods, any person who at the time has the charge, management or control of the means of containment must report the occurrence or imminence of the release. As well, every person required to make a report shall take all reasonable emergency measures to reduce or eliminate any danger to public safety that results or may reasonably be expected to result from the release.

3.4 PRIMARY PROVINCIAL LEGISLATIVE REQUIREMENTS

3.4.1 Alberta Land Stewardship Act

The *Alberta Land Stewardship Act* (“ALSA”) provides the legislative framework to support the Government of Alberta's Land-Use Framework (“LUF”). The LUF is a comprehensive strategy to guide the management of public and private lands and natural resources and is meant to provide a blueprint for land use management and decision-making in Alberta. As a component of the LUF, seven regional plans are being prepared to assist with managing cumulative effects at the regional level. All future development decisions and activities must be in accordance with the LUF and thus, the regional plans.

The Lower Athabasca Regional Plan (“LARP”) was the first regional plan under the LUF, put in place in the summer of 2012. LARP identifies and sets resource and environmental management objectives for air, land, water and biodiversity. LARP is intended to guide future resource decisions, while considering social and economic impacts.

The following management frameworks outline monitoring, evaluation and reporting requirements, set early warning triggers to determine the need for action, identify what actions may be taken, and generally set out the Government of Alberta's role in managing cumulative effects in the Lower Athabasca Region:

- Air Quality Management Framework;
- Surface Water Quality Management Framework; and
- Groundwater Management Framework.

The South Saskatchewan Regional Plan 2014-2024 ("SSRP") came into effect on September 1, 2014. This region is comprised of the South Saskatchewan River Basin, the Milk River Basin and the Alberta portion of the Cypress Hills. The SSRP is a policy planning tool in an effort to align economic, environmental, and social goals.

The following are noteworthy points to be taken from the SSRP:

- Eight new/expanded conservation areas, as well as two new and six expanded provincial parks and recreation areas. There will also be new recreation areas for camping and trails.
- Baselines for Air and Water Quality frameworks.
- A concerted effort to consult First Nations peoples on uses of land that may impact their treaty rights and treaty uses.

- Sustainable farming and ranching, energy, and forest management, as well as extension of grazing leases from 10-20 years.
- Development of sustainable and responsible methods for seeking and extracting energy resources.
- Maintenance and diversification of the forestry industry.
- Responsible development of aggregates on public land.
- Focus on developing and protecting the biodiversity and ecosystems of Regional, Crown land and Private land. This development and protection notably includes the maintenance of Native grasslands on public land.
- The management and development of healthy watershed systems.
- The creation and maintenance of safe, responsible transportation systems that can facilitate the future growth of the Province.

In addition, ALSA creates voluntary Conservation Easements supplementing the current legislative scheme set out under the *Environmental Protection and Enhancement Act* to protect agricultural land or land for agricultural purposes and Conservation Directives intended to protect, conserve, manage and enhance certain landscapes on both public land and privately owned land. ALSA provides persons with interests in affected lands a right to apply for compensation, and a mechanism for requesting a review of regional plans. ALSA also allows for the creation of Conservation Offsets and a Transfer of Development Credit Scheme.

3.4.2 Climate Change and Emissions Management Act

The *Specified Gas Reporting Regulation* under the *Climate Change and Emissions Management Act* requires that organizations, including the Crown, report the release of specified gases into the environment at or in excess of the amount specified in the Specified Gas Reporting Standard. The threshold level for submission of a Specified Gas Report under the legislation is currently 100,000 tonnes of certain gases. Currently, the *Specified Gas Reporting Regulation* is set to expire on December 31, 2017.

The *Renewable Fuels Standard Regulation* establishes technical requirements that must be met for a fuel to qualify as “renewable fuel”. This regulation requires suppliers and providers of renewable fuels to submit compliance reports at specified times. The compliance reports must include validation of greenhouse gas emissions from a qualified greenhouse gas validator established under the Regulation.

3.4.3 Dangerous Goods Transportation and Handling Act

The *Dangerous Goods Transportation and Handling Act* prohibits the handling and transportation of dangerous goods, such as explosives, gases, poisonous substances, nuclear substances, and corrosives, unless the requisite safety requirements are met and specific documentation is filed. The penalty for a first offence under this Act is a $50,000 fine and/or 2 years' imprisonment for a first offence.

3.4.4 Environmental Protection and Enhancement Act

Purpose and Scope

The *Environmental Protection and Enhancement Act* ("EPEA") is the key piece of environmental legislation in Alberta. Included are provisions that require the review of proposed projects that could cause an adverse effect on the environment, and the reclamation and conservation of land. Alberta Environment and Parks ("AEP") and the Alberta Energy Regulator ("AER") administer the Act. The legislation is binding on the provincial government. A Director under EPEA is appointed by the responsible Minister and is involved in making key decisions for approvals issued by AEP and the AER, and enforcement actions for contraventions of the legislation.

Environmental Impact Assessments

The primary purpose of the environmental assessment ("EA") process is to integrate environmental protection and economic decisions at the earliest stages of planning, predict the environmental, social, economic and cultural consequences of proposed activities, and assess plans to mitigate any adverse impacts (s. 40). All "mandatory" activities require an EA, and so do and any projects for which the potential environmental impacts warrant further consideration (s. 44).

Mandatory activities under the *Environmental Assessment (Mandatory and Exempted Activities) Regulation* include dams greater than 15 metres in height, water diversion structures and canals with capacity greater than 15 m^3/sec. and water reservoirs with capacity greater than 30 million m^3. Exempted activities include the:

- Widening or realignment of an existing highway; and
- Maintenance and rehabilitation of a water management project, including a dyke, dam, weir floodgate, breakwater, drain, groyne, ditch, basin, reservoir, canal, tunnel, bridge, culvert, embankment, headwork, fishway, flume, aqueduct, pipe, pump or measuring weir.

Where the project is not a mandatory activity, but the potential environmental impacts warrant further consideration, a Director appointed under EPEA will prepare a screening report to determine whether an EA report is required (s. 45(1)).

Where an EA report is required, the proponent must prepare the terms of reference for the EA, which are made available for public comment. Once the terms of reference are finalized, an EA report is prepared in accordance with the terms of reference and including the information set out in s. 49 (need for the project, site selection procedure, baseline data, positive and negative impacts, alternatives to project, mitigation plans, etc.). Once the EA report is complete, the Director submits it to the AER or the Natural Resources Conservation Board ("NRCB"), where the activity requires an approval by either body, or in any other case, to the Minister of Environment (s. 53). The Minister may advise the proponent to apply for an approval, registration or licence, as the case may be (s. 54), and may make any recommendations in respect of the proposed activity that he considers necessary (s. 55).

Water management projects that require an environmental assessment under EPEA (i.e. they are included in the list of mandatory activities in the *Environmental Assessment (Mandatory and Exempted Activities) Regulation*) are:

> The construction, operation or reclamation of
>
> (c) a dam greater than 15 metres in height when measured to the top of the dam
>
> > (i) from the natural bed of the watercourse at the downstream toe of the dam, in the case of a dam across a watercourse, or
> >
> > (ii) from the lowest elevation at the outside limit of the dam, in the case of a dam that is not across a watercourse
>
> (d) a water diversion structure and canals with a capacity greater than 15 cubic metres per second
>
> (e) a water reservoir with a capacity greater than 30 million cubic metres

If the proposed project is not a mandatory activity as defined by the regulation, the Director may decide that the potential environmental impacts warrant further consideration and order that an environmental assessment be undertaken (EPEA, s. 44).

Approvals, Registrations and Codes of Practice

Sections 60 and 61 of EPEA prohibit anyone from commencing or continuing an activity designated by the regulations as requiring an approval or registration unless they hold the required approval or registration. The *Activities Designation Regulation* ("ADR") lists the activities that require an approval (Schedule 1), a registration (Schedule 2) or the filing of a notice (Schedule 3)[3]. Registration activities are governed by a code of practice.

PITS

All pits (including those for sand and gravel extraction) in Alberta are required to comply with the EPEA and associated regulations, regardless of size.

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[3] There are only two activities that require a notice; all other activities listed in the ADR require either an approval or registration.

The *Code of Practice for Pits* (“Code”) was published on September 1, 2004, and forms part of the *Conservation and Reclamation Regulation* under the EPEA. The Code replaces the previous approvals process for all private land pits that are five hectares (12.5 acres) in size or larger under the under the ADR. The Code covers topics such as: registrations and authorizations, operational requirements, conservation and reclamation, reporting, record keeping, etc. For further information, Alberta Environment, as it then was, published A Guide to the Code of Practice for Pits (October 2004).

The Code includes the following specific provisions of interest:

- Written landowner consent will be required to conduct any activity in the pit;
- An "Activities Plan" (detailed in Schedule 2) must be prepared before operating the pit and must be updated and maintained to reflect the operation;
- Pit water cannot be released to an outside pit area if it does not meet criteria outlined in s. 4.2.1;
- Soil conservation requirements apply in respect of topsoil and subsoil; and
- A report on the status of the pit must be submitted every five years.

In addition to the Code, EPEA and the *Conservation and Reclamation Regulation*, operation of pits may invoke the following legislation and considerations:

- Pits less than 2 hectares (5 acres) in size will generally be exempt from the requirement to have an environmental assessment conducted (under the *Environmental Assessment (Mandatory and Exempt Activities) Regulation*, pursuant to EPEA).
- Fee schedules may be prescribed under the *Community Aggregate Payment Levy Regulation*, pursuant to the *Municipal Government Act*.
- Authorizations under the *Water Act* may be required for activities requiring the use of water, or the subject activity or pit may be exempt pursuant to Schedule 3 of the *Water (Ministerial) Regulation*.

ASPHALT PAVING PLANTS

A registration is required for the construction, operation or reclamation of an asphalt paving plant (ADR, Schedule 2, Division 2). Contractors must comply with the *Code of Practice for Asphalt Paving Plants* (“Code”). The *Code* is incorporated by the *Substance Release Regulation* . "Asphalt paving plant" is defined under the Code as "a plant that manufactures asphalt through the mixing of aggregate and asphalt oil or recycled asphalt material, but does not include hot in-place recycling equipment". The Code outlines the minimum operating requirements that asphalt paving plants that produce hot or cold mix asphalt must meet to ensure environmental protection. An asphalt paving plant must be equipped with pollution control technology that meets the requirements of the Code. There are specific operating requirements for plants that use wet scrubbers or a baghouse type system to control particulate emissions. The Code also sets out requirements for record keeping and reporting.

CONCRETE PRODUCING PLANTS

The *Code of Practice for Concrete Producing Plants* is incorporated by the *Substance Release Regulation*, under the authority of s. 36 of EPEA. Persons responsible for plants affected by this Code must register with AEP prior to commencing operation of a concrete producing plant.

"Concrete producing plant" is defined as a “stationary plant that manufactures concrete and has a designed production rate of at least 120 tonnes of concrete per hour or 50 cubic metres of concrete per hour”.

In addition to any information required by the Director under the *Approvals and Registration Procedure Regulation*, the person responsible is required to complete the registration form attached to the Code of Practice for Concrete Producing Plants and forward it to the Director. This Code sets out requirements for pollution control technology, operation, recordkeeping and reporting that must be met.

PESTICIDES

Under Schedule 1, Division 4 of the ADR, an approval is required for the application of pesticides in, on or within 30 horizontal metres of an open body of water. A special use approval is required under s. 9 of the *Pesticide (Ministerial) Regulation* to:

- Use or apply a pesticide in or on an open body of water;
- Use, apply or store a pesticide listed in Schedule 1, 2 or 3 within 30 horizontal metres of an open body of water;
- Store a pesticide within a horizontal distance of 30m from an open body of water; or
- Wash equipment or vehicles used to apply pesticides within 30 horizontal metres of an open body of water

Under Schedule 2, Division 4 of the ADR, a registration is required for:

- Storing or selling pesticides listed in Schedules 1, 2 or 3 of the *Pesticide (Ministerial) Regulation* as a wholesale vendor;
- Selling pesticides listed in Schedule 1 or 2 of the *Pesticide (Ministerial) Regulation* as a retail vendor; and
- Offering a pesticide service, including the use and application of pesticides listed in Schedule 1, 2 or 3 of the *Pesticide (Ministerial) Regulation*.

The *Pesticide (Ministerial) Regulation* requires anyone using or applying a pesticide to have an applicator certificate (s. 3), or to work under the supervision of a certified applicator. The classes of certificates are set out in Schedule 5 and include an "industrial" class for:

> *…the use of herbicides by ground application for controlling weeds on industrial areas including roadsides, power lines, pipelines, rights of way, easements, railways, petroleum well sites and equipment yards.*

In addition, this class includes herbicide applications to parking lots and landscaped areas surrounding industrial facilities for the control of designated noxious or restricted weeds.

In addition to the requirements of the Act and regulations, pesticides applicators, vendors and services must comply with the *Environmental Code of Practice for Pesticides* and the *Pesticide Sales, Handling, Use and Application Regulation*.

Currently, the *Pesticide (Ministerial) Regulation* is set to expire on June 30, 2018.

<u>Release Reporting Requirements</u>

Under ss. 108 and 109, it is prohibited to: (i) release or permit the release, or (ii) knowingly release or permit the release, of a substance into the environment in an amount concentration or level or at a rate of release that is in excess of an approval or a regulation, or that causes or may cause a significant adverse effect.

Section 110 creates a duty to report a release that has caused, is causing or may cause an adverse effect on the environment. The person who releases or causes or permits the release must report it as soon as they know of the release to:

- Director of AEP or AER, as applicable;
- The owner of the substance;
- Their employer;
- The person having control of the substance; and
- Any other person who may be directly affected by the release.

The release must be reported in person or by telephone or by electronic means and must include the information in s. 111(1)(a) to (e). This must be followed up by a written report to AEP within seven days of the verbal report. The written report must contain the information set out in s. 4(3) of the *Release Reporting Regulation*.

EPEA also creates a duty to take remedial measures where a substance is released into the environment that has caused, is causing or may cause an adverse effect. Section 112 places this duty on the "person responsible for the substance", which includes the owner or a previous owner of the substance, every person who has had charge, management or control of the substance and any person who acts as the principle or agent of any of these persons (s. 1(tt)). Required measures include repairing, remedying and confining the effects of the substance, removing or otherwise disposing of the substance, and restoring the environment to a condition satisfactory to AEP.

Under s. 113, where the Director is of the opinion that a release of a substance may occur, is occurring or has occurred, and the release may cause, is causing or has caused an adverse effect, the Director may issue an Environmental Protection Order (EPO) to the person responsible for the substance. An EPO may be issued under this section in respect of a substance released several years in the past.

In addition to the general releases provisions under EPEA, the *Substance Release Regulation* (“Regulation”) specifically addresses air emissions that result in “visible emissions” and “particulate releases.” The Regulation prohibits the release of any emissions into the ambient air that would impair the visibility along a highway or developed property (s. 5). Section 4 of the Regulation applies to prohibit visible emissions from a source that exceeds an opacity level of 40% for more than 6 consecutive minutes unless otherwise stated in an approval.

Part 2 of the Regulation applies to limit the amount of particulate matter that may be emitted by various types of operations. Section 8(1)(b)(v) of the Regulation establishes that operations, including the manufacturing of asphalt, are limited to emitting 0.20 grams per kilogram of effluent.

Part 3.1 of the Regulation applies to require that activities listed in the Schedule attached to the Regulation must comply with all provisions of the applicable Code of Practice. Asphalt paving plants have a Code of Practice that applies to limit the release of substances from these types of activities.

<u>Conservation and Reclamation</u>

Conservation and reclamation of land is dealt with in Part 6 of EPEA and in the *Conservation and Reclamation Regulation* (“CRR”). Under s. 137 of EPEA, an operator is required to conserve and reclaim specified land and obtain a reclamation certificate (unless the requirement for a certificate is exempted under the regulations). "Operator" is defined in s. 134 of EPEA and includes:

- An approval or registration holder who carries on/has carried on an activity on or in respect of specified land under the approval or registration;
- Any person who carries on/has carried on an activity on or in respect of specified land (other than under an approval or registration); and
- Anyone acting as a principal or agent of the persons referred to above.

"Specified land" includes land used for the construction, operation or reclamation of a pit or borrow excavation, and the construction or reclamation of a roadway (s. 1(t) of the regulation). “Pit” has the same definition as in the ADR. “Borrow excavation” is defined in s.

1(b.1) of the CRR as "an excavation[4] in the surface made solely for the purpose of removing borrow material for the construction of the sub-base for a specific roadway project or the construction of a dam, canal, dike, structure or erosion protection works associated with a provincial water management infrastructure project, and includes any associated infrastructure[5] connected with the borrow excavation. "Roadway" means a highway or road as defined in the *Public Highways Development Act* (includes a bridge forming part of the highway and any structure incidental to the highway or bridge).

Specified land must be returned to an "equivalent land capability" defined in s. 1(e) as the ability of land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land. The individual land uses will not necessarily be identical. The operator must obtain a reclamation certificate for all borrow excavations over 5 hectares in size. A reclamation certificate is not required for a borrow excavation less than 5 hectares (12.5 acres) in size. However, without a reclamation certificate the operator remains liable for conservation and reclamation issues.

The Department has published three guidelines relating to borrow excavations and reclamation:

- Alberta Transportation Pre-Disturbance Assessment Procedures for Borrow Excavation for Road Construction (December 2013);
- Alberta Transportation Post-Disturbance Reclamation Criteria and Assessment Procedures for Borrow Excavation (December 2013); and
- Alberta Transportation Guide to Reclaiming Borrow Excavation Used for Road Construction (December 2013).

Snow and Ice Removal and Disposal

Snow and ice removal and disposal does not require an approval, registration or notice under EPEA, however, it can pose a risk to the environment as snow on highways can contain contaminants such as suspended solids, organic chemicals, phosphates, dissolved salts, heavy metals, trash and oil.

The *Snow Disposal Guidelines for the Province of Alberta* (1994) set out siting and design guidelines for snow/ice disposal sites. The guidelines discourage the direct dumping of waste snow into watercourses or onto ice-covered water bodies and advise against the disposal of snow in or adjacent to landfills, on prime agricultural land, above a groundwater

[4] This definition is restricted to excavations that are outside the highway right-of-way. Excavations inside the right-of-way are treated as part of the right-of-way and subject to the *Environmental Protection Guidelines for Roadways* (see AESRD*IL 00-3: Borrow Excavation*).
[5] Defined in s. 1(h.1) of the CRR as "any works, buildings, structures, facilities, equipment, apparatus, mechanism, instrument or machinery belonging to or used in connection with a mine, oil production site, well, battery, pipeline, quarry, pit, borrow excavation, peat operation, coal processing plant, plant or transmission line, and includes any storage site or facility, disposal site or facility, access road, haul road, railway or telecommunication line".

aquifer with a high water table, on land with below ground or above ground utilities, closer than 350 meters from residential areas, near recreational areas, or closer than 200 meters from any water body.

The guidelines set out design mitigation measures that may be required: containment (e.g. earthen berms and compacted subgrades), settling ponds, grading, release of meltwater, site base (e.g. asphalt, clay or waterproof membrane) and security (fencing and lighting). Snow disposal sites are to be located to ensure melt water runoff does not flood adjacent lands and maximum exposure to the sun provides for rapid snowmelt.

Salt Contamination and Remediation

The *Salt Contamination Assessment and Remediation Guidelines* (2001) govern salt releases that occur in association with "salt/sand processing and storage facilities at highway maintenance yards". AEP regulates the release of salt through the general release of substances provisions under EPEA. Any remediation of salt impacted lands must meet the requirements of EPEA – specifically Part 5, Division 1. This includes prevention and mitigation of adverse effects caused by a release of salt into the environment and reclamation when there has been an impact.

The guidelines provide generic remediation procedures and objectives (soil and water quality guidelines). As an alternative, a site-specific risk management approach may be used to develop site-specific remediation procedures and objectives. The guidelines contain a comprehensive risk assessment procedure and outline various remediation methods and procedures that may be utilized on a site-specific basis.

Waste Management and Disposal

The disposal of waste is generally addressed under Part 9, Division 2 of EPEA. Section 176 of EPEA prohibits the disposal of waste except in accordance with an approval or registration, or as otherwise provided for within EPEA. EPEA also prohibits the disposal of waste on public land (s. 178), highways (s. 179) and on, into or under water or ice except in accordance with an approval, a Code of Practice or a registration or as otherwise provided for under this Act. (s.181). The *Waste Control Regulation* ("WCR") imposes specific requirements with respect to the management of both hazardous and non-hazardous wastes. Section 23 prohibits the disposal of waste in any place other than a waste management facility authorized under EPEA and the WCR. This prohibition does not apply to the disposal of agricultural waste by a farmer on his own land where the waste is produced on his farm, the depositing of earth, or inert waste used for reclamation.

The WCR creates three classes of landfills in Alberta. Class I landfills are for the disposal of hazardous waste; Class II landfills accept non-hazardous waste (municipal); Class III landfills accept inert waste (such as demolition debris, concrete, glass, etc.).

Road kill is considered "waste" under the provisions of EPEA and the WCR. There are some Class II landfills in Alberta that specifically accept animal carcasses. Road kill can also trigger the *Wildlife Act* (discussed below).

Remediation of Contaminated Sites

AEP applies the following guidelines to remediation of contaminated sites: *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* and *Alberta Tier 2 Soil and Groundwater Remediation Guidelines.*

The Tier 1 guidelines consolidate updated guidelines from a number of sources (Canadian Council of Ministers of the Environment, Health Canada, and Alberta Environment) into one document. The Tier 2 guidelines describe how the Tier 1 guidelines can be modified using site-specific information. Both provide information on managing contaminated sites and include common objectives for the assessment and remediation of all contaminated sites.

EPEA authorizes the Director or inspector to issue a remediation certificate where contaminated land has been remediated. Remediation certificates are issued pursuant to the *Remediation Certificate Regulation*. Remediation certificates are currently available for: (i) sites with petroleum storage tanks, (ii) facilities operating under approvals, (iii) facilities operating under codes of practice, (iv) other commercial and industrial contaminated sites, and (v) upstream oil and gas sites. While encouraging remediation of contaminated land, the remediation certificate also protects the responsible party from future regulatory liability. Remediation certificates can be issued after a third party verification process is completed.

Offences and Penalties

AEP can either take administrative enforcement action or prosecute in response to a contravention. There are four types of administrative enforcement tools: (i) warnings, (ii) environmental protection orders, (iii) enforcement orders, and (iv) administrative penalties. AEP may decide that the circumstances of the offence are serious enough to warrant prosecution, in which case the matter is referred to the Provincial Crown Prosecutor. Section 227 sets out the list of offences and s. 228 the list of penalties under EPEA. These are summarized in Table A.2 in Appendix A to the Manual.

An offender is liable for each day or part of a day that the offence occurs or continues (s. 231). Where the offender received monetary benefits as a result of the commission of the offence, the court may order the offender to pay an amount equal to those monetary benefits (s. 230). Section 234 sets out a list of possible orders that may be imposed by the court. Examples include directing the offender to publish the facts relating to the conviction, post a bond or pay money into court, and/or perform community service. Under s. 235, an offender may be ordered to compensate a victim for loss of or damage to property as a result of the commission of the offence.

Section 233 relates to liability of public officials. The relevant portions read:

(1) Where a person who is acting under the direction of

(a) a Minister of the Government, [or]

(b) an official of the Government,

commits an offence under this Act, the Minister [or] official… is also guilty of the offence and is liable for the punishment provided for the offence,… if he knew… or ought reasonably to have known of the circumstances that constituted the commission of the offence and had the influence or control to prevent its commission, whether or not the other person has been prosecuted for or convicted of the offence.

(2) No person shall be convicted of an offence by reason of the operation of subsection (1) if that person establishes on a balance of probabilities that he took all reasonable steps to prevent the commission of the offence by the other person referred to in subsection (1).

In addition to EPEA, a breach of the *Substance Release Regulation* is an offence and individual offenders are liable to a maximum fine of $50,000 or, in the case of a corporate offender, a maximum fine of up to $500,000 (s. 16.1 of the Regulation).

Most of the offences under EPEA and regulations are “strict liability” offences. Due diligence is a defence to strict liability offences. A successful due diligence defence is established if it is shown that all reasonable steps were taken to prevent the incident from occurring. These steps must have been taken prior to the incident in order for the defence to succeed. A due diligence defence can also be established if it the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

3.4.5 Forest and Prairie Protection Act

The *Forest and Prairie Protection Act* aims to control fire hazards on Alberta lands by placing restrictions on fires. For example, it is an offence under the Act to discard a burning substance in a place where it might result in a fire. The legislation also gives forest officers and fire guardians the power to inspect, investigate and make orders respecting fires.

3.4.6 Government Organization Act

The *Government Organization Act* generally governs the rights and responsibilities of government ministries, departments and staff. It also contains a Schedule dealing specifically with environmental matters. The Minister can expropriate land for environmental purposes, declare an environmental state of emergency, develop areas of restricted use and development, grant enforcement orders, and take other steps in furtherance of environmental objectives.

3.4.7 Historical Resources Act

Purpose and Scope

The *Historical Resources Act* is administered by the Minister of Alberta Culture. The purpose is to preserve, protect and present historical and archaeological resources of provincial, national and international significance. The definitions of "historical resource" and "archaeological resource" in s. 1 of the Act are very broad:

> *"archaeological resource" means a work of humans that (i) is primarily of value for its prehistoric, historic, cultural or scientific significance, and (ii) is or was buried or partially buried in land in Alberta or submerged beneath the surface of any watercourse or permanent body of water in Alberta*
>
> *"historical resource" means any work of nature or of humans that is primarily of value for its palaeontological, prehistoric, historic, cultural, natural, scientific or aesthetic interest including, but not limited to, a palaeontological, archaeological, prehistoric, historic or natural site, structure of object*

Title to all archaeological and paleontological resources in Alberta is vested in the Crown in right of Alberta (s. 32(1)).

Orders and Approvals

General prohibitions in the *Act* include s. 34(1), which prohibits anyone from altering, marking or damaging an archaeological resource or paleontological resource unless he is the holder of a research permit under s. 30 or has the written permission of the Minister. Any person who discovers an historic resource in the course of making an excavation for any purpose, other than research, must immediately notify the Minister of the discovery (s. 31).

Under s. 37, where any operation or activity will, or is likely to, result in the alteration, damage or destruction of historical resources, the person undertaking the activity or operation may be ordered to:

- Carry out an assessment to determine the effect of the proposed activity or operation on historical resources in the area where the activity is being carried on;
- Prepare and submit a report containing the assessment of the proposed activity or operation; and
- Undertake all salvage, preservation or protective measures or take any other action the Minister considers necessary.

Any project can attract the requirements of the *Act*, depending upon where the project is located, the existence of historic resources, the extent to which the area has already been disturbed, and the extent to which it will be further disturbed by the activity.

Offences and Penalties

A "temporary stop order" can be issued under s. 49. If a person is doing an activity that is likely to result in damage to or destruction of a potential historical resource, the Minister can order the person to cease the activity for a period not exceeding 15 days. If the potential historical resource qualifies for designation, the stop order can be extended for a further specified period to allow for salvage, recording or excavation of the historical resource and investigation of alternatives to its destruction (s. 49(2)). The person issued the order can appeal the order to the Court of Queen's Bench, and the Court may confirm, vary or rescind the order (s. 49(3)).

Under s. 53, the Crown is bound by the *Act* except for specific sections, including s. 52 (offences and penalties). As such, a government department is not liable for an offence, but can be issued a stop order under s. 49.

3.4.8 Natural Resources Conservation Board Act

Purpose and Scope

The *Natural Resources Conservation Board Act* is administered by the Natural Resources Conservation Board ("NRCB"). The Crown is bound by the Act. The purpose of the *Act* is set out in s. 2:

> *…to provide for an impartial process to review projects that will or may affect the natural resources of Alberta in order to determine whether, in the Board's opinion, the projects are in the public interest, having regard to the social and economic effects of the projects and the effect of the project on the environment.*

Projects that are reviewed by the NRCB include forest, recreation and tourism, mining, and water management projects, and projects referred to the NRCB by the provincial cabinet. "Water management projects" are defined in s. 1(j) as:

- a project to construct a dam, reservoir or barrier to store water or water containing any other substance for which an environmental impact assessment report has been ordered; or
- a project to construct a water diversion structure or canal capable of conducting water or water containing another substance for which an environmental impact assessment report has been ordered.

Approvals

No person may commence a reviewable project unless the NRCB, on application, has granted an approval for the project (s. 5(1)). NRCB approvals must be authorized by the Alberta cabinet and are in addition to any licenses, permits or approvals stipulated by other acts, regulations or by-laws. The NRCB decides if these projects are in the public interest and in making this determination must consider social, economic and environmental effects (s. 2).

3.4.9 Provincial Parks Act

The *Provincial Parks Act* aims to maintain and protect Alberta's parks and recreation areas. Pursuant to the *Act*, parks and recreation areas can be acquired and managed by the Minister in order to ensure their environmental integrity. The Minister must grant a disposition before construction, storage, landscaping, or other such activities may occur in a designated park or recreation area.

3.4.10 Public Highways Development Act

The *Public Highways Development Act* governs the construction, maintenance, use and protection of highways in the province. The *Act* prohibits actions that could injure highways, such as the deposit of any material without justification or excuse.

3.4.11 Public Lands Act

<u>Purpose and Scope</u>

The *Public Lands Act* ("PLA") only applies to public land under the administration of the Minister of Environment and Parks (s. 2(1)) and the Alberta Energy Regulator ("AER") (per s. 2.01). It does not apply to land under the administration of another Minister. All public land is under the administration of the Minister of Environment and Parks unless otherwise stated in an act or ordered by the Lieutenant Governor in Council (s. 2(2)). Rights of way for roads and road allowances are under the administration of the Minister of Transportation. However, naturally occurring water bodies fall under the authority of AEP and are therefore subject to the Act.

With a few exceptions, title to the beds and shores of (a) all permanent and naturally occurring bodies of water, and (b) all naturally occurring rivers, streams, watercourses and lakes, is vested in the Crown in right of Alberta (s. 3). Water and the use of water is also under provincial jurisdiction through the *Water Act*. The extent of the Province's ownership of the bed and shore is limited by the bank of the water body (defined in s. 17(2) of the *Surveys Act)*. This is the line along the upper limit of the bed and shore. It is formed by the normal, continuous action or presence of surface water on the land, that forms a natural boundary between the Crown owned bed and shore, and privately owned land. The location of the bank is not affected by occasional periods of drought or flooding. The 'bed' is the land on which the water sits, and the 'shore' is that part of the bed that is exposed when water levels are not at their normal fullest level.

<u>Approvals</u>

Generally speaking, approvals are required under the PLA for any activity that may disturb or modify the bed and/or shore of a water body or impact the aquatic environment (s.54(1)).

As well, approvals are necessary where a person creates a condition that may cause a danger by fire or soil erosion. To view a list of common activities that require a *Public Lands Act* approval visit the AEP and AER websites.

The following activities are exempt from the approval requirement:

- Temporary, seasonal docks/piers and associated mooring structures[6] - by policy, AEP does not currently require an approval for the placement of docks/piers and associated mooring facilities on the bed and shore of a lake or river, provided that:
  - Use of mooring structures is reasonable[7]
  - A single pier or dock that is appurtenant to a riparian landowner's upland
  - Associated mooring structures are limited to boat lifts and shelters, or a swimming raft
  - All structures are temporary for seasonal, non-commercial use
  - At the end of the recreational season, all such structures are completely removed from public land and stored on private property over the winter
- Pipeline watercourse crossings - pipelines installed across a watercourse and regulated by the *Code of Practice for Pipelines and Telecommunication Lines Crossing a Water Body* under the *Water Act* will only require an approval under the following conditions:
  - Public land is adjacent on both sides of the watercourse
  - Pipeline company requests an approval to ensure location is identified within departmental records
  - At the request of a departmental officer
- Road allowances on beds and shores – Generally, title to beds and shores of all permanent and naturally occurring waterbodies, including all naturally occurring rivers, streams, watercourses and lakes, is vested in the Government of Alberta, as indicated in section 3 of the Act. However, surveyed and un-surveyed road allowances that cross a Government of Alberta -owned waterbody or watercourse are considered to be highways or roads under Schedule 14 of the *Government Organization Act* and administration of the areas of the waterbody or watercourse in the road allowance is

[6] Some exceptions apply to the placement of mooring structures on the bed and shore of a water body, particularly in those areas or circumstances where: (i) the provincial or federal government identifies an environmentally sensitive area or a management concern and restrictions have been established, (ii) a local municipal development plan, a lake management plan, or a water management plan limits or restricts such uses, (iii) the proposed structure's design may interfere with the normal flow of water or is likely to increase the probability of bank or shoreline erosion, or (iv) such structures may block public access along the bed or shore of the water body.
[7] "Reasonable use" is defined as the balance between a riparian owner's right to access, construct, place and use a temporary pier or wharf on the bed of a navigable water body for the purpose of facilitating navigation; the rights of another adjacent riparian owner; and that which is in the general public's interest, including their right of access along the shore of a Crown owned water body, navigation, etc.

transferred to Alberta Transportation for administration as part of a highway right-of-way.[8]

A permit is required to divert water, or prior to developing the following structures or modifications on lake beds, shores and floodplains:

- Any project (temporary or permanent) that impacts the aquatic environment or involves the disturbance, modification, placement or removal of material on the lake's bed, shore or floodplain (includes removal of pressure ridges caused by ice thrusts and the placement of sand for beaches
- Any commercial development (temporary or permanent)
- Cutting or removal of aquatic vegetation
- Erosion protection, retaining walls, groynes, breakwaters and causeways
- Permanent piers, boat launches, boathouses, etc., and other associated improvements
- Permanent waterline installations into or beneath the lake
- Other permanent structures on the bed, shore or floodplain of the lake

Applications are reviewed for potential impacts to the water body's bed and shore, floodplain, water quality, fish and wildlife habitat, and public access.

<u>Offences and Penalties</u>

Under section 54 the following activities are prohibited, unless one is authorized under the PLA or any other applicable legislation:

- Loss or damage to public land;
- Existence of any conditions or activities on, or the use of, public land that is likely to result in loss or damage to public land;
- The accumulation of waste material, debris, refuse or garbage on public land;
- The existence on public land of any structure or excavation of any kind that is undesirable or otherwise in contravention of this Act or the regulations;
- The doing of any act on public land that may injuriously affect watershed capacity;
- 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; and

[8] See ESRD publication "Roadway Development Administered under the Public Lands Act", online:<http://aep.alberta.ca/forms-maps-services/directives/documents/RoadwayDevelopmentPublicLands-May2013.pdf>.

- The creation of any condition on public land which is likely to result in soil erosion.

Under section 59(2), the general penalty for an offence under the PLA or the regulations is a fine not exceeding $100,000 in the case of an individual, and a fine of not more than $1,000,000 for a corporation. Section 59 of the Act provides for the defence of due diligence (i.e., the person can show on a balance of probabilities that they took all reasonable steps to prevent the offence or that the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant).

Sections 59.01 and 59.02 enable courts to issue orders relating to penalties in addition to any other penalty that may be imposed under the PLA or the regulations. Courts may consider the nature of the offence and the circumstances surrounding its commission when issuing an order. An order may have effects such as:

- Prohibiting the offender from doing anything that might result in the continuation or repetition of the offence;
- Directing the offender to take any action the court considers appropriate to remedy or prevent any loss or damage to public land that results or might result from the act or omission that constituted the offence;
- Directing the offender to publish the facts relating to the conviction;
- Directing the offender to notify any person aggrieved or affected by the offender's conduct of the facts relating to the conviction, in the prescribed manner and at the offender's cost;
- Directing the offender to post a bond or pay money into court in an amount that will ensure compliance with any order made pursuant to this section;
- Directing the offender to compensate the Minister, in whole or in part, for the cost of any remedial or preventive action that was carried out or caused to be carried out by the Crown and was made necessary by the act or omission that constituted the offence; and
- Directing the offender to pay to the Crown or aggrieved person an amount by way of satisfaction or compensation for loss of or damage to property suffered by the Crown or aggrieved person as a result of the commission of the offence.

Whether or not a person has been charged with or convicted of an offence, the Director can issue an enforcement order under s. 59.1 ordering the person to, among other things, do or refrain from doing anything, carry out any specified measures, and remedy the effects of the contravention. If the person fails to comply with the order, the Director can carry out its terms and recover the costs from the person in an action in debt (ss. 59.1 (6). All persons named in an order are jointly responsible for carrying out the order and jointly and severally liable for the costs.

Section 170 of the *Public Lands Administration Regulation* allows the Director to determine the amount payable for an unauthorized use of public lands.

3.4.12 Responsible Energy Development Act

- Section removed -

3.4.13 Soil Conservation Act

The *Soil Conservation Act* imposes a duty on landholders to take appropriate measures in respect of their land to prevent soils loss or deterioration from taking place, or, in the event such soil loss or deterioration is taking place, to stop the loss or deterioration from continuing. The landholder is the occupant of the land, or the owner of the land, if there is no occupant. An occupant is a person other than the landowner who occupies or exercises control over the land.

Therefore, to the extent that the Department is occupying or exercising control over the land they are working on, they will be landholders for the purposes of this Act.

The Act contains an enforcement scheme to enforce remedial measures given by notice to a landholder by an officer under the Act. In addition, the Act permits “local authorities” (Municipal Council or Authority, or the Minister responsible for the *Municipal Government Act* and *Special Areas Act)* to regulate the removal of topsoil from and burning of stubble on land. Local authority by-laws and guidelines, if any, must be consulted to ensure compliance in respect of soil conservation (s.21).

This Act does not apply in respect of the specified land within the meaning of Part 6 of EPEA, which are provisions dealing with conservation and reclamation of land.

3.4.14 Special Areas Act

The *Special Areas Act* allows the Lieutenant Governor in Council to designate portions of Alberta as “special areas”. The Minister can then regulate what is allowed and prohibited on the land in the special area. For example, the Minister can order a landowner to adopt any method of farming or grazing that the Minister considers necessary to prevent soil drifting, water erosion, over-grazing or any hazard that might jeopardize the economic security of residents in the special area.

3.4.15 Water Act

<u>Purpose and Scope</u>

The *Water Act* regulates the allocation, protection and conservation of water in the Province of Alberta and is administered by Alberta Environment and Parks and the Alberta Energy Regulator. The Crown is bound by the Act.

Dam Safety

Regulatory authority over oil, gas and coal related energy dams was transferred to the Alberta Energy Regulator on April 1, 2014. AEP continues to be the primary regulator under the *Water Act* and Regulations and retains regulatory authority over all other dams in the Province. A review of the Dam Safety Regulatory System in 2016 has led to a number of changes, including: preparation of formal Dam Safety Strategic and Operational Plans, updating Dam Safety Guidelines, and launching dam safety web pages. A formal review of the *Water (Ministerial) Regulation* also started in 2015-16, but to date no amendments have been made to the Regulation concerning dam safety.

<u>Wetlands</u>

From 1993 to 2015, Alberta operated pursuant to an interim wetlands policy that applied only in the settled areas of the province. Currently, the Alberta Wetland Policy is in place to conserve, restore, protect, and manage Alberta's wetlands in both the Green Area and White Area of the province (these are Crown lands and settled lands, respectively). The implementation of the Alberta Wetland Policy has occurred in a phased manner. As of June 1, 2015 in the White Area, and July 4, 2016 in the Green Area, proponents that are planning an activity or water diversion that may impact a wetland must submit wetland-related *Water Act* and *Public Lands Act* applications in accordance with the Alberta Wetland Policy. This coincides with the beginning of the field season for conducting wetland field assessments.

Proponents that are planning an activity or water diversion that may impact a wetland must follow a three-stage application process which involves:

1. Planning and Legislative Alignment;
2. Wetland Assessment; and
3. Application Submission.

The first stage involves conducting a preliminary review of ownership, identifying and delineating wetlands, and estimating the relative value of the wetlands. The next step is to determine if regulatory approval is needed for the activity and if so, under which legislation (the *Public Lands Act* or the *Water Act*).

The assessment step requires a Qualified Wetland Science Practitioner ("QWSP") to perform a wetland assessment. Following this, the Alberta Wetland Mitigation Directive (at sections 5 and 6) provides criteria to help proponents review the assessment results, determine if they wish to proceed with an application, and identify best management practices for minimizing the impact of the planned activity on the wetland.

Once a proponent reaches the application submission stage, if avoidance is not an option, discussions with AEP may be appropriate to determine if replacement options can be considered. The Alberta Wetland Mitigation Directive dated July 4, 2016 provides details for wetland replacement requirements, including a Wetland Replacement Matrix. A Wetland Replacement Agent Program is also under development (there are presently only two designated replacement agents).

The following are applicable to all stages of the application process:

1. The Wetland Mitigation Hierarchy. This is provided for in both the Alberta Wetland Policy, and the Alberta Wetland Mitigation Directive. As noted, this Hierarchy informs the management approach to wetland impacts in Alberta. The mitigation hierarchy places a strong emphasis on wetland avoidance, but considers minimization if avoidance is not possible, and provides for wetland replacement as the last option. Replacement is the third and final element of the hierarchy, available as a last resort and where avoidance or minimization efforts are not feasible or have proven ineffective.

2. The QWSP program and standards provide professionals with information to assist applicants in completing all stages of the wetland application process; from desktop planning to replacement plans.

Reference should also be made to the September 2015 Wetland Application Checklist for full details of what a proponent should include in applications under the *Water Act* and *Public Lands Act* pertaining to wetland impacts.

<u>Approvals</u>

Section 36(1) of the Act prohibits anyone from commencing or continuing an activity unless that person holds the required approval. "Activity" is broadly defined in s. 1(1)(b) and can be summarized as:

- Placing, constructing, operating, maintaining, removing or disturbing works
- Maintaining, removing or disturbing ground, vegetation or other material
- Carrying out any undertaking in or on any land, water or water body that:
    - alters or may alter the flow or level of water,
    - changes or may change the location of water or direction or flow of water,
    - causes or may cause siltation of water or erosion of the bed or shore, or
    - causes or may cause an effect on the aquatic environment

- Altering the flow, direction of flow, level of water or changing the location of water for removing an ice jam, drainage, flood control, erosion control or channel realignment
- Drilling or reclaiming a water well or borehole
- Anything defined as an activity in the regulations

The *Water (Ministerial) Regulation* (“WMR”) defines "activity" as anything (i) conducted by a licensee subject to a license, (ii) impairing or may impair the rights of any household or traditional agricultural user, or (iii) causing a or may cause a significant adverse effect on the aquatic environment, human health, property or public safety.

There are two groups of activities exempt from the approval requirement: (i) activities listed in Schedules 1 and 2 of the WMR, and (ii) activities that require the giving of notice to the Director and are conducted pursuant to a code of practice.

Schedule 1 exempt activities include, but are not limited to:

- Placing, constructing, installing, maintaining, replacing or removing:
  - floating platforms, portable or seasonal piers, boat launches or docks in or adjacent to water bodies
  - fences in or adjacent to water bodies
  - crossings in water bodies that (i) are not frequented by fish, (ii) are not altered at flood events below the 1/25 year flood event, (iii) have a culvert 1.5 metres in diameter or less (where applicable), (iv) divert no water, and (v) the installation of the crossing is not part of a causeway through a lake, slough, wetland or other similar water body
- 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 license is not required for the diversion of the water
- Landscaping where it is not adjacent to a water course nor will change the flow or volume of water on an adjacent parcel
- 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
- Removing a beaver dam from a water body if the person removing the dam owns or occupies the land adjacent to it or has been authorized to remove it under s. 95 of the Act
- Constructing, installing, maintaining, replacing or filling in a dugout, except where the dugout is located in a watercourse, lake or wetland

Schedule 2 lists activities within designated areas of the province for which an approval is required.

Licenses

A license is required under s. 49(1) of the Act to commence or continue a diversion of water for any purpose, or to operate a works. "Works" is defined broadly as any man-made structure, device or contrivance (includes dam or canal) and the land and mitigative measures associated with it.

Diversions or works exempt from the license requirement include those:

- for household purposes;
- already subject to a registration or approval;
- diversions/works listed in Schedules 3 and 4 of the WMR; and
- temporary diversion carried out pursuant to a code of practice and requiring the giving of notice to the Director.

Codes of Practice

Sections 36(2) and 49(1) of the Act prohibit anyone from commencing or carrying on an activity, diversion of water or operation of a works that are subject to a code of practice unless notice is provided to the Director in accordance with the regulations. The following activities are subject to codes of practice:

- Pipeline crossing or telecommunication line crossing – *Code of Practice for Pipelines and Telecommunications Lines Crossing a Water Body*
- Watercourse crossing –*Code of Practice for Watercourse Crossings*
- Diversion of water for hydrostatic testing of pipelines –*Code of Practice for the Temporary Diversion of Water for Hydrostatic Testing of Pipelines*
- Outfall structure – *Code of Practice for Outfall Structures on Water Bodies*

CODE OF PRACTICE FOR WATERCOURSE CROSSINGS

A "watercourse crossing" is defined in the Code as any permanent or temporary structure that crosses or is being constructed to cross, over or through a water body, including associated permanent or temporary structures (i.e. isolation measures, erosion protection structures and sedimentation management structures). Owners of crossings and those who conduct works (i.e. construction, maintenance, replacement or removal of all or part of a crossing) are bound by the Code (s. 2). Notice must be given to the Director at least 14 days in advance of works being carried out (s. 3). The substantive requirements of the notice include schedule, plans, maps, class of water body, and type of watercourse crossing. Any variation in the works requires a new notice (s. 4). Notice is not required in emergency situations (s. 5) however the Director must be notified within 24 hours of the owner becoming aware of the emergency and within 30 days of completion of works to deal with the emergency the owner must provide further information to the Director. A restricted activity period for works may apply (s. 10). The owner must maintain records regarding the works undertaken under their notice (s. 13). Upon contravention of the Code, owners must report to the Director within 24 hours and must file a written report to the Director within seven days (s. 12).

Offences and Penalties

Section 142 of the Act sets out a number of offences, including:

- Contravening or knowingly contravening a water management order;
- Failing to provide information as required;
- Contravening or knowingly contravening an enforcement order;
- Contravening a term or condition of an approval or license; and
- Commencing or continuing or knowingly commencing or continuing an activity except under an approval or as otherwise authorized by the Act.

A Director can issue a water management order (s. 97), an enforcement order (s. 135, s. 136) or an administrative penalty (s. 152). Section 143 sets out the penalties that can be imposed if an accused is found guilty of an offence. For offences listed in s. 142(2) that require proof that the accused "knowingly" committed the offence, the maximum penalty for an individual is a $100,000 fine and/or imprisonment for a term not more than 2 years. For a corporation, the maximum penalty is a $1,000,000 fine. For offences listed in s. 142(1) (that do not require proof of intention), the maximum penalty for an individual is $50,000 and for a corporation, $500,000. There are a few offences listed under s. 142(1) that have less maximum penalties.

An offender is liable for each day or part of a day that the offence occurs or continues (s. 145). Where the offender received monetary benefits as a result of the commission of the offence, the court may order the offender to pay an amount equal to those monetary benefits (s. 144). Section 148 sets out a list of ”creative sentencing” that may be imposed by the court. Examples include directing the offender to publish the facts relating to the conviction, post a bond or pay money into court, and/or perform community service. Section 147(1) deals with liability of public officials and is the same wording used in s. 233 of the *Environmental Protection and Enhancement Act*.

For the "strict liability" offences in s. 142(1), a due diligence defence is established if it is shown that all reasonable steps were taken to prevent the incident from occurring. These steps must have been taken prior to the incident in order for the defence to succeed. A due diligence defence can also be established if it the accused reasonably but mistakenly believed in a set of facts which if true, would have rendered the activity in question compliant.

3.4.16 Weed Control Act

Purpose and Scope

Sections 2,and 3 of the *Weed Control Act* imposes a duty on the occupant or owner of lands to destroy all prohibited noxious weeds and control all noxious weeds to prevent the spread, growth, ripening or scattering of the weeds. The *Weed Control Regulation* outlines what are “noxious” and “prohibited noxious” weeds for the purposes of the Act. "Occupant" is defined as the person actually or having the right to occupy or exercise control of lands (s. 1(k)). Under s. 2(2) of the *Public Lands Act*, the Minister of Transportation has authority over all rights of way for roads and road allowances.

Section 4 prohibits the movement of machines or vehicles that if moved would likely cause the spread of noxious or prohibited noxious weeds. Section 13 of the Act outlines that an inspector under the Act shall, upon finding prohibited noxious weeds give notice to the occupant or owner to destroy such weeds. Section 14 provides that the inspector must direct the method and time for compliance with the Act. An occupant or owner in receipt of a notice has a duty to comply (s. 17), and if they fail to do so the inspector may carry out the action required in the notice (s. 18) – expenses will be assigned to the owner of the lands (s.21).

Offences and Penalties

The Minister may issue a stop order under s.16, to anyone who contravenes the Act or regulations or operates anything that contributes to the spread of weeds. Section 28 provides that anyone who fails to comply with the stop order is liable to a fine of $1,000 (maximum) for each day the offence continues. Contravention of the Act or regulations may result in a maximum fine of $5,000 (s. 28).

3.4.17 Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Act

The *Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Act* allows the Lieutenant Governor in Council to establish wilderness areas, ecological reserves, natural areas and heritage rangelands, and to take measures to protect and preserve these lands. A number of activities are prohibited on these lands, including hunting, fishing, depositing litter, removing plant or animal life, lighting a fire, or in any way disturbing the surface of the land.

3.4.18 Wildlife Act

Disturbance of Habitat

Section 36 of the *Wildlife Act* prohibits the disturbance of wildlife habitation. A person must not molest, disturb or destroy a house, nest or den of prescribed wildlife or a beaver dam in prescribed areas and at prescribed times of the year, unless the person is authorized to do so pursuant to the *Agricultural Pests Act*, the *Water Act*, a licence authorizing the control or collection of wildlife, or regulations under the Act.

The term of “domestic cervid” has been removed from the Act, such that the definition previously found at section 1(1)(f.1) is repealed and all reference to domestic cervids or its related terms are removed. In some instances, the provision with the term “domestic cervid” or “domestic cervid production farm” is repealed entirely or else the term is replaced by other phrases such as “wildlife”, “controlled animal” or “diversified livestock animal”.

Section 96 of the *Wildlife Regulation* prescribes the wildlife, areas and times of year to which s. 36 of the Act applies. Included are all endangered wildlife, upland game birds, some migratory birds, snakes, bats and beavers (re: the latter, except on privately owned land). For most wildlife, disturbing the habitat of these animals is prohibited throughout Alberta and throughout the year.

<u>Road Kill</u>

Section 8 of the *Wildlife Act* provides that property in dead wildlife belonging to the Crown vests in the Crown. Section 55 prohibits the possession of dead wildlife unless property in the wildlife has been transferred from the Crown under s. 9. However, s. 134 of the *Wildlife Regulation* outlines that a person who finds dead wildlife may take possession of it without a permit until such time as it becomes reasonably possible for him to apply for a permit to “possess found dead wildlife” under s. 18 of the regulation. Section 57 of the Act prohibits the transportation of dead wildlife without the prescribed documents. Section 138 of the regulation outlines that a permit to possess found dead wildlife issued under s. 18 of the regulation meets the requirement for prescribed documents.

<u>Offences and Penalties</u>

The maximum penalty for contravening the Act is a $100,000 fine and/or two years imprisonment (s. 92). The fine for an offence involving more than one animal is calculated separately for each animal (s. 90). Under s. 91(1), an employer or principal can be found guilty of an offence committed by an employee or agent: (i) while acting in the course of his or her employment, and (ii) the employer consented to or knew about the circumstances giving rise to that contravention. The Court can order the convicted person to pay an additional fine if the person financially benefited from the offence (s. 96). The Court can also order the convicted person to pay to the victim an amount for compensation for the loss or damage suffered (s. 96.1).

The Court can make additional orders, such as take action to remedy any harm to any animal or endangered organism or its habitat that resulted, publish the facts relating to that act or omission, perform community service, and pay money for the purpose of promoting proper management, control, conservation or protection of wildlife, endangered species or their habitats (s. 97).

3.5 PRIMARY MUNICIPAL LEGISLATIVE REQUIREMENTS

This section only reviews the municipal noise bylaws for the cities of Calgary and Edmonton to provide examples of the types of limits that apply in other jurisdictions. It should be noted that each city may use a different standard of sound pressure weighting (i.e. "A" or "C") and/or response ("slow" or "fast").

3.5.1 City of Calgary Bylaw No. 5M2004

Part 9 of the City of Calgary, Bylaw No 5M2004, *being a Bylaw of the City of Calgary to Regulate Neighbourhood Nuisance, Safety and Liveability Issues*, deals with the regulation of noise. The bylaw contains a general prohibition against noise within the city limits and prohibits any person[9] from causing any noise or from allowing property occupied or owned by him to have noise emanate from it such that it annoys or disturbs another person (s. 27). Whether any sound annoys or disturbs a person, or otherwise constitutes objectionable noise, is a question of fact to be determined by a Court hearing a prosecution pursuant to this section of the Bylaw (s. 27(5)).

Residential Development[10] continuous noise limits are restricted to the following limits, measured at any point of reception within the residential development (s. 28):

- 65 dBA Leq[11] measured over a one hour period during the daytime ("daytime" – 07:00 to 22:00 on weekdays and 09:00 to 22:00 on weekends)
- 50 dBA Leq measured over a one hour period during the night-time ("night-time" – 22:00 – 07:00 on weekdays or 22:00-09:00 on weekends)

However, the following continuous noise limits apply with respect to the operation of an air conditioner, fan, central vacuum system or generator within a Residential Development (s. 28.1):

- 70 dBC Leq measured over a one hour period during the daytime ("daytime" – 07:00 to 22:00 on weekdays and 09:00 to 22:00 on weekends)
- 60 (dBC) Leq measured over a one hour period during the night-time ("night-time" – 22:00 – 07:00 on weekdays or 22:00-09:00 on weekends)

Where the Ambient Sound Level for an area is at or above the maximum allowable Day-time or Night-time Sound Levels, measured over a one (1) hour period, a Sound Level must

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[9] "*Person*" includes a corporation, other legal entities and an individual having charge or control of a Premises (s. 1(2)(k)).
[10] *"Residential Development"* means any land, which is the site of a Residential Building, and is a listed land use district (see s. 26(1)(s) for list) as defined in the Land Use Bylaw.
[11] "*Leq"* means the equivalent continuous Sound Level over periods of time as specified in this Bylaw at a specified location as measured by a Sound Level Meter.

exceed 5 decibels (dBA) Leq over the Ambient Sound Level before it becomes an offence under either ss. 28 or 28.1.

Downtown[12] continuous noise limits are restricted to the following limits, measured at any point of reception within the downtown (s. 29):

- 75 dBA Leq measured over a one hour period during the daytime (“daytime” – 07:00 to 22:00 on weekdays and 09:00 to 22:00 on weekends)
- 60 dBA Leq measured over a one hour period during the night-time (“night-time” – 22:00 – 07:00 on weekdays or 22:00-09:00 on weekends)

Where the Ambient Sound Level for an area is at or above the maximum allowable Day-time or Night-time Sound Levels, measured over a one hour period, a Sound Level must exceed 5 decibels (dBA) Leq over the Ambient Sound Level before it becomes an offence.

Non-continuous noise limits are the same for residential developments and the downtown and are restricted to the following limits, measured at any point of reception within the residential development or the downtown. (s. 30)[13]:

- 85 dBA Leq non-continuous measured over a 15 minute period during the day
- 75 dBA Leq non-continuous measured over a 15-minute period during the night

Non-residential development[14] noise limits are restricted to the following limits, measured at any point of reception within a non-residential development (s. 32):

- For a continuous noise: the greater of 85 dBA Leq or 5 dBA Leq over the ambient noise level measured over a one hour period during the day or night
- 85 dBA Leq for a non-continuous noise measured over a one-hour period during the day or night

A person may make a written application to the Chief Bylaw Officer for a temporary permit allowing for noise or sound levels that would otherwise violate this bylaw (s. 36).

Penalties under the bylaw include fines ranging from $50 to $400 (for committing the same offence twice in a 24 month period) (s. 6) up to a fine of $10,000 for a conviction under the bylaw or 6 months in jail in default of payment (s. 5(2)).

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[12] *“Downtown”* means the area in the city of Calgary bounded on the east by 3rd Street East, on the south by the CPR tracks, on the west by 9th Street West, and on the north by the Bow River.
[13] This section appears to be misnumbered in the Bylaw available on the City of Calgary website at <http://www.calgary.ca/CA/City-Clerks/Documents/Legislative-services/Bylaws/5M2004-CommunityStandards.pdf>.
[14] *“Non-Residential Development”* means any land or building that is not a Residential Development or Residential Building.

As of November 2016, there are increased fines to deter offences including those that cause unsightly conditions, create a public safety concern or attract pests. This includes long grass and weeds, and accumulation of building materials stored improperly, offensive materials and harmful fluids.

3.5.2 City of Edmonton Bylaw No. 14600 (consolidated on JUNE 28, 2016)

Part III of the bylaw contains a general prohibition against noise within the city limits and prohibits any person[15] from causing or permitting any noise that disturbs the peace of another individual (s.14). Further, the bylaw provides that a person may be found guilty of a violation regardless of whether the noise complained of exceeds the dB(A)[16] limits permitted in the bylaw – no measurement of the noise by an approved device is required (s. 14 (3)).

Residential district[17] continuous noise limits are restricted to the following (ss. 19 & 20):

- 65 dB(A) during the day ("day" – 07:00 to 22:00)
- 70 dB(A) during the day for a maximum of 2 hours, in total per day
- 75 dB(A) during the day for a maximum of 1 hour, in total per day
- 80 dB(A) during the day for a maximum of 30 minutes, in total per day
- 85 dB(A) during the day for a maximum of 15 minutes, in total per day
- 50 dB(A) during the night ("night" – 22:00 – 07:00)

The noise reading is measured at the property line of the property from which the noise is emanating.

Non-residential continuous noise limits are restricted to the following (ss. 21 & 22):

- 75 dB(A) during the day ("day" – 07:00 to 22:00)
- 80 dB(A) during the day for a maximum of 2 hours, in total per day
- 85 dB(A) during the day for a maximum of 1 hour, in total per day
- 60 dB(A) during the night ("night" – 22:00 – 07:00)

The noise reading is to be measured at the property line of the property from which the noise is emanating.

The owner of a motor vehicle is liable for a contravention of the bylaw caused by any sound emitted from the motor vehicle (s. 23).

[15] "Person" means an individual, firm, partnership, association, corporation, trustee, executor, administrator or other legal representative.
[16] "dB(A)" is defined as "the sound pressure measured in decibels using the "A" weighted scale of a sound level meter."
[17] "Residential district" means an area or district classified as residential by the *Land Use Bylaw*.

4.0 Practices and Procedures

4.1 INTRODUCTION

The purpose of this chapter is to identify the Department's environmental practices and procedures. The Department develops practices and procedures to address its environmental activities. This includes the practices and procedures contained in various department specifications, tender documents, special provisions, manuals, standards, best management practices and guidelines.

Environmental practices and procedures clarify responsibilities for both Department employees and Service Providers with respect to the implementation and maintenance of the EMS, and undertaking the Department's activities and projects. These practices and procedures undergo regular revisions as required.

4.2 PRACTICES AND PROCEDURES

The tables below list the Department's environmental practices and procedures: those set out in specifications, tender documents, special provisions, manuals, guidelines and standards (Table 4.1), and those developed under the EMS (Table 4.2). In addition to the documents listed in Table 4.1, Service Provider agreements and contracts that are issued for specific projects contain environmental requirements, practices, and procedures. The specific terms of the agreements and contracts can vary from project to project and have not been included in Table 4.1. However, these documents form part of the roles and responsibilities for environmental issues and must be adhered to.

TABLE 4.1: ALBERTA TRANSPORTATION ENVIRONMENTAL PROCEDURES AND PRACTICES

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
POLICY			
Greenhouse Gas Emissions	A Guide to Energy Efficient Best Practices	Alberta Transportation Website	2012
Greenhouse Gas Emissions	Memorandum of Understanding - TRANS/AEP/ARHCA	Alberta Transportation Website	2010
PLANNING & DESIGN			
Alberta Wildlife Watch	AWW Wildlife Program.	Alberta Transportation Website	2016

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Borrow Areas Reclamation/Topsoil Conservation/Approvals	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 2, Construction Contract Administration	Section 1: Contract Administration – General, Section 1.13	2013
Borrow Excavations • AT Supply • Contractor Supply	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.7	2011
Conservation and Reclamation of Topsoil and Subsoil • Soil Stripping Plan	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.6	2011
Contaminated Sites	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.9	2011
Environmental Approvals & Authorizations	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.3	2011
Environmental Legislation, Approvals & Permits • Regulatory Framework	General Specifications, Specification Amendments and Supplemental Specifications for Highway and Bridge Construction Specifications, Edition 15	Section 1.2.50.1	2013
Drainage	Drainage-Guidelines for Highways Under Provincial Jurisdiction in Urban Areas	Design Bulleting #16	2003
Drainage	Stormwater Management at Rural Crossings	BPG 11. Alberta Transportation Website	2010
Environmental Evaluation	Alberta Transportation Terms of Reference for Environmental Evaluation	Alberta Transportation Website	2014
Environmental Considerations	Highway Geometric Design Guide	Chapter A, Section A-10	1999
Environmental Management System	Alberta Transportation Environmental Management System Manual	Alberta Transportation Website	2017
Environmental Management System	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.1	2011
Environmental Regulatory Tracking Application (ERTA)	ERTA Implementation.	Design Bulletin 90	2016

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Environmental Risk Assessment	Engineering Consultant Guidelines for Highway, Bridge and Water Projects – Volume 1, Design and Tender	Section 4.5	2011 *(ERA Updated 2016)*
Erosion and Sediment Control	Erosion and Sediment Control Manual	Alberta Transportation Website	2011
Erosion and Sediment Control Best Management Practices (BMPs)	Field Guide for Erosion and Sediment Control	Alberta Transportation Website	2011
Fisheries	Self-Assessment of Alberta Transportation Projects Under the Federal Fisheries Act.	Design Bulletin 91	2016
Fisheries	Bridge Inspection & Maintenance System Manual (3.1).	Section 9.6	2008
Fisheries	BIM Advisory Bulletin #5. Passage Inspection.	Alberta Transportation Website	2017
Navigation	Navigated Waters in Alberta 2014 Final Report.	Alberta Transportation Website	2014
Navigation	AT Navigation Assessment Form	Alberta Transportation Website	2015
Navigation	Alberta Transportation Drainage Basins and Navigated Streams Map	Alberta Transportation Website	2014
Navigation	Navigation Protection Act Contractor Responsibility – Special Provision.	Alberta Transportation Website	2015
Project Sponsor Sign Off for Environmental Regulatory Applications	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.3.1	2011
Special Provisions	Engineering Consultant Guidelines for Highway and Bridge Projects – Volume 1, Design and Tender	Section 4.4	2011
Weed Survey	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.8	2011
Wetlands	General Design Guidelines for a Constructed ‘Habitat’ Wetland – Boreal Forest Region of Alberta	Alberta Transportation Website	2014

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Wetlands	General Design Guidelines for a Constructed 'Habitat' Wetland – Grasslands Natural Region of Alberta	Alberta Transportation Website	2014
Wetlands	General Design Guidelines for a Constructed 'Habitat' Wetland – Parkland Natural Region of Alberta	Alberta Transportation Website	2014
Wildlife Passage	Wildlife Passage at Stream Crossings	BPG 14. Alberta Transportation Website	2010
Wetlands	Evaluation Form and Instructions for Assessing Candidate Sites for Alberta Transportation's Wetland Habitat Bank.	Alberta Transportation Website	2014
Wetlands	Standard Monitoring Protocols for Evaluating Wetland Performance for Constructed 'Habitat' Wetlands	Alberta Transportation Website	2014
Wetlands	Alberta Transportation's Guidelines for Conducting Wetland Assessments to Meet Water Act Application Requirements	Alberta Transportation Website	2014
Wildlife Passage	Planning Considerations for Wildlife Passage in Urban Areas	Alberta Transportation Website	2011
CONSTRUCTION AND REHABILITATION			
Borrow Excavation Pre-Disturbance Assessment	Alberta Transportation Pre-Disturbance Assessment Procedures for Borrow Excavation for Road Construction	Alberta Transportation Website	2013
Borrow Excavation Reclamation Post-Assessment	Alberta Transportation Post-Disturbance Reclamation Criteria and Assessment Procedures for Borrow Excavation	Alberta Transportation Website	2013
Borrow Excavation Reclamation	Alberta Transportation Guide to Reclaiming Borrow Excavation Used for Road Construction	Alberta Transportation Website	2013

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Control of Clubroot in Soil Disturbed Work	Engineering Consultant Guidelines for Highway, Bridge and Water Projects – Volume 2, Construction Contract Administration	General – 1.13	2013
Environmental management during construction and operations	Environmental Construction Operations (ECO) Plan Framework	Alberta Transportation Website	2014
Environmental Construction Operations (ECO) Plan	General Specifications, Specification Amendments and Supplemental Specifications for Highway and Bridge Construction Specifications, Edition 15	Section 1.2.50	2013
Environmental Construction Operations (ECO) Plan	Engineering Consultant Guidelines for Highway, Bridge and Water Projects – Volume 2, Construction Contract Administration	Section 2.2.2	2013
Environmental Management (General, Definitions, Statement of Environmental Commitment by the Minister, Minister's Environmental Site Management, Contractor's Environmental Commitment, Environmental Management Plan, General Environmental Protection Requirements)	Civil Works Master Specification (Water Infrastructure)	Section 01390	2006
Environmental Protection (General, Surficial Aquatic Resources, Ground Water Resources, Terrestrial Resources, Historical and Archaeological Resources, Socio-Economic)	Civil Works Master Specification (Water Infrastructure)	Section 01391	2006
Inspection of Permanent Erosion Control Devices	Engineering Consultant Guidelines for Highway, Bridge and Water Projects – Volume 2, Construction Contract Administration	General – 1.13	2013

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Erosion and Sediment Control • Temporary • Permanent • Transfer • Maintenance of	General Specifications, Specification Amendments and Supplemental Specifications for Highway and Bridge Construction Specifications, Edition 15	Section 1.2.50.1	2013
Erosion and Sediment Control – Rip Rap	Standard Specifications for Highway Construction	Section 2.5	2013
Erosion and Sediment Control – Permanent Environmental Protection Devices	Standard Specifications for Highway Construction	Section 6.5	2013
Erosion and Sediment Control – Gabions	Standard Specifications for Highway Construction	Section 6.10	2013
Monitoring & Reporting	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.10	2011
Regulatory Requirements (General, Regulatory Responsibility, Variations Between Contract Documents and the Regulatory Requirements, Alberta Building Code, Minister Obtained Approvals)	Civil Works Master Specification (Water Infrastructure)	Section 01410	2006
Conservation and Reclamation of Topsoil and Subsoil • Soil Stripping Plan	Engineering Consultant Guidelines for Highway, Bridge and Water Projects - Volume 1, Design and Tender	Section 4.6	2011
Topsoil Conservation with the Right-Of-Way	Engineering Consultant Guidelines for Highway, Bridge and Water Projects – Volume 2, Construction Contract Administration	General – 1.13	2013
Topsoil Placement	Standard Specifications for Highway Construction	Section 2.6	2013
Turbidity	Turbidity – Special Provision	Alberta Transportation Website	2017
Turbidity	The Conversion of Nephelometric Turbidity Units	Alberta Transportation Website	2007
Seeding	Standard Specifications for Highway Construction	Section 2.20	2013

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Seeding	Grass Seed Mixtures Used on Highway and Bridge Projects	Design Bulletin #25	2005
	MAINTENANCE		
Alberta Wildlife Watch	AWW Smartphone Application Contract Administration Manual.	Alberta Transportation Website. Section 1.5	2016 2018
Beaver Control	Standard Specifications for Highway Maintenance, Edition 5	General Specifications – Section 54.34	2010
Bridge Structure Cleaning	Standard Specifications for Highway Maintenance, Edition 5	General Specifications – Section 54.30	2010
Clean Up	Alberta Transportation Highway Clean-up Program	-	-
Clean Work Site	Standard Specifications for Highway Maintenance, Edition 5	Section 51.2.55	2010
Culvert Cleaning/Removal	Standard Specifications for Highway Maintenance, Edition 5	Section 54.5 – 54.8	2010
Chemical Vegetation Control / Mowing	Standard Specifications for Highway Maintenance, Edition 5	Section 54.4	2010
ECO Plan	Contract Administration Manual.	Section 1.5	2018
Environmental Management at Highway Maintenance Yards	Environmental Management Plan for Salt Handling at Highway Maintenance Yards	Alberta Transportation's Highway Maintenance Contracts. Section 1.5 Contract Administration Manual.	2011
Environmental Regulatory Tracking Application	Contract Administration Manual.	Section 1.5	2018
Hand Brushing	Standard Specifications for Highway Maintenance, Edition 5	Section 54.2	2010
Migratory Birds Protection	Contract Administration Manual.	Section 1.5	2018
Pollution Control	Standard Specifications for Highway Maintenance, Edition 5	Section 51.2.54	2010
Pollution Control	Standard Specifications for Highway Maintenance, Edition 5	General Specifications – Section 51.2.54	2010

PRACTICE/PROCEDURE	DOCUMENT	SECTION	DATE
Maintenance Yards	Environmental Management Plan	Available through the Environmental Section	2005
Wildlife Reflectors	Standard Specifications for Highway Maintenance, Edition 5	Section 54.20	2010

5.0 Release Response Procedures

5.1 INTRODUCTION

It is essential that Department staff and our Service Providers understand the release reporting requirements that the Department is subject to under various pieces of legislation, and that these reporting procedures apply to all Department staff and Service Providers. The following procedures ensure consideration of the environmental effects resulting from accidental releases and that there will be an appropriate reporting response to environmental incidents.

These procedures are intended to address the release of hazardous materials and sediment under the federal *Fisheries Act*, the *Transportation of Dangerous Goods Act* and the Alberta *Environmental Protection and Enhancement Act* ("EPEA").

In general, EPEA requires that all releases that have caused, are causing, or have the potential to cause adverse effects on the environment must be reported (s. 110). Failure to report a release is itself an offence under EPEA (s. 227).

In addition to the reporting requirements set out in the legislation mentioned above, there may be site-specific or project-specific reporting requirements set out in the various approvals, licences, permits, etc. for those particular sites or projects. This part of the Manual discussed only general reporting requirements and any approvals, licences, permits, etc. should be checked for specific reporting requirements that may be included. Additional reporting requirements may also be imposed by municipalities and other regulators applicable to certain projects and activities.

Important: This procedure is not intended to address actions required for imminent emergency response – please refer to the procedures in the ECO Plan Framework and the DANGEROUS GOODS PROCEDURES in the Alberta Transportation Safety Manual.

5.2 DEFINITIONS:

"Adverse Effect" – impairment of or damage to the environment, human health or safety or property.

"AEP" – Alberta Environment and Parks

"Environment" – the components of the earth including:

- air, land and water;
- all layers of the atmosphere;
- all organic and inorganic matter;

- living organisms (including humans); and
- the interacting natural systems.

"Release" – includes to spill, discharge, dispose of, spray, inject, inoculate, abandon, deposit, leak, seep, pour, empty, throw, dump, place and exhaust.

"Substance" – any matter that is capable of becoming dispersed into the environment, or is capable of becoming transformed in the environment. This includes any sound, vibration, heat or other form of energy.

5.3 THIRD PARTY RELEASES

5.3.1 Motor Vehicle Accidents

Releases related to motor vehicle accidents are to be reported to the authorities by the person who causes the release or is in control of the substance that is released during the course of the accident. Authorities to notify include AEP and other potentially responsible agencies, for example the local fire department if the release poses a fire hazard. <u>However, if a Department employee becomes aware of a release into the environment such information should be reported to AEP notwithstanding that the Department did not have control of the substance.</u>

5.3.2 Illegal Dumping

In the event that a substance, that has the potential to cause or is causing an adverse environmental effect, has been illegally dumped along a right-of-way by an undetermined third party and the Department becomes aware of the illegal dumping, <u>the onus is on the Department to report the release to AEP as soon as it becomes aware or ought to be aware of the illegal dumping</u>.

5.4 TYPICAL UNAUTHORIZED RELEASES ON DEPARTMENT PROJECTS

5.4.1 Sedimentation

The potential release of deleterious or harmful substances into watercourses is a significant environmental impact that may result from the Department's activities. The most common type of release into watercourses is silt or other sediment.

5.4.2 Hazardous Materials

Diesel, gasoline, ethylene glycol, hydraulic fluid, pesticides, fertilizers and road salts are some of the many substances that have the potential to cause an adverse effect to soil and water.

The federal *Fisheries Act* prohibits any person from releasing a substance into water that is deleterious to fish or fish habitat. Under provincial jurisdiction, EPEA prohibits any person from releasing a substance that causes or may cause a significant adverse environmental effect. The following explains the procedures related to who is responsible for reporting and how and to whom the reports must be made.

5.5 RELEASE REPORTING REQUIREMENTS

5.5.1 What Must Be Reported

a) The release of a substance to the environment that has caused, is causing, or may cause an adverse effect. Adverse effect may be determined by a number of factors including, but not limited to:

- The chemical and physical characteristics of the substance released;
- The receiving media;
- The location of the release;
- The risk to the environment;
- The risk or impact to properties owned by third parties;
- The release is at or in excess of the amount listed in the Table in Part 8 of the federal *Transportation of Dangerous Goods Regulations* (“TDGR”); and
- The substance is listed in the Table in Part 8 of the TDGR and is released into a watercourse, groundwater, or surface water in any quantity.

b) The release of a deleterious substance into water capable of supporting fish habitat, waters that feed into those capable of supporting fish habitat or a serious and imminent danger thereof by reason of any condition, where any damage or danger to fish habitat or fish or the use of fish by man, results or may reasonably be expected to result from the release.

c) It is recognized that the cumulative effect of numerous small releases could result in a potential adverse effect even if the individual release itself may not have caused an adverse effect. For example, a number of small releases may not be of sufficient quantity individually to harm groundwater. However, if they continue at the same location over a prolonged time period, there is the potential for an adverse effect on the groundwater. The person who causes or caused the release, or who has control of the released substance, that has had, is having or may have an adverse effect on the environment shall report the release immediately upon discovery.

5.5.2 Transportation of Dangerous Goods Reporting

The Table from Part 8 of the TDGR is reproduced at the end of Chapter 5. The Table summarizes the levels or quantities of substance releases that are reportable if exceeded, even if it appears as though no adverse environmental effect has occurred. However, any release of the listed substances, even below the quantities listed in TDGR, must be reported if it enters a watercourse or groundwater. In situations where it may be difficult to determine whether the quantities or levels listed in the TDGR are exceeded, it is advisable to report the release. The rule of thumb is: when in doubt, report. Remember, under EPEA, any level or quantity of these substances released that has caused or is causing an adverse effect or has the potential to cause an adverse effect must be reported.

Immediate oral reports under TDGR should be made to the local police and provincial authority at 1-800-272-9600.

Immediate reports of a release or anticipated release of dangerous goods that are being offered for transport, handled or transported by road vehicle, railway vehicle or ship must include:

a) the name and contact information of the person making the report;

b) in the case of a release of dangerous goods, the date, time and geographic location of the release;

c) in the case of an anticipated release of dangerous goods, the date, time and geographic location of the incident that led to the anticipated release;

d) the mode of transport used;

e) the shipping name or UN number of the dangerous goods;

f) the quantity of dangerous goods that was in the means of containment before the release or anticipated release;

g) in the case of a release of dangerous goods, the quantity of dangerous goods estimated to have been released; and

h) if applicable, the type of incident leading to the release or anticipated release, including a collision, roll-over, derailment, overfill, fire, explosion or load-shift.

i) A written follow-up report must also be submitted to the Director General within 30 days of the release event.

Further, provincial dangerous goods transportation regulations will also apply. Section 13(1) of the Alberta *Dangerous Goods Transportation and Handling Act* sets out that where an accidental release occurs or is immanent from a means of containment any person who has charge, management or control of the substance shall report the incident.

5.5.3 Fisheries Act Reporting

Sections 38(4) and (5) of the *Fisheries Act* require reporting of any deposit of a deleterious substance in water frequented by fish or a serious and imminent danger thereof by reason of any condition, where any damage or danger to fish habitat or fish or the use by man of fish results or may reasonably be expected to result therefrom. Any such events must be reported to an inspector or fishery officer by:

- The owner of the deleterious substance or the person who has the charge, management or control thereof; or
- The person who causes or contributes to the causation of the deposit or danger thereof.

It is important to note the wide definition of “deleterious substance”, which included:

- Any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water; or
- Any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.

The definition also, without limiting the foregoing, includes:

- Any substance or class of substances prescribed pursuant to the regulations;
- Any water that contains any substance or class of substances in a quantity or concentration that is equal to or in excess of a quantity or concentration prescribed in respect of that substance or class of substances pursuant to the regulations; and
- Any water that has been subjected to a treatment, process or change prescribed pursuant to the regulations.

The relevant regulations for determining whether a substance meets the threshold of a “deleterious substance” include the federal *Pulp and Paper Effluent Regulations* and *Metal Mining Effluent Regulations*.

Section 38(6) imposes a duty to minimize any adverse effects that result or may reasonably be expected to result from the unlawful deposit of a deleterious substance.

Reporting obligations under the *Fisheries Act* are not triggered if the release is otherwise authorized by that Act or an approval thereunder. It is advisable to confirm that a reportable occurrence is in fact authorized before deciding not to report.

5.6 WHO MUST REPORT

Under EPEA (s. 110), the following persons have an obligation to make an oral report:

a) The person who releases or causes or permits the release of the substance;

b) The person having control of a substance that is released (unless they have reasonable grounds to believe it has already been reported); and

c) A police officer or employee of a local authority or other public authority who is informed of or who investigates a release of a substance (unless they have reasonable grounds to believe it has already been reported).

The reporting duty on police officers and local or other public authorities is consistent with their existing obligations relating to environmental emergency response. Although it is not an offence under EPEA for them to fail to report, it is expected that they will notify the Environmental Response Centre of the release.

The onus is on the person who causes or permits the release, or has control of the released substance, to determine whether there is an adverse effect. <u>WHEN IN DOUBT, REPORT</u>!

5.7 HOW TO REPORT AND TO WHOM

5.7.1 Immediate Reporting Requirements

The release should be reported as soon as a person knows or ought to have known of the release. This means the release must be reported at the first available opportunity, not when it is convenient. A person 'ought to have known' a release has occurred when, based on the information available, it is reasonable to know that a release has occurred. That person must make a decision whether a report is required.

Section 110(2) of EPEA provides that the person having control of the substance released that may cause, is causing or has caused an adverse environmental effect shall "immediately on becoming aware of the release", report to the following persons:

- AEP Director;
- The owner of the substance (where able to ascertain);
- Any person to whom the person reporting reports in an employment relationship;
- The person having control of the substance; and
- Any other person who may be directly affected by the release.

5.7.2 Oral Reporting

Contact the **Environmental Response Centre** (AEP) at – **(780) 422-4505 or 1-800-222-6514 (24 hrs).** A reference number will be provided at the time of the oral report.

<u>Once the oral report has been made, the Environmental Response Centre will ensure that relevant federal and provincial authorities are contacted on Alberta Transportation's behalf.</u>

5.7.3 Written Reports

Written reports must be submitted to the Environmental Response Centre within 7 days of the oral report. The *Release Reporting Regulation* sets out the content and manner required for a written report. A written report must include the following information:

a) The date and time of the release;

b) The location of the point of the release;

c) The duration of the release and the release rate;

d) The composition of the release including concentration, total weight, quantity or amount released;

e) A detailed description of the circumstances leading up to the release;

f) The steps or procedures which were taken to minimize or stop the release;

g) The steps or procedures which will be taken to prevent future releases; and

h) Any other information required.

Mail or fax to:

Alberta Environment and Parks
Environmental Response Centre
111 Twin Atria Building
4999-98 Ave.
Edmonton, Alberta T6B 2X3
Fax: (780) 427-3178

Email : ERC.Environment@gov.ab.ca

5.8 EXEMPTIONS FROM THE DUTY TO REPORT TO AEP

The following releases are exempt from reporting to AEP under EPEA:

- Substances released in an amount not exceeding the level specified in an EPEA approval or registration;
- Substances released in an amount permitted by a regulation under EPEA;
- Releases of substances that are regulated by the *Oil and Gas Conservation Act* or any regulation made under that Act;
- Releases of substances classified as Class 1 dangerous goods (explosives) or Class 7 dangerous goods (radioactive materials) as set out in the Schedule to the *Transportation of Dangerous Goods Act, 1992* (Canada); and

- Releases regulated by the Alberta *Dangerous Goods Transportation and Handling Act* and regulations thereunder.

However, such releases may be reportable to other regulators despite the exemptions with respect to EPEA and AEP.

In the event that it cannot be readily determined whether a report should be made, report the release to AEP for due diligence purposes – if in doubt, report.

5.9 ALBERTA TRANSPORTATION NOTIFICATION REQUIREMENTS

Contractors are required to submit an incident report of unauthorized releases to the Consultant within 72 hours of the release. Consultants are to provide a copy of the report to the Department Project Sponsor immediately.

5.10 REFERENCES:

- *Reporting Spills and Releases*, February 2016.
- *Release Reporting Regulation*, Alta. Reg. 117/93.
- *Dangerous Goods Transportation and Handling Regulation*, Alta. Reg. 157/97.

Transportation of Dangerous Goods Regulation Reportable Quantities

Table Identified in Section 8.2 of Part 8 of the *Transportation of Dangerous Goods Regulation*		
Class	**Packing Group or Category**	**Quantity**
1	II	Any quantity
2	Not applicable	Any quantity
3, 4, 5, 6.1 or 8	I or II	Any quantity
3, 4, 5, 6.1 or 8	III	30 L or 30 kg
6.2	A or B	Any quantity
7	Not applicable	A level of ionizing radiation greater than the level established in section 39 of the "Packaging and Transport of Nuclear Substances Regulations, 2015"
9	II or III, or without packing group	30 L or 30 kg

6.0 Non-compliance and Corrective and Preventive Action

6.1 INTRODUCTION

This chapter describes the Department's procedures for investigating and correcting non-conformances, and for preventing the re-occurrence of non-conformances. Non-conformances are activities and/or incidents that do not conform to identified requirements. These requirements include Department specifications, legislation, regulations and contracts.

The Department has two classifications of non-conformances. The first is known as a *Minor Non-conformance,* which is an isolated deficiency that has not led to an adverse environmental effect. Minor Non-conformances could include such things as missing documentation from files, or improperly maintained erosion control devices that have not resulted in a sediment release. The second type of non-conformance is known as a *Major Non-conformance,* which is defined as a serious deficiency that has led to a break-down of the 'system'. This includes incidents where adverse environmental impacts have occurred and/or where there has been a failure to conform to regulatory or departmental requirements. Any administrative penalty, no matter how small, is regarded as a Major Non-conformance. *Non-compliance* is defined as a failure to adhere to municipal, provincial, or federal legislation/regulation (including conditions of approvals and authorizations) and can result in court action.

Non-compliance/non-conformance incidents are typically identified during audits, Department site inspections, or by regulators. In identifying non-compliances/non-conformances, the Department ensures that appropriate steps for correcting the situation are implemented and that preventative measures to prevent similar occurrences are taken.

6.2 PROCEDURES FOR HANDLING ENVIRONMENTAL INCIDENTS

6.2.1 Reporting

It is the responsibility of Department employees (Project Sponsor/MCI/etc.) and Service Providers to report any environmental incidents they observe to the regulatory authorities as discussed in Chapter 5 of this manual. The Environmental Working Group meetings can be used as the vehicle to share information regarding non-compliance incidents.

6.2.2 Investigation Process

If an environmental incident occurs it is imperative that the proper investigation procedure is followed in order to establish the Department's due diligence. This has an added importance as the details of the investigation also form the basis for the incident report that is submitted to the regulatory authorities. The investigation must include, but is not limited to, the following information: the location, date, time, substance released, the receiving media, the determination of the root cause of the incident and the immediate action taken. Environmental Services will aid in the investigation process as required however, it is the responsibility of the relevant Department employee or Service Provider to ensure that an investigation is immediately launched once safe to do so. Copies of all investigations are to be entered in the Environmental Regulatory Tracking Application.

<u>Being Investigated By Regulatory Authorities</u>

ENVIRONMENTAL INSPECTIONS AND INVESTIGATIONS RESPONSE GUIDELINES

Construction and maintenance activities have the potential to cause adverse effects on the environment. Most notable are the potential effects to fish and fish habitat resulting from activities in or near water bodies, destruction of vegetation impacts to wildlife habitat, disturbance to soils and the use of pesticides or herbicides.

The legislation that will most likely impact Department activities are the Alberta *Environmental Protection and Enhancement Act*, the Alberta *Water Act* enforced by AENV, and the federal *Fisheries Act* and *Canadian Environmental Protection Act* enforced by Fisheries and Oceans Canada and Environment Canada. The respective personnel charged with the responsibility of enforcing the environmental legislation will likely require and request some degree of assistance. What follows are suggestions regarding future interactions with regulatory inspectors/investigators.

Regulatory Inspection Procedures

1. The Department representative <u>should not, under any circumstances, interfere with or impede any investigation or inspection</u>. If there are questions posed to you that are beyond your authority to answer or beyond your knowledge, politely advise the environmental officer of that fact.

2. An open and cooperative attitude is recommended.

3. At the start of either an inspection or investigation by a regulatory agency, ask the regulatory officer for his/her identification and a business card.

4. Inquire as to the nature of the visit by the regulatory officer. You may request information about what incident or work is being inspected. The regulatory officer may not be obliged to advise what offence, if any, is being investigated, but a polite request may result in the information being given.

5. A Department representative should accompany the regulatory officer. The Departmental representative should take notes of the nature of the inspection and details of any sampling or testing procedure used by the regulatory officer.

   The Departmental representative should request a copy of the results of any analysis or test. This request may or may not be granted. If practical or possible, the Departmental representative should take similar samples to those taken by regulatory officer. These samples should be labeled, kept sound and referred to the counsel appointed to deal with charges, if any that may be filed.

6. If the regulatory officer takes photographs, request copies of those photographs. Again, this request may or may not be granted. If it is practical to do so, take similar photographs or additional photographs that show the context of the investigation.

7. If the regulatory officer requests a statement from you or any Department employee, ask the officer for a copy of the statement at the start of the interview. If this request is refused, take a verbatim transcript of the interview as best you can under the circumstances. If possible provide the statement in the presence of a third party.

8. If the regulatory officer wishes to review Departmental records:

   a. Ask under what authority the officer wishes to review the documents.
   b. If the regulatory officer has a court order or search warrant, do not interfere or obstruct the search in any way. If the environmental officer asks for assistance, you may wish to provide this assistance.
   c. If the regulatory officer does not have a warrant or court order, and wants to take documents, request that the officer take copies. If this is refused, request an opportunity to take copies.
   d. If the regulatory officer wishes to take documents that you think are privileged, such as documents to and from legal counsel, place these documents in a sealed envelope marked “Privileged: DO NOT OPEN without a Court Order.” Give this envelope to the regulatory officer.
   e. Keep good notes that describe the investigation or inspection. These should identify the time, date, and place of the investigation, and the activities of the regulatory officer.

9. If a directive or enforcement order, either verbal or written, is issued they should be followed as soon as possible. Take immediate action and report to the appropriate Construction Manager, Operations Manager and Environmental Services. Track all costs related to the directive or enforcement order and any other suggestion put forth by the regulatory officer.

10. If a “Warning” has been issued by the enforcement agency, request any background information that led to the issuance of the “warning.”

In all of the foregoing, it is important to remember that there are legislative requirements to be cooperative. Therefore, it is also important you avoid any conduct that could lead to charges of obstructing or interfering with an investigation.

Project Sponsor Procedures

If a warning has been issued for your project, or you anticipate the receipt of one please complete the following:

1. Inform the Director of Environmental Services and provide a copy of the warning or other documentation. The Director may inform legal counsel of the warning.

2. On receipt of a request from legal counsel compile all relevant facts relating to the incident in the enforcement action and particularly evidence that can be used to rebut the allegations. This could include illustrated maps and diagrams, dated and annotated photographs, meeting minutes, documentary evidence. Also, provide environmental audits, inspection and monitoring results, and the significance of this data. You should also include recollections of conversations between Department staff or agents and the regulatory authorities.

3. Write an account of the incident clearly explaining the facts and sequence of events leading to the incident and the responsibilities of the individuals involved. If the offence was an accident or not committed intentionally, the adverse environmental affect was limited, or due diligence was exercised, this should be clearly stated. Obtain similar accounts from other Department staff as appropriate.

6.2.3 Corrective & Preventive Action

Corrective action is the process for identifying the underlying causes of the incident and implementing mitigation measures, and while not all incidents require corrective action each environmental incident should be evaluated to determine whether corrective action is required. *Preventive action* is the process of preventing the re-occurrence of a potential non-conformance. Part of having an effective preventive action program includes a systematic effort to identify potential problems. These efforts include inspections, monitoring, and a periodic review of records to identify trends.

The Project Sponsors are responsible for determining the appropriate corrective and preventive actions in the event of an environmental incident where an adverse environmental effect has occurred. Environmental Services will provide assistance as requested in these matters. The corrective and preventive actions will identify responsibility for the development and implementation of necessary actions and reasonable time frames for completion. These actions may include revising in-house procedures or mitigation measures.

Copies of all pertinent documentation related to the incident are to be maintained in the project file and submitted into the Environmental Regulatory Tracking Application.

7.0 Inspection and Monitoring

7.1 INTRODUCTION

This chapter outlines Alberta Transportation's processes for inspection and monitoring of the key characteristics of the Department's environmental activities. This includes tracking of the Department's environmental liabilities, regulatory monitoring, and site inspections. These activities allow the Department to establish its due diligence and evaluate its environmental performance on an annual basis.

7.2 DEFINITIONS

"Approvals" – an approval to conduct work issued under any Act (except for the federal Fisheries Act).

"Authorizations" – an authorization to conduct work issued under the Fisheries Act.

"Inspections" – work site visits conducted by Service Providers or Department staff to verify compliance and conformance to regulatory requirements and Department procedure.

"Monitoring" – periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements as required by an approval or authorization.

"Regulatory Inspection" – work site visits conducted by regulatory authorities to confirm compliance.

7.3 MONITORING ACTIVITIES

7.3.1 Regulatory Approval Tracking

The federal *Fisheries Act* and *Navigation Protection Act*, and the provincial *Environmental Protection and Enhancement Act* and *Water Act* are examples of environmental legislative requirements that have provisions for approvals or authorizations. It is essential, prior to the commencement of work that project sponsors carefully consider all environmental legislation and obtain the necessary approvals and authorizations. However, obtaining these approvals/authorizations can be time consuming, confusing and complex, as the various regulatory authorities often require different information.

In order to effectively manage the application process, please ensure that the Environmental Regulatory Tracking Application is utilized as a means of ensuring that applicable approvals/authorizations are considered, and in place, before the commencement of work activity.

Highway Projects

On highway projects that require approvals/authorizations from regulatory authorities the Department may be required to conduct monitoring and reporting activities as part of the conditions to proceed with work. These activities commonly include short-term monitoring and reporting requirements throughout the construction phase of the project as well as long-term monitoring and reporting during the operations phase. Service Providers conduct all regulatory monitoring and reporting requirements on the Department's behalf.

Water Projects

For water infrastructure projects most short-term monitoring and reporting activities specified in the approvals/authorizations are conducted by Service Providers on behalf of the Department during the construction phase of the project. As projects are completed and transferred to Alberta Environment and Parks, all obligations for remaining monitoring and reporting are transferred with the structure.

7.3.3 ECO Plan Monitoring Provisions

On highway and bridge construction and rehabilitation projects Contractors must submit an Environmental Construction Operations Plan (ECO Plan) to the Consultant prior to the commencement of work. Within the ECO Plan there are provisions for monitoring and reporting activities required throughout the duration of the project. The Consultant also has ECO Plan monitoring responsibilities as identified in the Consultant Guidelines. This responsibility includes verifying the Contractor implements monitoring and reporting activities as documented in the ECO Plan. The Department will be conducting audits to verify ECO Plans are properly developed and implemented.

7.3.4 Environmental Management Plans

It is a requirement that Highway Maintenance Contractors (HMCs) develop Environmental Management Plans (EMPs) for highway maintenance yards. Within the EMP there are provisions for monitoring and reporting activities by the HMCs. The Department also conducts audits to verify that EMPs are properly developed and implemented. HMCs are required to submit EMPs, and related inspections, into the Environmental Regulatory Tracking Application.

7.3.5 Total Suspended Solids Monitoring

Construction activities in water bodies have the ability to cause significant environmental damage therefore it is imperative that these activities are closely monitored. The Department has specifications in place for monitoring Total Suspended Solids (TSS) during in-stream activities to ensure that the environment is being protected at all times and to ensure that activities are being conducted within compliance of federal and provincial legislation/regulation. The project contract documents identify the requirement to monitor TSS on Department projects where in-stream activities are taking place. Please refer to the TSS monitoring specification for full details.

Environmental Liabilities Tracking

7.3.7 Land and Aggregate Information System

In an effort to identify the Department's existing environmental liabilities associated with borrows and gravel pits the Department has established the Land and Aggregate Information System (LAIS). The LAIS allows the Department to formally record the existence of the liabilities and to document the environmental issues associated with the liability.

7.3.8 Contaminated Sites

Department coordination between Environmental Management Services and the Regions exists to prioritize the contaminated sites for securing adequate budget resources. Environmental Services has responsibility for managing offsite contamination at highway maintenance yards that are owned, or were once owned, by the Government of Alberta. The Regions are responsible for the management of contaminated sites as they related to spills within the right-of-way or properties related to capital work.

7.4 ENVIRONMENTAL SITE INSPECTIONS

Site inspection tours are conducted at all phases of a project (construction/operations/maintenance) to verify conformance to Department procedure and compliance to legislation. Site inspection reports are important records as they help to establish the Department's due diligence.

7.4.1 Department Inspections

The Consultant is responsible for day-to-day site inspections on project work sites. The purpose of the inspections is to verify that regulatory requirements and Department specifications are adhered to. The results of these inspections are to be documented in the weekly reports and discussed at regularly scheduled on-site meetings.

Site inspections are conducted by focusing on activities of potential significant environmental risk. The inspections focus on:

- adherence to legislation and Department specification,
- hazardous materials management,
- erosion and sediment control, and
- ensuring proper documentation is on site (ECO Plan/approvals/authorizations).

7.4.2 Regulatory Authorities

Regulatory authority inspections can occur anywhere at any-time on Department projects. Regulatory authorities are not obliged to provide advance notice of inspections. ESRD and the DFO are just two of the regulatory authorities that regularly inspect Department projects. For procedures related to regulatory inspections and investigations, please refer to Chapter 6 of this Manual.

All identified issues, as a result of inspection activities, must be brought to the attention of the Project Sponsor immediately. The Project Sponsor ensures that the Consultant communicates with the Contractor to implement effective corrective action and preventive measures as required. The original site inspection form, and corrective action plans, will be retained in the project file and copies entered into the Environmental Regulatory Tracking Application.

7.5 EQUIPMENT CALIBRATION PROCEDURES

All equipment used to measure environmental parameters must be adequately calibrated at all times. Please follow the manufacturer's specifications or generally accepted practices when calibrating equipment. Calibration logs are to be kept as records in the project file after the completion of the project – remember, where there are no calibration records there can be no confidence in the measurement and resulting data!

8.0 Communication

INTRODUCTION

An EMS requires that an organization have in place a system of communication that ensures:

- Relevant employees within the organization are kept informed regarding the EMS and environmental issues associated with the organization's operations, and
- Communication from interested external parties is received and handled according to established procedures

The purpose of this chapter is to describe the Department's approach to the ongoing management of comments and information requests from internal and external stakeholders.

INTERNAL STAKEHOLDERS COMMUNICATION

Communication procedures for internal stakeholders (relevant Department employees and relevant Service Providers) are intended to meet two overarching goals:

1. Awareness of:
    - Roles and responsibilities under the EMS and
    - The overall performance of the EMS, including reporting the results of EMS monitoring, audit results and management reviews
2. Providing employees and Service Providers with the opportunity to voice their concerns about environmental issues and ensure these concerns have been effectively addressed.

The following practices and procedures will be in place to meet these goals.

<u>Department Employees</u>

1. Initial EMS awareness is provided to the Environmental Working Group membership. It is expected that the members will use this information to provide consistent leadership and direction with respect to environmental stewardship in their respective areas of responsibility.
2. Environmental Services communicates information to senior management and the Environmental Working Group membership regarding the EMS and general environmental performance.

Service Providers

1. The EMS Manual will be available on the Department's web site.

2. Industry associations (e.g., CEA, ARHCA, TAC) and their environmental committees are utilized to develop and disseminate environmental procedures and specifications.

3. For specific projects, environmental information is shared via:

   - Direct reporting relationships between the Department Project Administrators and Service Providers
   - ECO Plans
   - EMPs
   - Project start-up and pre-construction meetings
   - Weekly reports
   - Department specifications
   - Environmental Regulatory Tracking Application

Employee/Service Provider Comments Procedure

Employees and Service Providers can use the Department's Electronic Suggestion Box to submit comments, concerns and other feedback regarding the EMS or other environmental issues. Comments can be submitted anonymously and will be carefully considered. Once a request is approved it is processed and implemented in a timely manner. The address for the Electronic Suggestion Box can be found on the Department's intranet and internet web sites.

Environmental Services is also available to discuss issues related to the EMS or the environment.

EXTERNAL STAKEHOLDERS COMMUNICATION

With respect to external stakeholders, the Department encourages all employees and Service Providers as our agents on-site to ensure that any environmental comments they receive from external stakeholders (positive and negative) are managed in a responsive and respectful manner.

Comments Procedures

The Department has been able to take advantage of the numerous communications procedures and methods already in place, and the services offered by the Department's Communications staff.

- The Department's web-site, e–mails, letters, open houses, media, newsletters, informal meetings, and approval advertisements are mechanisms the Department utilizes to ensure effective communication with interested external parties.
- For individual projects, regulators are able to contact Department staff directly. This allows for effective lines of communication to be established at the outset, ensuring vital information is exchanged as efficiently as possible. Environmental Services provides assistance with liaisons between the Department and the regulatory authorities as required.

NOTE:

Stakeholders indicate that one of the key factors determining whether they develop a positive or negative impression of an organization they have contacted with a concern or question is the extent to which they receive a <u>timely response from someone who is knowledgeable</u>. In addition, Stakeholders often also indicate that an organization's reputation depends on <u>whether it follows through on any follow up actions</u>. Remember: Nothing damages trust like saying you will look into things and never reporting back to the person.

Environmental Services, with input and advice from Communication's staff, is available to assist employees and Service Providers in responding to comments from stakeholders that require more detailed technical, environmental or corporate responses.

<u>Media Requests</u>

Media requests for information generally are routed through the Communications Branch. When any staff member responds to a media request, a Media Contact Sheet must be filled out and sent within two hours to the Minister's Executive Assistant, Appointment Secretary, the Deputy Minister, the appropriate Assistant Deputy Minister, the Communications Branch, and any other relevant Department staff. <u>Only staff members who have taken media training courses should directly address the media.</u>

9.0 Training and Competence

9.1 INTRODUCTION

The goal of environmental training is to make Department staff and Service Providers aware of their roles and responsibilities as outlined in the EMS, and for all personnel to have a basic understanding of the environmental issues associated with the Department's operations, while personnel whose work may directly affect environmental performance will be competent to complete their tasks.

The purpose of this chapter is to identify the environmental training responsibilities and to outline the skills-based training opportunities required to maintain and potentially improve the Department's environmental performance.

9.2 SKILLS-BASED TRAINING RESPONSIBILITIES

9.2.1 Department Staff

Skills-based training is required for specific duties that are directly related to the Department's activities or operations that can have an impact on the environment. The intent of skills-based training is to ensure that Department employees who have such duties are knowledgeable about the environmental issues involved in their day-to-day activities.. To support the Department's EMS and to meet the Department's environmental performance, skills-based training may be required for specific Department personnel.

It is the responsibility of the individual employee and their supervisor to identify relevant skill-specific environmental based training during completion of the annual learning and development planning process. Records of skills-based training efforts are maintained by ACSC Training & Development.

9.2.2 Service Providers

As the Department's representatives on site, Service Providers play an integral role in helping the Department fulfill its commitment to environmental protection. Therefore, it is essential that the Department's Service Providers are competent by possessing the appropriate knowledge and expertise necessary to meet their environmental responsibilities. Skills-based training is required for all Service Providers with "front-line" responsibilities that are involved in operating equipment or machinery, or supervising/monitoring workers on site.

It is the responsibility of the Service Provider to ensure all staff and sub-contractors have the relevant skill-specific based training prior to conducting work on behalf of

the Department. Records of skills-based training efforts must be maintained by the Service Provider and must be available for review upon request.

The Department has three avenues in which to determine Service Provider competency:

1. The Department can request evidence of Service Provider experience and ability prior to a contract being awarded.
2. The Department considers the Service Provider's competency while evaluating the ECO Plans for specific projects. It is the Department's expectation that ECO Plans submitted to the Consultant for review are completed in a manner that showcases the Service Providers knowledge and expertise with regards to environmental protection.
3. The site inspection and monitoring process (described in Chapter 7 of this manual) is another tool the Department utilizes to evaluate Service Provider competency at the work site.

9.3 ENVIRONMENTAL AWARENESS/TRAINING OPPORTUNITIES

Departmental Initiatives

Environmental awareness sessions coincide with annual meetings, workshops/seminars, and at industry functions in order to reach the largest number of Department employees and Service Providers as possible. Environmental awareness topics at these functions may include discussion introducing new departmental specifications, guidelines or BMPs, updates regarding Departmental environmental performance, and/or recent regulatory trends to name a few.

Third Party Opportunities

There are numerous organizations and associations throughout Alberta that provide excellent skill-specific training courses, workshops, and seminars tailored to almost every environmental discipline. Department staff and Service Providers are encouraged to take advantage of these opportunities in order to maintain a high standard of environmental awareness on the job site. Records of these courses must be retained by the employer.

10.0 Environmental Audit Programs

10.1 INTRODUCTION

One of the requirements of an EMS is to have in place programs and procedures for auditing environmental performance. Environmental audit have two goals. The first goal is to determine whether the appropriate procedures, processes and plans are in place to ensure good environmental stewardship. The second is to determine if these processes are being properly implemented. The results of the audits are presented to management so that department environmental performance may be evaluated.

10.2 ALBERTA TRANSPORTATION ECO PLAN AND ENVIRONMENTAL MANAGEMENT PLAN AUDIT PROGRAMS

The ECO Plan audit program, as well as the Environmental Management Plan (EMP) audit program, consists of the following components:

- Audits are conducted by third parties auditors to assess:
    - Project-specific ECO Plans for road and water infrastructure construction activity.
    - Verify highway maintenance yards are being managed, by the highway maintenance contractor, in accordance to the EMP Framework.
- Management reviews designed to provide a general assessment of the on-going effectiveness and suitability of the Department's environmental specifications and guidelines.

10.2.1 Audit Procedures

<u>Scope</u>

The scope of the audit programs are to:

- Determine if ECO Plans or EMPs are being properly implemented and maintained;
- Assess if the environmental requirements within the contract and if the Consultant agreement (ECO Plan audits) are being adhered to;
- Determine if identified Departmental specifications and guidelines are being adhered to; and
- Survey the level of compliance to relevant environmental legislation.

<u>Methodology</u>

Audits will be undertaken using tools/protocols chosen by agreement with the external auditor and Environmental Services.

Responsibilities

- Audits will be co-coordinated by Environmental Services.
- Environmental Services will appoint a Lead Auditor. The Lead Auditor will appoint an audit team who will perform the audit in accordance with the audit plan prepared by the Lead Auditor.
- The audit team identifies all non-conformances/non-compliances and communicates these to Environmental Services via an approved audit report format.
- Deficiencies identified during the audit will be brought to the attention of the relevant Delivery Services staff who will be responsible for coordinating corrective actions through to closure of the finding.

Reporting

Audit findings will be communicated in an audit report format that has been approved by Environmental Services. Audit reports are maintained by Environmental Services as records.

Frequency

Environmental audits will be undertaken on an annual basis.

10.2.2 Management Review

Scope

The Management reviews will include:

- Environmental Services is responsible for ensuring that audit findings are reported to the Executive Director, Technical Standards Branch.
- An assessment of the continuing suitability, adequacy and effectiveness of the department's environmental specifications and guidelines.
- An assessment of the Department's environmental performance over the past year.

6. AT Erosion and Sediment Control

EROSION AND SEDIMENT CONTROL MANUAL

Government of Alberta
Transportation

June 2011

ALBERTA TRANSPORTATION
EROSION AND SEDIMENT CONTROL MANUAL

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VERSION HISTORY

Version No.	Date	Description
1	May 2003	Updates/Edits/Revisions to Design Guidelines (March 27, 2003 Paper Publication) for Erosion and Sediment Control for Highways
1a	March 2009	New BMPs added to the Guidelines
2	March 2011	Revision Update to Entire Erosion and Sediment Control Manual

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PREFACE

This document provides guidelines for analysis, design, construction, and maintenance of erosion and sediment control structures for highway construction projects. This document was developed with the intent that it would provide a convenient and comprehensive resource and a rational basis for the design of erosion and sediment control structures. It is intended primarily for use by design consultants but also provides valuable information for contractors and field personnel. It is intended to assist and provide direction in the analysis and design of erosion and sediment control structures, but is not intended to preclude innovative or alternative designs.

A general review of all sections and appendices within the manual was completed. Major updates from the first edition include:

- Provide a more thorough description of Temporary and Permanent Erosion Control Plan;
- Updating the list of Best Management Practices (BMPs) in Appendix C; and
- Added Streambank Applications to the list of BMPs.

Continuing comment is essential to the regular updating of this document and any feedback is welcome. Periodic updates and revisions will be undertaken in response to user feedback, changes in technology, regulatory requirements and many other factors. The most current version of this document will be posted on the Alberta Transportation (AT) website (www.transportation.alberta.ca/686.htm). Inquiries and comments may be sent to the Director of Geotechnical and Materials Services, Technical Standards Branch, Alberta Transportation, 4999-98 Avenue, Edmonton, Alberta, T6B 2X3.

Much appreciation is expressed to all those who have contributed to the development of this document. Special thanks are expressed to EBA, A Tetra Tech Company (EBA) who was given the task of developing and updating the document. Thanks are also expressed to members of the Consulting Engineers of Alberta (CEA), Alberta Roadbuilders and Heavy Construction Association (ARHCA) and staff of Alberta Transportation who were involved with development and updating of the document and review of the draft versions.

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Erosion and sedimentation are naturally occurring processes of loosening and transport of soil through the action of wind, water or ice and its subsequent deposition. However, construction activities can result in accelerated rates of erosion and sedimentation where soil surfaces are exposed and initially not revegetated. If left uncontrolled, these processes may result in an adverse impact to the environment, such as degradation of surface water quality, damage to adjacent land and degradation of aquatic habitat. Erosion and sediment control techniques are activities or practices, or a combination of practices that are designed to protect an exposed soil surface, to prevent or reduce the release of sediment to environmentally sensitive areas, and to promote revegetation as soon as possible.

The purpose of this document is to provide guidelines and standard procedures so that construction and maintenance activities are carried out in a manner to minimize erosion and sediment transport particularly where there are potential impacts to environmentally sensitive areas.

In this document, the process of sedimentation control is synonymous to sediment control.

1.1 Objectives

The objectives of this document are:

- Provide reference to the regulatory requirements related to sediment control;
- Clarify the roles and responsibilities of the owner (Alberta Transportation (AT)), their consultants, and the contractors involved in a construction project;
- Provide guidelines and standard procedures for selecting, designing and implementing erosion and sediment control measures for highway construction and maintenance;
- Provide details of erosion and sediment control measures commonly used on Alberta highway construction sites as well as their applications and limitations; and
- Provide a platform to assist AT in educating consultants and contractors with regards to erosion and sediment control.

This document is intended for use in the design, construction and maintenance of erosion and sediment control measures for terrestrial (land-based) highway infrastructure. The information, guidelines and reference material presented in this document is intended to supplement the experience and judgement of the individual or firm responsible for preparing an erosion and sediment control plan. **This document is not applicable for instream works.** The guidelines presented in the AT document "Fish Habitat Manual" (AT, 2009) are recommended for instream works.

A Field Guide titled "Erosion and Sediment Control Field Guide" compliments this document.

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2.0 REGULATORY REQUIREMENTS

There are a number of federal and provincial acts and regulations governing activities that cause, or can cause harm to the environment, including construction projects that result in erosion and/or sedimentation. Regulatory agencies also publish codes of practice, guidelines and standards that set out requirements for undertaking certain types of activities. Most legislation and other types of regulatory tools make reference to preventing the release of harmful or deleterious substances, including silt, to the environment.

Fisheries and Oceans Canada (DFO) operates in Alberta to enforce the relevant federal legislation. Alberta Environment enforces relevant provincial legislation in collaboration with DFO federal legislation.

Brief overviews of the major acts are presented below. More thorough descriptions are provided in the AT Environmental Management System (EMS) Manual at http://www.transportation.alberta.ca/2643.htm.

2.1 Federal

2.1.1 Navigable Waters Protection Act

The *Navigable Waters Protection Act* applies to in-stream work involving construction or placement in, on, over, under, through, or across any navigable water. This Act contains prohibitions related to the deposition of materials (e.g., sediment) in navigable waters.

2.1.2 Fisheries Act

The *Fisheries Act* exists to protect fish and fish habitat. The Fisheries Act prohibits any person from depositing or permitting the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance may enter such water. Silt is among the most common types of deleterious substance.

The Act creates a duty to report the deposit of a deleterious substance, where a deposit occurs in water frequented by fish and results or may result in damage to fish or fish habitat.

Persons are also required to take all reasonable measures to prevent any deposit or to counteract, mitigate or remedy any adverse effects that result or may result from a deposit.

The Act prohibits the carrying on of any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat, unless authorized by the Minister.

Additional sections of the Fisheries Act relevant to roadway construction activities require that fishways be maintained, fish passage be kept free, and that sufficient water flow is maintained in watercourses.

2.2 Provincial

2.2.1 Environmental Protection and Enhancement Act (EPEA)

The *Environmental Protection and Enhancement Act* exists to support and promote the protection, enhancement and wise use of the environment. Under the Act, it is prohibited to release or permit the release of a substance into the environment in an amount, concentration or level or at a rate of release that is in excess of an approval or a regulation that causes or may cause a significant adverse effect.

One of the definitions of substance is "any matter that is capable of becoming dispersed in the environment". This includes erosion of soil particles resulting from construction activities.

Under the Act, there is also a duty to take remedial measures "where a substance is released into the environment that has caused, is causing or may cause an adverse effect".

Under the Act, "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 shall, as soon as that person knows or ought to know of the release, report it".

2.3 Due Diligence

Most environmental legislation provides for "due diligence" as a defence to the majority of environmental offences.

AT is working to meet its due diligence obligations with respect to erosion and sediment control by taking the following steps:

- Publication of this document for its implementation in the highway construction industry by both contractors and consultants;
- Offering training workshops on the proper use of this document;
- Increasing awareness of erosion pollution adverse impacts, regulatory requirements and penalties for contravention; and
- Enforcing the proper use of best management practices for erosion and sediment control for the highway construction industry through contracts and training.

3.0 EROSION AND SEDIMENT CONTROL MANAGEMENT STRATEGY

3.1 Alberta Transportation Requirements

Alberta Transportation intends that the Erosion and Sediment Control Plans be prepared by experienced, competent individuals or firms. It is the intention that the contractor delivers the construction work in conformance with the specifications. Construction monitoring is provided and interim audits are conducted by AT or the consultant of record for the construction project.

Consultants and contractors are required to meet various responsibilities concerning environmental protection. Their responsibilities are discussed in the following sections.

3.1.1 Consultant Responsibility – Permanent Erosion and Sediment Control Plan

The design consultant is required to prepare the Permanent Erosion and Sediment Control Plan (PESC Plan) for the project.

This document is provided to the contractor for use in preparing the temporary erosion and sediment control strategy contained in the ECO Plan.

The requirements for the PESC prepared by the consultant are detailed in Section 9.0.

3.1.2 Contractor Responsibility – ECO Plan

During the execution of the contract, the contractor, as the prime occupant of the site, will be responsible for environmental protection of the site and to minimize potential environmental hazards that can arise as a result of his construction activities. The contractor is required to implement an Environmental Construction Operations (ECO) Plan detailing environmental protection measures under the guidelines of the ECO Plan Framework (AT et al. 2011). The most up-to-date details on the ECO Plan Framework are found on AT's website at http://www.transportation.alberta.ca/571.htm.

3.1.3 Consultant's Qualification to Design and Audit

Both the ECO Plan and PESC Plan must be completed by individuals or firms with appropriate experience in both highway design and construction and erosion and sediment control practice. The designer and auditor of the PESC Plan or reviewer of the erosion and sediment control strategy contained within the ECO Plan should also be one of the following:

- Registered Professional Engineer or Geoscientist (APEGGA Professional member); and/or
- Certified Professional in Erosion and Sediment Control (CPESC).

3.2 Overview of Preparation of Erosion and Sediment Control Plans

The process involved in preparing an erosion and sediment control strategy as well as maintaining and revising the measures contained therein is presented in Figure 3.1. In this figure the general steps involved in preparing permanent and temporary erosion and sediment control plans throughout the various phases of a highway construction project are presented as a flow chart.

Design Phase

Permanent Erosion & Sediment Control Plan

May Include:
- Soils information
- Environmental and hydrotechnical information
- Identification of erosion and sediment control issues
- Design of permanent erosion and sediment control measures

⇩

Tender Phase

Contract Specifications & Special Provisions may include:
- Specific requirements related to Erosion & Sediment Control

⇩

Construction Phase

Contract Awarded

⇩

ECO Plan Prepared by Contractor
(to include temporary erosion and sediment control measures)

Based on:
- Contract Specifications & Special Provisions
- ECO Plan Framework
- Erosion and Sediment Control Manual
- Permanent Erosion & Sediment Control Plan
- Design information
- Contractor experience
- Proper construction planning

⇩

Implementation and Maintenance of Measures Contained in ECO Plan

- Update ECO plan to include information obtained during construction
- Maintain records for interim audits
- Ensure implemented measures result in compliance with environmental regulations

⇩

Implementation of Measures Contained in Permanent Erosion and Sediment Control Plan

- Designer to update permanent measures to include information obtained during construction
- Contractor to implement permanent measures as part of construction as early as possible

⇩

Post Construction Phase

Post Construction Monitoring

- AT and maintenance contractor(s) to verify permanent measures implemented result in compliance with environmental regulations

Figure 3.1: AT Management Strategy for Erosion and Sediment Control on Construction Projects

4.0 EROSION AND SEDIMENT PROCESS

4.1 Mechanics of Erosion

Erosion is the wearing away of material by naturally occurring agents through the detachment and transport of soil materials from one location to another, usually at a lower elevation. Natural agents are mostly responsible for this phenomenon but the extent to which erosion occurs can be considerably accelerated through human activities.

Water is the predominant agent of erosion on highway construction sites. Wind erosion is not considered a major contributing factor to erosion on highway construction projects because of the localized nature of the exposed areas and the relatively short construction time periods. Thus, methods of controlling water erosion will be the principal focus of this manual. However, many of the methods effective in reducing erosion caused by water are also effective in reducing erosion caused by wind.

4.2 Sedimentation

Sedimentation is the deposition of soil particles previously held in suspension by flowing water. The phenomenon of sedimentation takes place at those locations experiencing a reduction in the velocity of flow. Initially the larger particles settle out. As the flow velocity reduces further, the smaller particles settle, eventually, leaving only the clay sized particles, being the smallest, as the last to be deposited. Sedimentation can also occur in slower-moving, quiescent waterbodies, or in treatment facilities such as stormwater ponds. For the purpose of this document, the process of sediment control is equivalent to the control of the sedimentation process.

Suspended material, particularly fine organic material such as organic silt, can have low total suspended solids (TSS) test values but high turbidity measurements. TSS is the mass of suspended solids per volume of water whereas turbidity is an indication of the ability of light to pass through the water. Both TSS and turbidity can have detrimental effects on an aquatic environment.

Clay particles will only settle out after extended periods of time due to their fine particle size and, the potentially, elevated pH of the water. As a result, settling by gravity alone is often ineffective for clay size particles.

4.3 Types of Water Erosion

There are generally four types of erosion that result from water which are illustrated in Figure 4.1.

1. **Raindrop (Splash) Erosion:** Movement of soil particles caused by the direct impact of raindrops on unprotected exposed soil surfaces.

2. **Sheet Erosion:** Movement of soil particles by runoff flowing over the ground surface as an unconcentrated thin sheet layer. Erosion is caused by shear stresses associated with water flow.

3. **Rill and Gully Erosion**: Movement of soil particles due to concentration of runoff in the depressions (rills) in the ground surface. Erosion potential is greater than with sheet flow due to the greater velocity and depth of flow. Further increases in the

velocity and depth of flow will increase the erosion potential which may gradually enlarge the rills into gullies. Rills are 75 mm or less in depth. Once the depth exceeds 75 mm then formation of gullies occurs (Fifield, 2001).

4. **Stream and Channel Erosion:** Movement of soil particles on the bed and banks of streams and channels due to concentration of runoff. Scouring, another facet of channel erosion, occurs along channels where eddies form as a result of sudden expansion, contraction or change in flow direction. Scouring may lead to rapid soil loss from the channel bed or sideslopes.

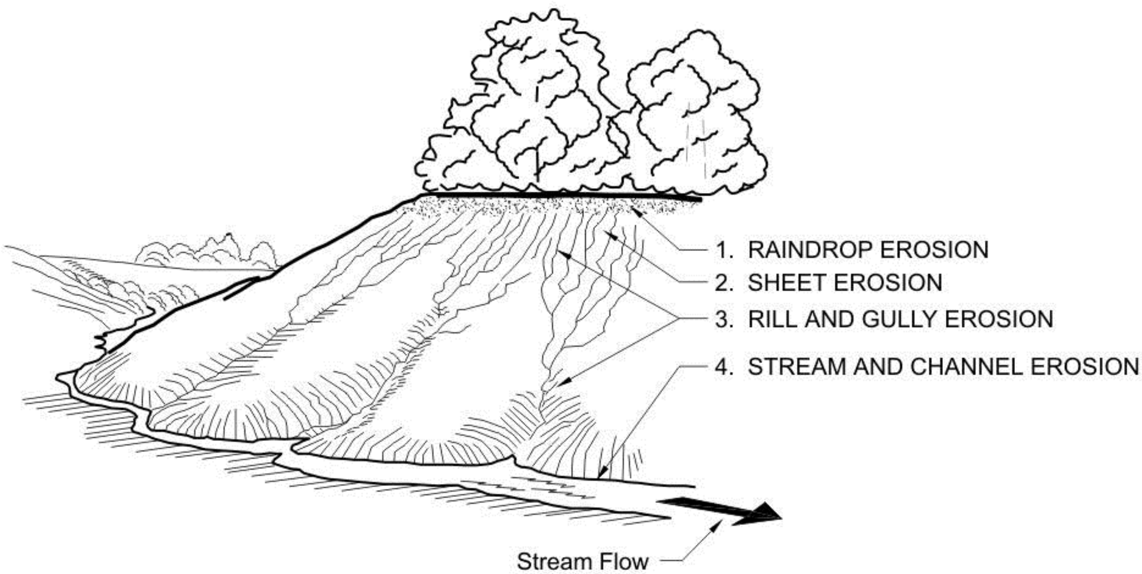


Figure 4.1: Types of Water Erosion

Erosion potential is reduced by minimizing rainfall impact and by reducing the velocity and depth of surface water flow. The erosion potential increases with increasing flow velocity and depth.

4.4 Factors Affecting Erosion

4.4.1 General

Erosion occurs as a result of a number of interacting factors and processes. Four broad factors that affect erosion are as follows:

- Climate;
- Soil characteristics;
- Vegetative cover; and
- Topography.

Each of these factors is described in the following sections.

4.4.2 Climate

The regional climate varies across the province of Alberta. As such, design rainfall event duration and intensity may vary for a given return period based on the location of the site. Rainfall events of greater duration and intensity are more likely to increase the potential for erosion on any given site.

Indirectly, the climate of a location determines the amount of annual precipitation, the length of the growing season and some other factors that affect plant growth and hence the vegetative cover. The climate may have a long term effect on topography especially in reference to wind eroded gully formation in Southern Alberta. The climate also affects soil characteristics. Arid terrain with intermittent intense rainfall events can be highly erosive environments.

4.4.3 Soil Characteristics

Soil characteristics that have been identified as primarily affecting soil erodibility are listed as follows:

- Particle Size Distribution and Texture;
- Permeability (structure); and
- Fibrous organic matter content (structure).

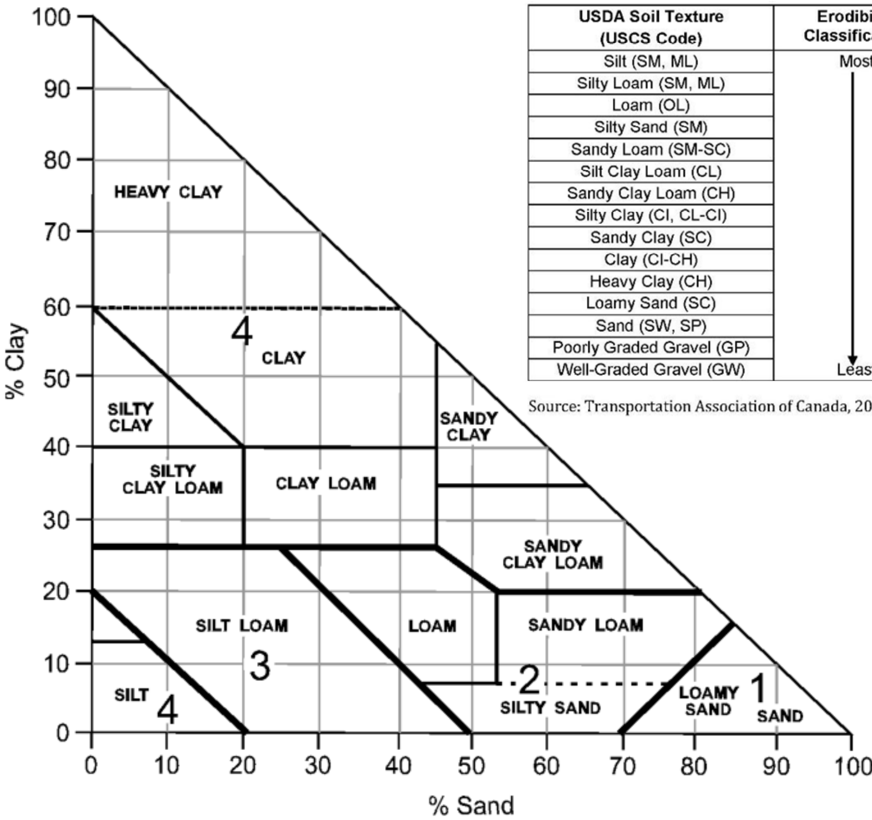
A preliminary estimate of soil erodibility in relationship to soil type is presented in Figure 4.2.

In general, soils containing high proportions of silt and very fine sand are usually the most erodible. Erodibility generally decreases as the plasticity (clay content) of the soil increases (Figure 4.2). However, once eroded, clays are readily transported. Well-graded gravel and predominantly gravel mixtures with trace amounts of silt are the least erodible soils. Soil descriptions prepared using the guidelines suggested in the Unified Soil Classification System (USCS) can be used in a preliminary assessment of soil erodibility. This classification system is presented in Figure 4.3. The various descriptions given for grain size according to various other engineering soil classification systems are presented in Figure 4.4.

The ability of a soil to absorb rainfall or surface runoff is best characterized by its permeability. The potential for erosion is reduced if the soil tends to absorb rainfall or surface runoff as this decreases the volume of water available to cause sheet or rill and gully erosion. However, after a prolonged period of hot and dry weather, there may be a lag time between the onset of rainfall and the onset of infiltration due to the unsaturated nature of the exposed surface soils. In this event, the initial amount of runoff may be significant. A general relationship between soil type and precipitation runoff is presented in Figure 4.5.

Construction site experience in Alberta indicates that topsoil can be effective in reducing or preventing erosion. This observed behaviour is mainly due to the permeability and fibrous nature of the organic material in the topsoil. An organic rich soil placed in an unsaturated condition generally has the ability to absorb a significant amount of water. Furthermore, the various rootlets and fibres present in topsoil act as reinforcement that minimizes the effect of raindrop, sheet or rill and gully erosion.

Available examples of tested data for typical Alberta soil types are presented in Appendix A to illustrate typical plasticity and gradation characteristics. This information is included for the sole purpose of illustrating the variety of soils that could be encountered on highway construction sites in Alberta. It is not intended as an exhaustive list of soil types, nor should it be used to replace or supplement soil testing data for sites near or at the locations listed.



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

Source: Transportation Association of Canada, 2005

Figure 4.2: Soil Texture Nomograph and Erodibility Rating

Source: Wall et al, 1997

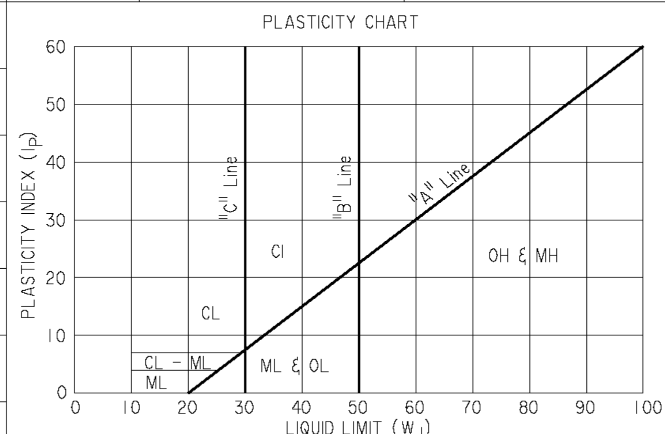
Government of Alberta ■ Transportation

UNIFIED SOIL CLASSIFICATION SYSTEM

(Modified by PFRA)

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (More than half of material is larger than No. 80 sieve size)	GRAVELS (More than half of coarse fraction is larger than No. 5000 sieve size)	CLEAN GRAVELS (Little or no fines)	GW	Well-graded gavels, gravel-sand mixtures, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ is greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ is between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		GRAVELS WITH FINES (Appreciable amount of fines)	GM* d / u	Silty gravels, gravel-sand-silt mixtures	Atterberg Limits below "A" Line or P.I. is less than 4	Above "A" Line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg Limits above "A" Line with P.I. greater than 7	
	SANDS (More than half of coarse fraction is smaller than No. 5000 sieve size)	CLEAN SANDS (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ is greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ is between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		SANDS WITH FINES (Appreciable amount of fines)	SM* d / u	Silty sands: sand-silt mixtures	Atterberg Limits below "A" Line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands: sand-clay mixtures	Atterberg Limits above "A" Line with P.I. greater than 7	
FINE GRAINED SOILS (More than half of material is smaller than No. 80 sieve size)	CLAYS (Above "A" Line on PLASTICITY CHART; negligible organic content)	$W_L < 30\%$	CL	Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays	PLASTICITY CHART	
		$30 < W_L < 50\%$	CI	Inorganic clays of medium plasticity, gravelly clays, sandy clays, silty clays		
		$W_L > 50\%$	CH	Inorganic clays of high plasticity, fat clays		
	SILTS (Below "A" Line, negligible organic content)	$W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
		$W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
	ORGANIC SILTS AND CLAYS (Below "A" Line)	$W_L < 50\%$	OL	Organic silts and organic silty clays of low plasticity		
		$W_L > 50\%$	OH	Organic clays of medium to high plasticity, organic silts	(NOTE: For soils passing No. 400 sieve & sieve size in μm)	
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils	Strong colour or odour and fibrous textures	

Determine amount of sand and gravel from grained size curve. Depending on percent of fines (fraction smaller than No. 80 sieve size), coarse-grained soils are classified as follows:
Less than 5 % .... GW, GP, SW, SP
More than 12 % .... GM, GC, SM, SC
5 to 12 % .... Borderline cases requiring dual symbols **



REVISED APRIL 5, 2007

OTHER SYMBOLS

- BEDROCK (Unclassified)
- SANDSTONE
- SHALE
- LIMESTONE
- CONGLOMERATE
- COAL
- OVERBURDEN
- TOPSOIL

NOTE:

* Division of GM and SM groups into subdivisions of d and u are for roads and airfileds only. Subdivision is based on Atterberg Limits; suffix d is used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u is used when L.L. is greater than 28.

** Borderline classifications, used for soils processing characteristics of two groups, are designated by combination of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

Figure 4.3: Unified Soil Classification System (modified by PFRA)

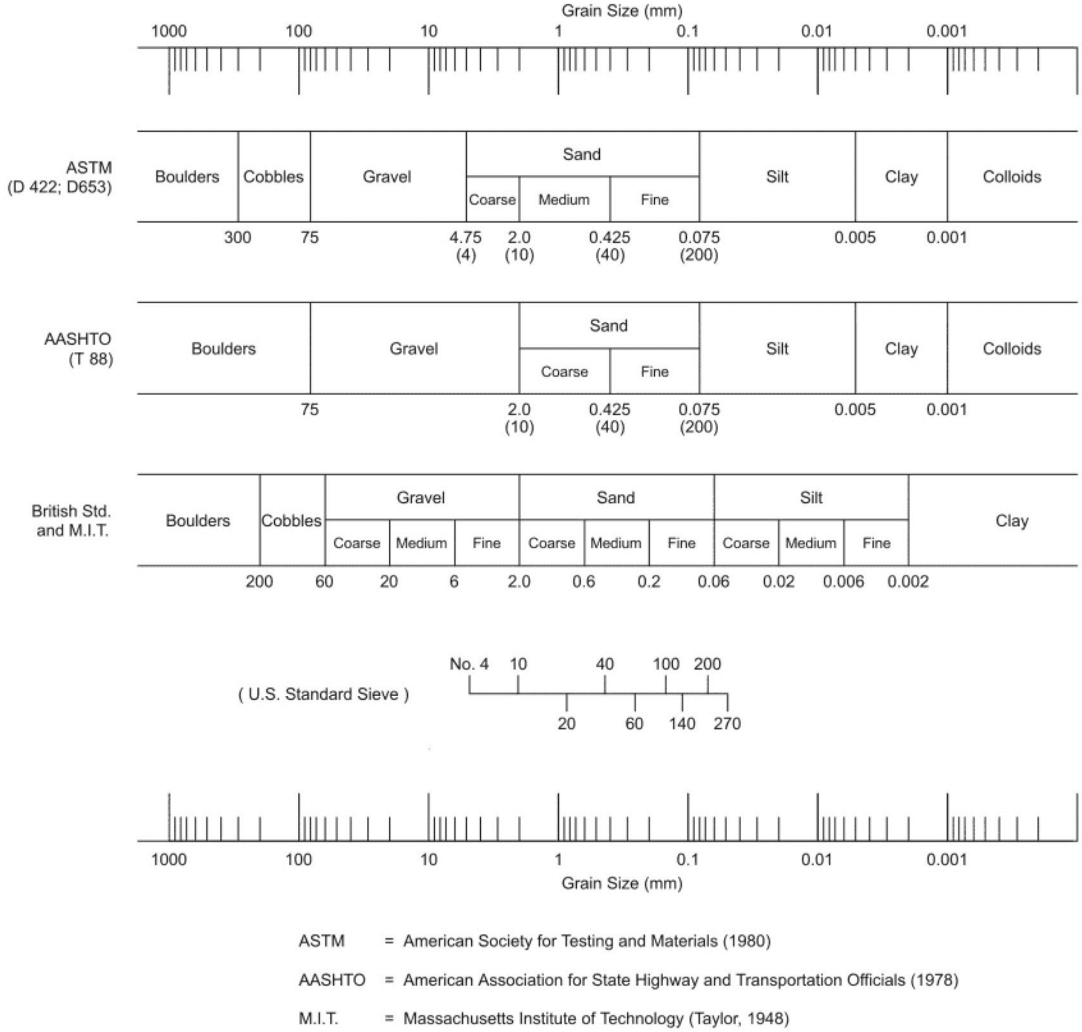


Figure 4.4: Grain Size Description According to Various Engineering Soil Classification Systems

Source: Holtz and Kovacs, 1981

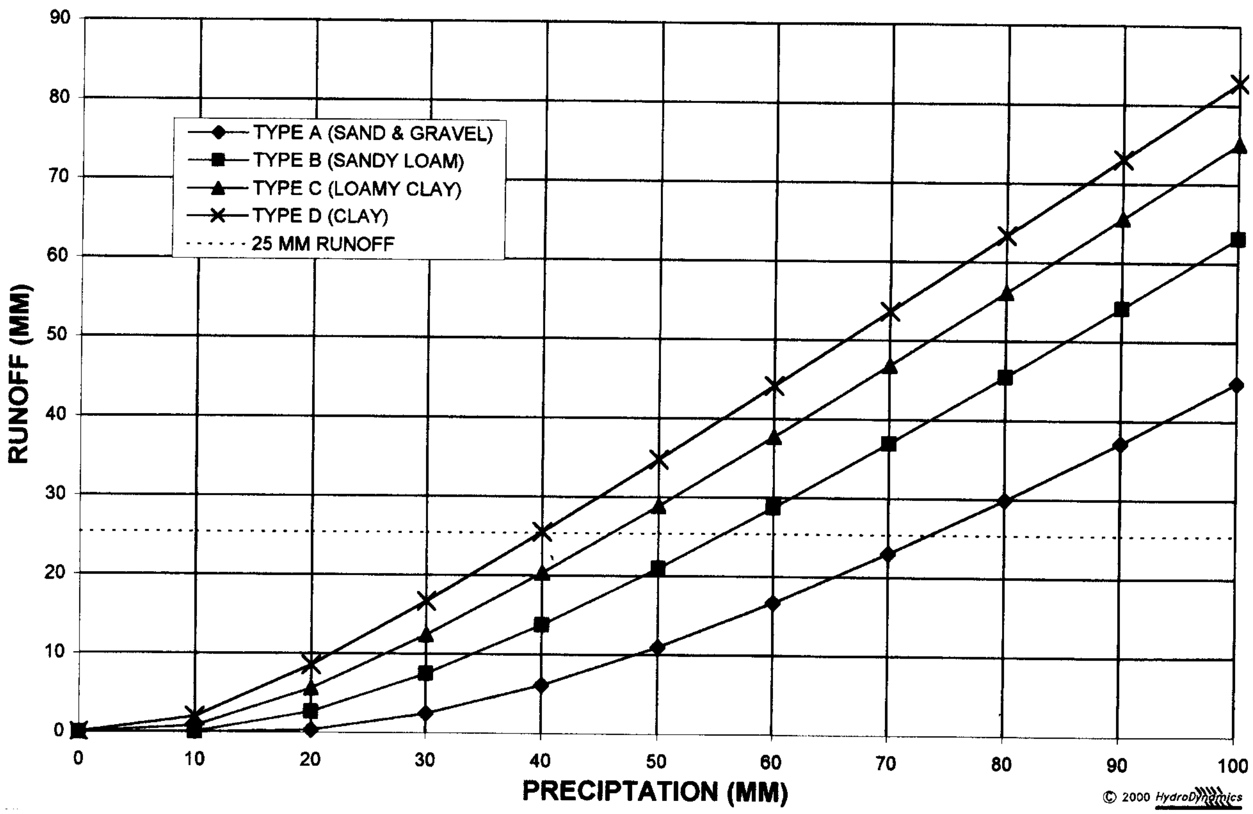


Figure 4.5: Estimated Runoff from Precipitation for Different Soil Types

Source: Fifield, 2001

4.4.4 Soil (Vegetative) Cover

In nature, the extent of vegetative cover determines to a large extent the erosion that takes place. Vegetative cover is a very durable and highly effective erosion control measure. It achieves its objective by:

- Shielding the ground from direct rainfall impact;
- Improving the soil permeability;
- Reducing velocity of runoff; and
- Holding soil particles in place with a root structure from living and dead vegetation (topsoil).

Because of the effectiveness of vegetative cover in controlling soil erosion, it is usually the primary choice for long-term erosion control unless there are reasons for doing otherwise.

4.4.5 Topography

Topography refers to the shape, length, inclination and aspect of a slope. The length and inclination are critical factors with longer and steeper slopes producing greater soil erosion. Slope aspect also affects soil erosion. For example, south-facing slopes tend to dry faster and have a better growing regime than north-facing slopes. The shape of a slope also influences the potential extent of erosion. Concave slopes with less inclination at the base are generally less erodible than convex slopes.

5.0 SITE ASSESSMENT

5.1 General

Background information for the proposed construction site should be assembled to permit a preliminary assessment of the drainage and erosion potential of the site as well as for identification of environmentally sensitive areas. Identifying these areas will assist in evaluating the erosion and sediment control measures to be implemented on and downstream of the proposed construction site.

Various sources of information for use in preparing a site assessment are discussed in the following sections. This section is not intended to be an exhaustive list of information sources. Therefore, it is the responsibility of the individual or firm preparing an erosion control strategy to ensure they have considered the appropriate relevant information.

5.1.1 Review of Construction Drawings

Design drawings will provide some of the information necessary for the preparation of an erosion and sediment control plan. This information includes, but is not limited to, the location, size and gradient of grubbing areas and stripping areas, vertical and horizontal road alignments, cut slopes and embankment slopes, ditchlines, culverts, bridges and watercourse crossings, riparian zones, and special sites such as borrow pits, gravel pits, and spoil areas.

5.1.2 Geotechnical Investigation Reports

Geotechnical information such as borehole logs, test pit logs, and accompanying reports are available for the majority of highway construction projects in Alberta. This information will likely indicate the type of soils encountered in the area, detailed soil descriptions, the thickness of each unit, moisture contents, soil strength values, and water table levels from discrete locations. In some cases, topsoil assessments or slope stability assessments may have been conducted.

Geotechnical investigation for highway design usually includes aerial photo review, terrain assessment and soil survey investigation for both gradeline and borrow sources. An assessment of difficult/adverse site conditions (i.e., unstable slope, soft subgrade, high groundwater, highly erodible soils) may also be provided. Current AT geotechnical investigation requirements are provided in Engineering Consultant Guidelines for Highway and Bridge Projects Volume 1, Design and Tender (AT, 2002). In general, the depths of soil sampling should extend beneath the design grade for cut slopes, ditch bottoms, and to the maximum depths of proposed borrow source areas. Site assessment of riparian and other sensitive areas of water bodies, floodplains and river crossings may be undertaken to evaluate stability of fills as well as to identify possible erosion and sediment control concerns.

For a typical earthwork grading project, the following soil testing information is provided on the design drawings:

- Plasticity index (PI);
- Soil classification according to USCS;

- Moisture content (%);
- Estimated optimum moisture content (%); and
- Estimated maximum dry density from moisture density relationship testing (kg/m^3).

Depending on the scope of work, the geotechnical report may include the following additional information related to erosion and sediment control concerns:

- A review of the gradeline design from a geotechnical as well as an erosion perspective;
- Hydrometer (gradation) and Atterberg Limit testing results for fine-grained soils;
- Soil permeability; and
- Stability of large cuts and high fill areas.

Furthermore, additional reports prepared for environmental and hydrotechnical aspects of the project may contain the following information:

- Identification of possible environmentally sensitive areas including riparian zones, wetlands and fish bearing watercourses;
- Identification of obvious watercourses and assessment for fish habitat; and
- Construction timing restrictions related to fish and wildlife considerations.

5.1.3 Aerial Photography/Imagery

A review of available aerial photographs can provide an overview of landforms and surface features in and adjacent to the construction site. Overlaying the proposed highway alignment on the aerial photos will allow an assessment of conditions such as slope instability. A review of aerial photos will be useful in evaluating drainage patterns, such as drainage catchment size, historic drainage features, ephemeral streams, and lowlands.

Web-based aerial image technology can provide additional information such as type and extent of soil cover, and type and extent of vegetation.

Sources of aerial photographs in Alberta include the following:

- Alberta Environment;
- William C. Wonders Map Collection, University of Alberta;
- Municipalities;
- Alberta Sustainable Resource Development; and
- Alberta Transportation.

5.1.4 Surficial Geology Maps

Surficial geology maps are another source of information regarding the soils that may be encountered during construction. These maps may be used to interpolate soil conditions between drill holes or test pits (with inherent uncertainty) and may also assist in the delineation of the boundaries of various soil types.

The type of information found on surficial geology maps may include type and extent of soil, thickness and bedding characteristics of each soil type, soil stratigraphy, depth to bedrock, and in some instances, the erodibility rating.

Sources for surficial geology maps include:

- Alberta Geological Survey;
- Alberta Research Council;
- Alberta Environment; and
- Geological Survey of Canada.

5.1.5 Vegetative Cover Maps

Vegetative cover maps are typically developed through the analysis of moisture and nutrient regimes. They can provide information about the type and extent of vegetation, the drainage class and soil texture.

Information on vegetative cover will help identify the rooting conditions that may be encountered during grubbing and stripping operations. Furthermore, the existing vegetation will provide the best model for success of revegetation efforts by defining the biogeoclimatic zones and indicating the advantages and limitations of the site for revegetation (for example, arid versus wet conditions).

Vegetative cover maps come in various forms. Some are developed to address specific concerns such as new development and others are developed for inventory purposes. For the purpose of erosion and sediment control planning, site level vegetative cover maps (scale 1:10,000 or less) are the most useful and provide the level of detail required for characterizing a construction site and developing specific erosion and sediment control measures. Overview maps of larger scale may not provide enough detail to plan specific measures, but may be useful for characterizing general site conditions.

Sources for vegetative cover maps include:

- Alberta Environment;
- Environment Canada; and
- Agriculture and Agri-Food Canada.

5.1.6 Floodplain Information

Floodplain information is important data to identify siltation processes associated with natural flooding as opposed to sedimentation caused by construction activities. Sources for floodplain information include:

- Alberta Environment;
- Environment Canada;
- Agriculture and Agri-Food Canada; and
- Local Municipalities.

Floodplain information should be shown on the drawings that accompany the documentation for an erosion and sediment control strategy.

5.1.7 Site Inspection

A site inspection of the proposed construction site is a fundamental step in the preparation of an erosion and sediment control strategy. Observations of the site conditions will provide the greatest level of detail for characterizing potential erosion and sediment control concerns. A site inspection should be conducted at the appropriate time of year with no snow cover and/or after a rainfall event if possible.

Site inspections should be conducted after the aforementioned sources of information are reviewed. A site inspection should involve a reconnaissance of the highway alignment route to assess and document the following information:

- Soil Types: The soil types in an area to be disturbed by construction activities should be described according to the USCS in conjunction with Agriculture Soil Structure Code in the Soil Erodibility Rating table as presented in Figure 4.2. This information may be assessed by inspecting existing soil exposures or by conducting shallow test pits in the area. The focus should be on areas of anticipated high erosion potential.
- Watercourses: Potential areas of concentrated drainage and areas of surface or groundwater concentration should be noted on the site plans. The field inspection should focus on determining the potential for sedimentation and consequences downstream of the construction site. Depending on the nature of the construction an estimate of the bank full elevation may be required.
- Water Crossings: Water crossings, including watercourses and drainage ditches, should be noted.
- Riparian Zones: The location, size, and general descriptions of riparian zones should be noted. Furthermore, the presence of watercourses originating from or passing through the construction site that are buffered by these zones and their respective gradients should be noted.
- Vegetation: Existing and adjacent vegetation should be noted in terms of location, type and extent.
- Slope Failures: Signs of recent or historic slope failures or evidence of instability should be noted. Assessment by a geotechnical engineer may be required to determine the cause of slope failure.
- Erosion Sites: Areas of recent or past erosion and sedimentation events should be noted.
- Sensitive Sites: Potentially sensitive sites such as drinking water supplies, wildlife habitat, private property, utilities, and recreational areas should be noted.

5.1.8 Referrals with Regulatory Agencies

Various regulatory agencies may have specific and/or detailed information about the construction site. Therefore, consultation is an important step in conducting a site assessment. Information from regulatory agencies may include detailed fish and wildlife habitat information, historical data such as rainfall records or past slope failures, revegetation limitations or requirements, information on previously implemented erosion and sediment control measures and permitting requirements.

Where applicable, site specific information should be obtained from the appropriate regulatory agencies. These agencies may include the following:

- Alberta Environment;
- Alberta Agriculture and Rural Development; and
- Alberta Sustainable Resource Development.

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6.0 SITE EROSION POTENTIAL AND EVALUATION

6.1 General

The foremost challenge facing the designer is to correctly assess the erosion potential resulting from the construction activities. The site erosion potential is an estimate of the quantity of soil that could be removed from the construction site due to erosion and transportation by unconcentrated surface water flow. With certain modifications, established soil loss evaluation methods used in agricultural practice can be reasonably applied to the highway construction practice. The estimates produced by using these methods should be supplemented with judgement and experience so that the site erosion potential assessment is appropriate for the construction site.

6.2 Revised Universal Soil Loss Equation (RUSLE)

A number of methods to assess site erosion potential have been developed. Two approaches are in current practice for estimating highway construction site erosion potential. One is an empirical method based mainly on experience, the other is the Revised Universal Soil Loss Equation (RUSLE) which is an update of the Universal Soil Loss Equation (USLE). RUSLE's calculations are computerized as are the databases which include information on soil erodibility (K) and climate (R) data for all major soils and cities across the United States. As this program was developed in the United States no data is available for Canadian locations. The Revised Universal Soil Loss Equation for Application in Canada (RUSLE–FAC) (Wall et al, 1997) is a revision of RUSLE, modified for use in Canada and is not available in the form of a computerized software and data package.

The upgraded version of the RUSLE has been developed and is known as RUSLE Version 2, (RUSLE2). It uses the same input parameters as RUSLE to provide erosion and sediment delivery estimates. The new aspects of RUSLE2 are:

- Most factors and relationships have been revised.
- More current climate data.
- Model calculates soil loss for every day of the year. The average annual soil loss is the sum of all daily values.
- Windows based graphical user interface which allows the user flexibility in the types of situations to be represented.

RUSLE2 does not contain data for Canadian locations.

Additional information about RUSLE2 can be found at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

USLE/RUSLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion nor does it calculate sediment yield.

For the remainder of this manual, references and examples will focus on RUSLE-FAC, which will be simply referred to as "RUSLE".

The RUSLE formula is as follows:

$$A = R \times K \times LS \times C \times P \qquad \text{(Equation 6.1)}$$

Where:
- A = Annual soil loss (tonnes ha^{-1} $year^{-1}$)
- R = Rainfall factor (MJ mm ha^{-1} $hour^{-1}$ $year^{-1}$)
- K = Soil erodibility factor (tonne hour MJ^{-1} mm^{-1})
- LS = L and S are the slope length and steepness factors, respectively (dimensionless)
- C = Vegetation and Management Factor (dimensionless)
- P = Support Practice Factor (dimensionless)

Supporting information to assist in the selection of these factors is presented in Appendix B.

6.2.1 Rainfall Factor, R

The rainfall factor, R, is a measure of the total annual erosive rainfall for a specific location, combined with the distribution of erosive rainfall throughout the year. The high energy thunderstorms of the summer months are generally regarded to be the most potentially erosive events in most areas of Alberta.

The rainfall factor is the average annual sum of the products of the two variables most critical to a storm's erosivity:

- Volume of rainfall and runoff (E); and
- Prolonged-peak rates of detachment and runoff (I) (Wischmeier and Smith, 1978).

EI is the total kinetic energy of a storm multiplied by the maximum 30-minute intensity.

R is estimated through the use of the following three primary methods:

1. Measured rainstorm EI values. This method is suitable if 22 or more years of rainfall intensity data is available (Wischmeier and Smith, 1978).
2. Equations which rely on an empirical relationship between R and the one-in-two year, 6 hour storm, (Ateshian, 1974; Madramootoo, 1988; Wall et al., 1983).
3. Hourly precipitation records, where available, to predict R (Wigham and Stolte, 1986).

The aforementioned three methods used to estimate R have been used to produce the following reference materials for Canadian conditions:

- Isoerodent maps which indicate annual R values for an area and can be used to calculate average annual soil losses;
- Monthly distribution of R which indicates the proportion of annual erosive rainfall that falls during each month; and
- Mean annual rainfall on frozen soil maps, which may indicate areas where rain falling on frozen soil could pose an erosion risk.

It is typical in roadway construction to re-establish grass vegetation as soon as practicable after grading has been complete. In many cases, the contractual requirements necessitate that seeding and fertilizing be quickly undertaken by the contractor, preferably as soon as cut and fill slope surfaces are completed. Through this activity, the sediment yield from a site can be reduced from that anticipated for an entire year of exposure. In these cases, it is more appropriate to assign a monthly distribution of the soil loss over a time period where the soils are anticipated to be exposed. Therefore, an R value can be estimated for the entire year (R_t) or for a portion or season of the year (R_s). The estimation of R_t and R_s is discussed in the following paragraphs.

Estimation of R_t

The following procedure may be followed to estimate a value of R_t:

1. Locate the area of interest in Figure B-1, Appendix B, Isoerodent map showing R_t values (yearly) for the Prairie Region. Extrapolate point or area relative to R_t factor contours.
2. Similarly, locate the area of interest in Figure B-3, Appendix B, adjustment for winter conditions, R_s for the Prairie Region.
3. R values for spring to fall are presented in Figure B-2, Appendix B for non-winter conditions.

Estimation of R_s

The following procedure may be followed to estimate a value of R_s:

- Determine time of interest;
- Select the monthly distribution from climatic station closest to the area of interest from Figure B-4 and Table B-1, Appendix B;
- Add the monthly values for the time of interest and determine a percentage of R_t for the construction period; and
- Multiply the value by the total annual R_t value to obtain the seasonal R value.

6.2.2 Soil Erodibility Factor, K

6.2.2.1 Estimation of K

The K factor is a quantitative measure of a soil's inherent susceptibility to erosion. Generally, on the basis of soil characteristics alone, soils with a high percent content of silt and very fine sand particles, as well as a low fibrous organic matter content, will be most erodible. A preliminary assessment of soil erodibility has been presented in Figure 4.2. K values estimated using the methods detailed herein are appropriate for soils encountered in agricultural practice. As such, a soil erodibility adjustment factor ($Ø_K$) is proposed to permit application of the estimated K values to highway construction sites and is discussed in Section 6.2.2.2.

A K value can be calculated for a specific soil, using the following equation (Wischmeier and Smith, 1978).

$$K = [2.1 \times 10^{-4}(12-a)M^{1.14} + 3.25(b-2)+2.5(c-3)]/100 \qquad \text{(Equation 6.2)}$$

Where: M = (% silt + very fine sand) x (100 - % clay)

a = % organic matter

b = the soil structure code used in soil classification (Figure B-6), and

c = the profile permeability class (Figure B-7)

The input parameters for the aforementioned equation are routinely characterized through standard soil profile descriptions and laboratory analyses. These parameters are listed as follows:

- % silt plus very fine sand (soil particle sizes between 0.05 and 0.10 mm);
- % sand greater than 0.10 mm;
- Soil structure;
- Permeability; and
- Organic matter content.

Of these variables, organic matter content can usually be assumed to be zero in road embankments or deep cuts.

The soil erodibility nomograph (Figure B-5, Appendix B) provides a graphical solution for determining a soil's K value, and can be used if the percent sand and organic matter fractions in a particular soil are known.

The soil erodibility potential is low for high plasticity clayey soil and coarse to medium grained granular soils; therefore, gradation analysis including hydrometer testing of these soils would not usually be required for an erodibility assessment. The soil erodibility can be high to medium for low to non-plastic soil and soil with significant amounts of silt and fine sand. Therefore gradation analysis including hydrometer testing is required.

Where the soil fractions are not known, K factors have been estimated for a number of surface textures and for approximate organic matter content. Major textural groups and their corresponding K values are listed (Table B-2, Appendix B).

6.2.2.2 Soil Erodibility Adjustment Factor ($Ø_K$)

It should be noted that the soil erodibility factor (K) has been developed for an agricultural setting. It is important to recognize that the level of consolidation and/or compaction of soils encountered on cut and fill areas in a highway construction setting is usually much greater than that encountered in an agricultural setting. Cutslopes in highway construction will consist of consolidated material and fill slopes will have undergone significant compaction effort and moisture conditioning. For fill embankments, compaction energy was exerted on the soils at thin lifts with moisture conditioning (to moisten or dry the soil to an optimum moisture content) to achieve a maximum dry density (Standard Proctor Density). Most highway fills are constructed with mineral soils with minimal organic content. This situation differs greatly from an agriculture setting where soils have been machine agitated to produce loose conditions that promote plant growth. Furthermore, a compact soil in an agricultural setting is not the same as a well compacted or consolidated soil on a highway construction site. However, despite the compaction efforts to improve soil structure strength in a highway construction setting, silty and low plasticity fine-grained soils are generally considered as highly erodible.

Based on the aforementioned differences in the erodibility for soils encountered in highway construction and agricultural settings, the soil encountered in a highway should have a lower erodibility rating. Thus, a modification factor ($Ø_K$) should be applied to lower the K factor determined as part of the RUSLE approach to estimating soil loss. Based on engineering judgement, a range of 0.5 to 1.0 (with a suggested value of 0.8), is considered appropriate for $Ø_K$. However, the selection of $Ø_K$ is to be conducted at the discretion of the individual or firm engaged in estimating soil loss potential should be based on site conditions, experience and judgement. The suggested modification factor of 0.8 has been developed based on judgement for this document and represents a highway construction specific factor to be used in the RUSLE.

6.2.3 Topographic Factor, LS

6.2.3.1 Estimation of LS

The topographic factor, LS, is a combined factor that accounts for the effect of slope length (L) and slope steepness (S) factors on the site erosion potential. It adjusts the erosion prediction for a given slope length and slope angle to account for differences from slope conditions present at the standard erosion monitoring plot on which the USLE was based (LS=1 for slopes 22 m long with 9% grade).

For consolidated soil conditions, such as freshly prepared construction sites, with no to little vegetative cover, values of LS can be evaluated from the Topographic Factor Chart (Table B-3, Appendix B) for slope lengths varying from 2 to 300 m, and slopes ranging from 0.2 to 60%.

The upper end of a slope can be defined as the top of the slope, or the divide down a ridge in the field. The lower end of a slope can be located by moving down the slope, perpendicular to the contours, until a broad area of deposition or a natural or constructed waterway is reached. Reducing either the length or steepness of a slope can reduce soil loss. However, reducing the steepness of a slope results in an increased slope length, thus the overall reduction of soil erosion may not be significant. Another way to reduce soil loss is to place intercepting berms along the contours. While this procedure will effectively reduce the cross-section to a series of simple slopes, costly earthworks may be required to establish the berms, which may not be justified unless fill material is readily acquired at a nearby location.

Estimation of the LS factor for uniform slopes and irregular slopes is discussed in the following paragraphs.

<u>Uniform Slopes</u>

The equation of the LS factor for a uniform slope is given as follows:

$$\mathbf{LS = (sl/22.13)^m \times S} \qquad \text{(Equation 6.3)}$$

The slope factor "S" in RUSLE is given as follows (McCool et al., 1989):

$$S = 10.8\sin(\theta) + 0.03$$

when slope is <9%, length ≥ 5 m

$$S = 16.8\sin(\theta) + 0.50$$

when slope ≥ 9%, length ≥ 5 m

$$S = 3.0\sin(\theta)^{0.8} + 0.56$$

when length <5 m

Where: sl is the slope length of the site (m)

θ is the angle of the slope (in degrees)

m is a coefficient related to the ratio of rill to inter-rill erosion presented in Table B-4.

Irregular Slopes

The RUSLE provides a procedure for separating an irregular slope into segments. This procedure recognizes and adjusts for differences in the type of slope. For example:

- A **convex slope** will have a greater effective LS factor (i.e., a higher erosion estimate) than a uniform slope with the same average gradient; conversely
- A **concave slope** will generally have a lower effective erosion rate than a uniform slope of the same average gradient.

The irregular slope should be divided into a two to five segments that describe varying conditions down slope (i.e., soil type, practices, etc.).

Design examples illustrating evaluation of LS for irregular slope are presented in Appendix H as Examples H.4 and H.5.

6.2.3.2 Topographic Adjustment Factor ($Ø_{LS}$)

The RUSLE Topographic factor (LS) was developed for typical agricultural slopes with loosened surficial soils for most soil types of moderate to low erodibility. For highway construction applications, slopes are generally much steeper than this and the surficial soils are much denser. Typical slopes for a highway construction site in Alberta range from 3H:1V (33%) to 6H:1V (16%). Using RUSLE for a typical highway construction slope results in a relatively high LS value and subsequently high site erosion potential based on an agricultural setting. Although it is apparent that steeper slopes are more prone to erosion as a result of increased runoff velocities, the RUSLE classifications for site erosion potential are calibrated or standardized to a much lower slope gradient and therefore will require modification for use on highway construction sites.

In the agriculture practice of assessing the erodibility for slope with loose surficial soils, a gentle slope (9% slope, 22 m length) (Wischmeier and Smith, 1978) was chosen to calibrate a baseline value for slope erodibility factor (LS=1 in RUSLE) with other slope configurations of steepness and length. As a result, the LS factor is dependent on soil conditions, even though it is intended as a modifier for varying slope steepness. In highway slopes with compacted soils, the same baseline slope configuration will yield a lower slope erodibility (LS) value due to the higher density in highway soils.

Based on the aforementioned differences between a highway construction and agricultural setting, the soils encountered in a highway setting should have a lower slope factor rating. Thus a Topographic Adjustment Factor ($Ø_{LS}$) is applied to lower the LS factor determined as part of the RUSLE approach to estimating soil loss. An $Ø_{LS}$ of 0.8 is suggested to address the inherent differences between highway construction and agricultural settings. However, the selection of $Ø_{LS}$ is to be conducted at the discretion of the individual or firm estimating soil loss potential based on site conditions, experience and judgement. The adjustment factor has been developed based on judgement for this document and represents a highway construction specific factor to be used in the RUSLE.

6.2.4 Vegetation and Management Factor, C

The C-factor is used to determine the relative effectiveness of soil management systems in terms of vegetation, crop cover and/or artificial protection cover (such as mulch, synthetic erosion protection matting) to effect preventing or reducing soil loss. For bare soil, C=1 can be used; for soil surface protected by mulch C=0.1 to 0.2 is common. Some construction site C-factor values are shown in Tables B-6a and B-6b (Appendix B).

6.2.5 Support Practice Factor, P (Practice Factor)

The P-factor is a measure of the effects of practices designed to modify the contouring flow pattern, grade, or direction of surface runoff and thus reduce the amount of erosion. Generally, a support practice is most effective when it causes eroded sediments to be deposited far upslope, very close to their source. In the absence of any support practices, P should be assumed to be 1.0 in the RUSLE formula. With the use of appropriate construction practice, the P factor can be reduced. For example, the practice of track roughening of bare slope (up/down slope) can reduce the P factor from 1.0 to 0.9. Estimation of P may well be the least accurate and most subject to error of the RUSLE factors, because of less data compared to other factors in the RUSLE formulation.

Some construction site P-factor values are provided in Table B-7, Appendix B.

The RUSLE brings in a mixture of empirical and process-based erosion technology to provide a better measure of the effect of land management on erosion rates. Values are based on hydrologic groups, slope, row grade, ridge height, and the 10-year single storm index values.

6.3 Empirical Method for Sediment Storage/Impoundment

The empirical method presents a general relationship between required storage capacity for sediment laden runoff from the construction site and the area of disturbed or exposed soil. This method should only be used for small drainage areas. Disturbed areas greater than 10 ha or long steep slopes must utilize better estimating procedures such as the RUSLE. It is important to note that consideration of various site specific factors that affect soil erosion rate are taken into account. Therefore, the empirical method should be used with caution. The main advantage of the empirical approach is in its simplicity and ease of application.

Various jurisdictions utilize storage volume requirements ranging from 40 to 250 m^3/ha. Sediment storage/impoundment ponds are normally designed at 1 m depth with a design volume varying from 150 m^3/ha (minimum) to 250 m^3/ha (recommended). It is assumed that vegetation will be established within one to two years of land disturbances taking place or that there will be at least one clean out of the sedimentation facilities per year. If neither is performed, a storage volume of 250 m^3/ha (whenever possible) is recommended for sensitive areas and a minimum storage of 150 m^3/ha will be required under conditions of restricted space availability. For design considerations, climate variability of different parts of the Province may affect or may require larger storage/impoundment capacity than mentioned above.

6.4 Examples for Estimating Site Erosion Potential

Examples using the RUSLE for determining the soil erosion potential are presented in Appendix H as Examples H.1, H.2 and H.3.

6.5 Site Evaluation

Once a site assessment has been completed, the information should be summarized to provide a complete summary evaluation of the slope and drainage conditions. The site evaluation is a critical step in the preparation of an erosion and sediment control plan and the summary information should be clearly indicated on drawings and supporting documents.

6.5.1 Slope Analysis Summary

As a minimum, a summary of the conditions of the slope to be exposed should be conducted to estimate the potential sediment loss from a site. Areas of exposure generally include all cut and fill slopes as well as large stockpiles and non-dugout borrow sources. It may be necessary to divide a slope area by drainage breaks and/or soil type. A representative value for each of the following parameters should be indicated on the erosion and sediment control plan drawings and supporting documents:

- Soil Type: Each distinctly separate soil type to be encountered should be delineated by area on the site plan. Where distinct soil type boundaries are not known or cannot be inferred, estimations of soil type areas are acceptable. Information from the site assessment will be helpful in defining the various soil types by area. Additional information gathered during construction can be used to update the soil type areas.
- RUSLE Factors: The RUSLE factors (R, K, LS, C, and P) as defined in Section 6.2 should be summarized for the general conditions of the site and for the specific conditions for each distinctly separate soil/ slope area to be encountered on the site.
- Site Erosion Potential / Hazard Class: Using the RUSLE factors, the soil erosion potential (tonnes/ha/year) should be estimated for each distinct area and period of anticipated construction activity. For the soil loss estimated for a particular site, the associated hazard classification can be obtained from Table 6.1.

- Special Sites: Any sites of special consideration should be indicated on the site plan, such as locations of potential slope instability, seepage, or borrow sources.

6.5.2 Drainage Analysis Summary

As a minimum, a summary of the drainage conditions to be encountered should be conducted and provided as information on the erosion and sediment control plan drawings and support documents.

- Drainage Catchment Areas: A topographic site plan of the construction site and contributing drainage catchment area(s) needs to be divided into smaller drainage areas based on topographic breaks in slope. Then, for each of the drainage areas identified, an estimate of size in hectares (ha) should be provided. Where the site has to be re-graded to final elevations, the direction of sediment-laden flow could change. Overland flow routes, for both initial and final site grade conditions, should be checked to ensure that the appropriate downstream environmental sensitivity has been evaluated.
- Watercourses: If not already shown on the topographic site plan, all watercourses should be identified and labelled. Watercourses consist of all areas of channelized flow (streams, creeks, ditches), as well as drainage collection features such as swamps, ponds and lakes. Design drawings should show all proposed ditchlines, catchments and crossings in addition to the natural drainage features. Information on watercourses should extend beyond the limits of the construction site. As a minimum, drainage connectivity should be established to the nearest body of sensitive water downstream of the construction site.
- Fisheries Classifications: Watercourses should be labelled with the appropriate fisheries classification.
- Floodplain Information: Where applicable, a clear definition of the floodplain limits should be shown on the drawings.
- Special Sites: Sites of special consideration should be indicated on the drawings.

6.5.3 Site Hazard Classification

Site hazard classification can be obtained from Table 6.1 below based on the estimate of site erosion potential (tonnes / ha / year).

Table 6.1: Site Hazard Classification (RUSLE-FAC *)

Site Erosion Potential (tonnes / ha / year)	Hazard Class
< 6	Very Low
6-11	Low
11-22	Moderate
22-33	High
> 33	Very High

Source: Wall et al, 1997*

6.5.4 Connectivity to Downstream Aquatic Resources

The location of the construction site with respect to downstream aquatic resources is a very important factor in preparing an erosion and sediment control plan. Establishing the connectivity of the construction site to downstream water supplies, flood control, fish habitat, navigation, and recreational activities can be conducted using information from the drainage analysis summary.

As far as this manual is concerned, the most negative, and therefore monitored, consequence from erosion and sedimentation is the degradation of water quality and more particularly the impact on fish habitat. The connectivity rating for each distinct segment on a construction site should be shown on the erosion and sediment control plan drawings.

The following table provides ratings based on connectivity to aquatic resources:

Table 6.2: Connectivity Rating to Aquatic Resources

Connectivity Rating	Criteria[1]
Direct	Any sediment from a construction site is transported directly downstream at a significant gradient (i.e., greater than 5%) to locations where it may result in adverse effects to water quality or aquatic resources.
Indirect	Sediment laden water from a construction site empties into a secondary watercourse (i.e., stream, ditch, swale) before connecting with any stream with water quality or aquatic resource values. The secondary watercourse must be a non-fish habitat watercourse, with a channel gradient no more than 5% for a minimum length of 100 m.
No Connectivity	For no connectivity, the sediment laden runoff flows into a non-significant[*] swamp or pond and sediment is trapped where water quality or aquatic resources are not a concern, or must terminate before connecting with any stream that has water quality or aquatic resource values.

[1] Criteria adapted from British Columbia Ministry of Forests (2001).

[*] Assessment of the significance of a swamp/pond should be undertaken by an environmental engineer/specialist.

7.0 EROSION AND SEDIMENT CONTROL METHODS

7.1 General

It is important to recognize the difference between erosion control measures and sediment control measures when preparing an effective erosion and sediment control plan. The difference between erosion and sediment control methods is defined and summarized for the purposes of this document and all related activities on construction sites as follows:

- Erosion Control is the process whereby the potential for erosion is minimized; and
- Sediment control is the process whereby the potential for eroded soil being transported and/or deposited beyond the limits of the construction site is minimized. In this document, the term "sediment control" is synonymous to sedimentation control.

Erosion control should be viewed as the primary means in preventing the degradation of downstream aquatic resources whereas sediment control should be viewed as a contingency plan. Most erosion control measures are initiated to facilitate the earliest shift to vegetation as the erosion control medium. A greater emphasis must be placed on erosion control, particularly in areas of elevated erosion potential where fine particles that will not readily settle out in a practical time frame are exposed during construction. However, measures to address both erosion control and sediment control are required for most sites.

The design of erosion and sediment control measures should be viewed as a flexible process that responds to new information that is obtained throughout the construction phase. As such, the design of temporary and permanent erosion and sediment control measures should be expected to evolve throughout construction to varying degrees based on site conditions and field performance of implemented measures.

Erosion and sediment control measures are classified into the following categories:

- Temporary measures;
- Permanent measures;
- Minimum requirements (Planning Strategy); and
- Best management practices (BMP).

Each of these categories and BMPs are described in the following sections.

7.1.1 Temporary and Permanent Control Measures

Erosion and sediment control measures can be classified into two broad categories:

- <u>Temporary Measures:</u> Those measures during the construction phase that will be completely removed once permanent measures are installed and/or vegetative cover is established; and
- <u>Permanent Measures:</u> Measures incorporated into the overall design to address long-term, post construction erosion and sediment control.

Temporary erosion and sediment control measures should be installed at the start of the construction phase. Additional measures will likely need to be installed throughout the construction phase. Permanent erosion and sediment control measures can be installed during or at the end of the construction phase.

A listing of erosion and sediment control BMPs are presented in Tables C-1, C-2 and C-3 in Appendix C. Examples of temporary measures include topsoiling, seeding, slope texturing, synthetic permeable barrier, mulching, RECP coverings, silt fence, rolls, wattles, straw bale barriers, etc. Examples of permanent measures include offtake ditch, energy dissipator, berm interceptor, gabion, rock check, sediment pond/basin, etc. Dependent on site conditions, some temporary measures will be retained for a longer duration to render its life span more permanent. Streambank application BMPs are added (Table C-4) in Appendix C.

7.2 Procedural BMPs and Planning Strategy

Procedural BMPs (Table C-5) in Appendix C are often called minimum requirements which are non-structural methods or procedures that can reduce erosion and sediment transport. Proper planning generally constitutes the minimum requirement for preparing an erosion and sediment control strategy. Proper construction planning includes implementing erosion or sedimentation control BMPs early in construction and recognize the impact of different seasons on highway construction sites (e.g., rainfall, snow melt). Various methods of scheduling construction activities can provide the first, best opportunities to help minimize the potential for erosion and sedimentation. However, the minimum requirements are generally not sufficient on their own. As such, many construction projects will require site specific erosion and sediment control measures to be implemented as site conditions dictate. The effectiveness of the erosion and sediment control measures on a site is highly dependent on proper implementation of a well prepared erosion and sediment control plan.

The minimum requirements for planning strategies and procedural BMPs for an erosion and sediment control strategy are presented in Table 7.1.

7.2.1 Understanding the Practice of Erosion and Sediment Control (ESC) as a Whole System

It is important that the designer and contractor recognize that successfully implementing ESC measures requires a good understanding of the principles of the ESC process by both design and field staff. Installing BMPs correctly to specific site conditions and ongoing timely upgrading and maintenance are essential for a successful outcome. The planning strategies and BMPs presented in this document are as equally important as the understanding of the principles of their implementation to achieve good construction performance and protection of the environment.

It is essential to understand that the objectives of the ESC measures begin with education and interaction throughout the planning, design, construction and post construction stages.

Table 7.1: Planning Strategies and Procedural BMPs for ESC Plans

BMP	Applications				Comments	
	Slopes	**Ditches and Channels**	**Large Flat Surface Areas**	**Borrow and Stockpile Area**	**Advantages**	**Limitations**
Minimize Exposed Soils	✓	✓	✓	✓	Decreases erosion potential and decreases quantity of erosion and sediment control measures required thus decreasing costs	May require topsoiling/seeding be completed on areas before stripping of new areas
Observe Environmental Timing Restrictions	✓	✓	✓	✓	Minimizes possible negative impacts on fish and wildlife	May affect project schedule
Maximize Work During Favourable Weather	✓	✓	✓	✓	Minimizes volume of work required in less desirable (wet) conditions, thus decreasing potential for erosion and sediment transport	May require additional resources to increase scale of production/construction
Install BMPs Early	✓	✓	✓	✓	Minimizes sediment losses during construction	May cause difficulties with site access or traffic
Avoid Wet Weather Periods	✓	✓	✓	✓	Minimizes erosion potential	Shutdowns may prolong/delay construction activities
Topsoil and Seed Early	✓	✓	✓		Covers exposed soil and reduces erosion potential	
Surface Roughening (Slope Texturing)	✓		✓	✓	Reduces erosion: estimated 12% for a dozer ripping on the contour, 52% for track walking up and down the slope, 54% for sheep's foot rolling, and 76% for imprinting (Mike Harding, 2010)	Equipment may need to be retasked at a slight increase in construction cost
Preserve and Use Existing Drainage Systems	✓	✓	✓	✓	Minimizes exposed soils in drainage system	May affect scheduling of certain construction activities
Control Construction Traffic				✓	Avoids over-trafficking sensitive areas or areas with increased disturbance	Forcing traffic into localized areas may increase disturbance in high-traffic areas
Signage	✓	✓	✓	✓	Clearly labelling sensitive zones or areas not to be disturbed makes workers aware of work restrictions	Increased costs of signs

Table 7.1: Planning Strategies and Procedural BMPs for ESC Plans

BMP	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Scheduling of Work	✓	✓	✓	✓	Placement of topsoil and seeding should be scheduled throughout construction phase. New sections should not be stripped far in advance of construction	May require construction to be completed in one area before starting in another.
Stockpile Control				✓	Stockpiles should be located well away from watercourses and environmentally sensitive areas	May result in longer haul distances.
Direct Surface Water Flow Around Site	✓	✓	✓	✓	Keeps surface water from off-site from increasing erosion	Diversion ditches may require erosion and sediment control measures to be implemented.

7.3 Water Management BMPs

Water management BMPs are measures which can be implemented on-site or off-site. These are intended to control water and reduce erosion potential by following these general principles:

- Keep clean water clean, by diverting clean water around the site and by conveying clean water from undisturbed areas within the site to natural receiving streams;
- Minimize watercourse disturbance by using existing drainage where possible and by integrating on-site drainage into the project design;
- Design new drainage channels to accommodate design discharges and use natural channel design for watercourse diversions; and
- Anticipate and manage groundwater where applicable.

Commonly used water management BMPs are listed in Table 7.2, where the applicability of each BMP to each roadway construction site is noted.

Table 7.2: Surface Water Management BMPs for ESC Plans

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

Source: Transportation Association of Canada, 2005

7.4 Erosion Control BMPs

BMPs for erosion control are measures that have been proven to work on construction sites when they were properly planned and constructed. These measures reduce erosion potential by stabilizing exposed soil or reducing surface runoff flow velocity. There are generally two types of erosion control BMPs that can be used in conjunction with the minimum requirements:

- Source Control BMPs for protecting exposed surfaces; and
- Runoff Control BMPs.

Overall experience is an integral component in the successful selection of the appropriate BMP(s) and the design and implementation of an overall erosion and sediment control plan. It is the designer's responsibility to select BMPs which are appropriate for site conditions.

Erosion control BMPs may involve the use of bio-engineering methods. Bio-engineering methods are permanent erosion control measures that involve using the roots, stems and leaves of vegetation to reduce the potential for erosion. This is achieved by introducing foliage that decreases impact erosion of rain drops, and increases infiltration of rain into the soil resulting in anchoring of the soil with root systems. As the plants grow, the strength of the bio-engineered erosion control system strengthens. Typically bio-engineering is used to prevent erosion where there are environmental or aesthetic enhancement requirements; however, if properly selected and implemented, it will provide a simple and cost effective measure for controlling long-term erosion problems. Revegetation of exposed soil with locally compatible grass growth on topsoil is the main bio-engineering erosion control method utilized in highway construction in Alberta.

Source Control

The protection of exposed surfaces from the erosive energy of rain splash and surface runoff flow should be the primary goal when selecting appropriate control measures. Cover is the single most effective erosion control BMP for preventing erosion. Cover can include topsoiling in conjunction with one or more of the following: seeding, mulching, hydroseeding, sodding, erosion control blankets, turf reinforcement matting (TRM), riprap, gabion mat, aggregate cover and paving.

An overview of appropriate BMPs for the protection of exposed surfaces with their respective advantages and limitations is presented in Table 7.3.

Runoff Control

During construction it is not always possible or practical to provide surface cover for all disturbed areas. Commonly used methods for runoff control include the modification of slope surfaces, the reduction of slope gradients, controlling flow velocity, diverting flows around the affected area, and providing upstream storage for runoff.

An overview of appropriate BMPs for the runoff control is presented in Table 7.4 with their respective advantages and limitations.

Table 7.3: Erosion Control Measures – Source Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
25	Topsoiling	✓	✓	✓	✓	Placing topsoil provides excellent medium for vegetation root structure development, organic content promotes plant growth, reuse organics (topsoil or peat) stripped from the site at start of grading; absorbs raindrop energy to minimize erosion potential	Cannot be effective without seeding and allowing time for plant growth; not appropriate for slopes steeper than 2H:1V (steep slopes will require soil covering over topsoil and specialized design); dry topsoil susceptible to wind erosion, susceptible to erosion prior to establishment of vegetation
22	Seeding	✓	✓	✓	✓	Inexpensive and relatively effective erosion control measure, effectiveness increases with time as vegetation develops, aesthetically pleasing, enhances terrestrial and aquatic habitat	Must be applied over prepared surface (topsoiled), grasses may require periodic maintenance (mowing), uncut dry grass may be a fire hazard, seeding for steep slopes may be difficult, seasonal limitations on seeding effectiveness may not coincide with construction schedule, freshly seeded areas are susceptible to runoff erosion until vegetation is established, reseeding may be required for areas of low growth
23	Mulching	✓	✓	✓	✓	Used alone to protect exposed areas for short periods, protects soil from rainsplash erosion, preserves soil moisture and protects germinating seed from temperature extremes, relatively inexpensive measure of promoting plant growth and slope protection	Application of mulch on steep slopes may be difficult, may require additional specialized equipment. May deplete available nitrogen. Nitrogen rich fertilizer may need to be added

Table 7.3: Erosion Control Measures – Source Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
24a 24b	Hydroseeding / Hydromulching	✓	✓	✓	✓	Economical and effective on large areas, mulch tackifier may be used to provide immediate protection until seed germination and vegetation is established, allows revegetation of steep slopes where conventional seeding/mulching techniques are very difficult, relatively efficient operation, also provides wind erosion control	Site must be accessible to hydroseeding / hydromulching equipment (usually mounted on trucks with a maximum hose range of approximately 150 m), may require subsequent application in areas of low growth as part of maintenance program
26	Sodding	✓	✓	✓	✓	Provides immediate vegetation and protection, instant buffer strip and/or soft channel lining, can be used on steep slopes, relatively easy to install, may be repaired if damaged, aesthetically pleasing	Expensive, labour intensive to install, sod may not be readily available in all areas of the province, relatively short 'shelf-life' (sod can't be stored on-site for excessive periods of time)
14	Riprap Armouring	✓	✓			Most applicable as channel lining with geotextile underlay, used for soils where vegetation not easily established, effective for high velocities or concentrations, permits infiltration, dissipates energy of flow from culvert inlets/outlets, easy to install and repair, very durable and virtually maintenance free	Expensive, may require heavy equipment to transport and place rock, may not be feasible in areas of the province where rock is not readily available, may be labour intensive to install; generally thickness of riprap is higher when compared to gabion mattress
13	Rolled Erosion Control Products (RECP)	✓	✓			Provides a protective covering to bare soil or topsoiled surface where need of erosion protection is high, can be more uniform and longer lasting than mulch, wide range of commercially available products	RECP use is labour intensive to install, temporary blankets may require removal prior to restarting construction activities, RECP not suitable for rocky slopes, proper site preparation is required to seat RECP onto soil correctly; high performance is tied to successful vegetation growth

Table 7.3: Erosion Control Measures – Source Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
15	Cellular Confinement System	✓	✓			Lightweight cellular system and easily installed, uses locally available soils for fill to reduce costs	Not commonly used in Alberta highway construction, expensive, installation is labour intensive (hand installation), not suitable for slopes steeper than 1H:1V
27a	Live Staking	✓		✓		Establishes vegetative cover and root mat, reduces flow velocities on vegetative surface, traps sediment laden runoff, aesthetically pleasing once established, grows stronger with time as root structure develops, usually has deeper root structure than grass	Expensive, may be labour intensive to install, not commonly used in Alberta highway construction projects, revegetated areas are subject to erosion until plants are established, plants may be damaged by wildlife, watering is usually required until plants are established
30	Riparian Zone Preservation	✓	✓	✓	✓	Preserve a native vegetation buffer to filter and slow runoff before entering sensitive (high risk) areas, most effective natural sediment control measure, slows runoff velocity, filters sediment from runoff, reduces volume of runoff on slopes	Freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment
32	Scheduling	✓	✓	✓	✓	Identifies protection issues and plans for efficient, orderly construction of BMPs; minimizes bare soil exposure and erosion hazard; allows early installation of perimeter control for sediment entrapment; and early installation of runoff control measures	
34	Slope Texturing	✓			✓	Roughens slope surface to reduce erosion potential and sediment yield; suitable for clayey soils	Additional cost; not suitable for silty and sandy soils; not practical for slope length <8 m for dozer operation up/down slope

Table 7.3: Erosion Control Measures – Source Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
36	Polyacrylamide (PAM)	✓	✓		✓	Increase cohesion of soil particles, thus enhancing terrestrial and aquatic habitat and improving water quality	Not for application to surface waters. Not commonly used in highway construction projects and may be expensive. Treatment area must be accessible to spray equipment. Temporary measure only. Performance decreases due to exposure to UV light and time
35	Straw Mulching & Crimping (Straw Anchoring)	✓			✓	Economical method of promoting plant growth and slope protection	Availability of straw. “Punching” of straw does not work on sandy soils. Application of straw by hand is labour intensive. If using straw blowers, treatment area must be accessible to trucks
37	Compost Blanket	✓		✓	✓	Economical. Appropriate on slopes 2H:1V to level surface	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks

Table 7.4: Erosion Control Measures – Runoff Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
34	Slope Texturing	✓		✓	✓	Contouring and roughening (tracking) of slope face reduces runoff velocity and increases infiltration rates; collects sediment; holds water, seed and mulch better than smooth surfaces; promotes development of vegetation, provides reduction in soil erosion compared with untracked slopes	May increase grading costs, may cause sloughing in sensitive (wet) soils, tracking may compact soil, provides limited erosion control and should not be used as primary control measure
21	Offtake Ditch	✓		✓	✓	Collects and diverts sheet flow or runoff water at the top of a slope to reduce downslope erosion, incorporated with permanent project drainage systems	Channel must be sized appropriately to accommodate anticipated flow volumes and velocities, lining may be required, may require design by qualified personnel, must be graded to minimize ponding
17	Energy Dissipator	✓	✓			Slows runoff velocity and dissipates flow energy to non-erosive level in relatively short distances, permits sediment collection from runoff	Small diameter rocks/stones can be dislodged; grouted riprap armouring may breakup due to hydrostatic pressures, frost heaves, or settlement; may be expensive, may be labour intensive to install; may require design by qualified personnel
19	Slope (Down) Drains	✓				Directs surface water runoff into drain pipe or lined channel instead of flowing over and eroding exposed soils of slope face	Must be sized appropriately to accommodate anticipated flows, erosion can occur at inlet/outlet if protection is not incorporated into design, slope drain pipe must be anchored to slope

Table 7.4: Erosion Control Measures – Runoff Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
2	Gabions		✓			Relatively maintenance free, permanent drop structure, long lasting, may be less expensive than riprap, allows smaller diameter rock/stones to be used, relatively flexible, commercially available products, commonly used in Alberta highway construction projects; suitable for resisting high flow velocity	Construction may be labour intensive (hand installation), extra costs associated with gabion basket materials
7	Rock Check Dam		✓		✓	Permanent drop structure with some filtering capability, cheaper than gabion or armouring entire channel, easily constructed, commonly used in Alberta highway construction projects	Can be expensive in areas of limited rock source, not appropriate for channels draining areas larger than 10 ha, requires maintenance after high flow storm events, can fail if water undermines or outflanks structure
10	Synthetic Permeable Barriers		✓			Reusable/moveable, reduces flow velocities and dissipates flow energy; retains some sediments; used as grade breaks in conjunction with sturdy permanent drop structures along steep grades	Not to be used as check structures, must be installed by hand in conjunction with RECP, become brittle in winter and are easily damaged by construction equipment or recreational vehicles, only partially effective in retaining some sediment
20	Groundwater Control (Subsurface Drain)	✓				Relief of subsurface groundwater seepage and winter ice build-up; lowers groundwater table to minimize piping erosion; enhances slope stability performance	Requires design by a qualified person; can be a slope instability issue

Table 7.4: Erosion Control Measures – Runoff Control

BMP #	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
38 28	Rolls (Fibre) Wattles	✓				Function well in freeze-thaw conditions, low cost solution to sheet flow and rill erosion on slopes, low to medium cost flow retarder and silt trap, can be used on slopes too steep for silt fences or straw bale barriers, biodegradable	Labour intensive to install (hand installation), designed for slope surfaces with low flow velocities, designed for short slope lengths with a maximum slope of 2H:1V, not currently widely used on Alberta highway construction projects
4	Continuous Perimeter Control Structures	✓		✓	✓	Economical, no trenching required, flexible with continuous contact with ground. Appropriate on slopes 2H:1V to level surface	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks if installing compost berm

7.5 Sediment Control BMPs

BMPs for sediment control are measures that have been proven to work on construction sites when they were properly planned and constructed. These measures reduce off-site sedimentation by promoting sedimentation before surface water leaves the construction site. There are generally two types of BMPs that can be used in conjunction with the minimum requirements:

- Filtering and Entrapment BMPs; and
- Impoundment BMPs.

Overall experience is an integral component in the successful selection of appropriate BMPs, and the design and implementation of an overall erosion and sediment control plan. It is the designer's responsibility to select BMPs which are appropriate for site conditions.

A sediment control plan may involve the use of bio-engineering methods. Bio-engineering methods can be permanent sediment control measures that involve using vegetation to promote sedimentation. The roots, stems and leaves promote sedimentation by reducing the velocity of water flow, with subsequent sedimentation of varying degrees depending on the sediment load, nature of sediments and reduction of flow velocity.

An overview of appropriate sediment control BMPs is presented in Table 7.5 with their respective advantages and limitations.

Filtering and Entrapment BMPs

Soil particles suspended in runoff can be filtered through porous media consisting of natural and artificial materials (i.e., vegetative strips, stone filters, man-made fibre filters). Filtering can be effectively applied to concentrated channel flows at inlets of permanent or temporary drainage systems and outlets of sedimentation ponds. This application requires careful maintenance to ensure continued effectiveness as sediment can clog these measures during storm events and/or during prolonged use.

Filtering is most effective when applied to unconcentrated sheet flow as a linear measure placed perpendicular to the direction of flow. Stream banks and the perimeter of regions of high-erosion potential are typical sites where filtering BMPs are employed for sediment control.

The most commonly used entrapment method is a silt fence. This measure is more effective for trapping particle sizes of fine, medium sand to coarse silt, depending on the mesh size used, for low flow velocity (<1.0 m/sec) and gentle grades (<3%). This method should only be used when there are **small runoff flow rates and volumes**; otherwise, its effectiveness will decrease and the system can be undermined or breached.

Check dams constructed from coarse granular material could be selected for steep grade situations where high flow velocity or volumes is anticipated.

Impoundment BMPs

The temporary impoundment of sediment-laden surface runoff lowers its internal energy by reducing flow velocity which promotes sedimentation. However, sedimentation may take a long time if the suspended sediments contain a significant portion of colloidal/clay or organic particles. This technique is normally applied to **concentrated flow** within the permanent or temporary drainage system of a site. Common types of impoundment structures are:

- Sedimentation basin/trap designed for a large runoff area; and
- Temporary barriers (synthetic weave barrier, rock check) along ditch or slope toe areas.

The design sediment containment is discussed in Section 12. A number of variations to the basic design can be used ranging from relatively small single basins to multiple interconnected basins.

Ideally, impoundment basins should be located within the site near the sediment source. Roadside ditches and old drainage channels can also be used as sediment impoundment areas upon installation of permeable or impermeable berms. Sediment traps/basins should be installed at the perimeter of the site, especially adjoining the sensitive environmental areas. Sedimentation traps/basins may be constructed by excavation and/or earth dyke construction, together with installation of a granular berm as an outlet flow structure. Where at all possible, the height of dykes or dams constructed to form impoundments should be kept as low as possible; otherwise dam safety considerations may apply. Correctly constructed and well maintained, sediment basins and traps can be an effective means of minimizing the quantity of sediment that is transported off-site. Regular maintenance and sediment removal will be required to ensure that adequate capacity and drainage is maintained.

Extended detention ponds allow runoff to be detained through slow release rates. Detention allows the sediment to settle out. Due to the slow release, these ponds are generally designed to be dry between runoff events. However, clogging of the outlet is the main concern due to the slow release rate. Therefore, the outlet should be protected or designed accordingly.

Table 7.5: Sediment Control Measures

	BMP Name	BMP #	Applications				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Filtering and Entrapment	Riparian Zone Preservation	30	✓	✓	✓	✓	Preserve a native vegetation buffer to filter and slow runoff before entering sensitive areas, most effective natural sediment control measure	Freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment
	Straw Bale Barrier	12		✓	✓	✓	Relatively inexpensive if bales are locally available, biodegradable, cheaper and easier to install than other barriers	Short service life due to biodegradation, straw bales may not be readily available in all areas of the province, maximum barrier height of one straw bale, require extensive maintenance after high flow storm events, require proper keying and staking
	Rolls (Fibre) Wattles	38 28	✓				Function well in freeze-thaw conditions, low cost solution to sheet flow and rill erosion on slopes, low to medium cost flow retarder and silt trap, can be used on slopes too steep for silt fences or straw bale barriers, biodegradable	Labour intensive to install (hand installation), designed for slope surfaces with low flow velocities, designed for short slope lengths with a maximum slope of 2H:1V, not widely used on Alberta highway construction projects
	Pumped Silt Control Systems (Silt Bags)	31		✓			Filter bag is lightweight and portable, simple set up and disposal, sediment-laden water is pumped into this filter bag, different aperture opening sizes (AOS) available from several manufacturers; normally for emergency use only	May be expensive, requires special design, not usually used in Alberta highway construction projects, requires a pump and power source for pump, suitable for only short periods of time and small volumes of sediment laden water, can only remove particles larger than aperture opening size (AOS)

Table 7.5: Sediment Control Measures

	BMP Name	BMP #	Applications: Slopes	Applications: Ditches and Channels	Applications: Large Flat Surface Areas	Applications: Borrow and Stockpile Area	Comments: Advantages	Comments: Limitations
	Silt Fence	1	✓		✓	✓	Economical, most commonly used sediment control measure allows water to pond and settle out coarse grained sediment, more effective than straw bale barriers	May fail under high runoff events, applicable for sheet flow erosion only, limited to locations where adequate space is available to pond collected runoff, sediment build up needs to be removed on a regular basis, damage to silt fence may occur during sediment removal, usable life of approximately one year
Filtering and Entrapment	Berm Interceptor	5	✓		✓	✓	Easy to construct, relatively inexpensive as local soil and material is used	Geotechnical design required for fill heights in excess of 3 m, may not be suitable for all soil types or sites; riprap spillway and/or permeable outlet may be required
Filtering and Entrapment	Gabions	2		✓			Relatively maintenance free, permanent drop structure, long lasting (robust), may be less expensive and thickness than riprap, allows smaller diameter rock/stones to be used, relatively flexible, commercially available products, commonly used in Alberta highway construction projects; suitable for resisting high flow velocity	Construction may be labour intensive (hand installation), extra costs associated with gabion basket materials
Filtering and Entrapment	Rock Check Dam	7		✓		✓	Permanent drop structure with some filtering capability, cheaper than gabion and armouring entire channel, easily constructed, commonly used in Alberta highway construction projects	Can be expensive in areas of limited rock source, not appropriate for channels draining large areas, requires extensive maintenance after high flow storm events, susceptible to failure if water undermines or outflanks structure

Table 7.5: Sediment Control Measures

	BMP Name	BMP #	Applications: Slopes	Applications: Ditches and Channels	Applications: Large Flat Surface Areas	Applications: Borrow and Stockpile Area	Comments: Advantages	Comments: Limitations
Filtering and Entrapment	Synthetic Permeable Barriers	10		✓			Reusable/moveable, reduces flow velocities and dissipates flow energy; retains some sediments; used as grade breaks in conjunction with sturdy permanent drop structures along steep grades	Partially effective as check dam structure, must be installed by hand in conjunction with RECP, become brittle in winter and are easily damaged by construction equipment or recreational vehicles, only partially effective in retaining some sediment, primarily used for reducing flow velocities and energy dissipation
Filtering and Entrapment	Continuous Perimeter Control Structures	4	✓		✓	✓	Temporary measure; divert and intercept sheet or overland flow to form pond and allow sedimentation; no trenching	Require specialized continuous berm machine to manufacture earth-filled geotextile berm on site; sandy/gravel soil is preferable fill material
Filtering and Entrapment	Storm Drain Inlet/Sediment Barrier	6			✓		Temporary measure; easy to install and remove	Limited sediment entrapment capacity; requires regular clean-out maintenance
Filtering and Entrapment	Compost Blanket	37	✓		✓	✓	Economical. Appropriate on slopes 2H:1V slope or flatter	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks
All BMPs	Scheduling	32	✓	✓	✓	✓	Identifies protection issues and plans for efficient, orderly construction of BMPs; early installation of perimeter control for sediment entrapment; early dimension planning of sediment control measures	

Table 7.5: Sediment Control Measures

BMP Name		BMP #	Applications				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Impoundment	Sediment Traps/Basins	18		✓		✓	May be constructed of a variety of materials, collects sediment laden runoff and reduces velocity of flow and deposition of sediment, can be cleaned and expanded as needed, capable of handling large volumes of sediment laden runoff	"Last resort" measure. Normally requires 250 m^3/ha storage volume per area of exposed soil, Can require large areas of land, requires periodic maintenance to remove sediment build up, requires design by qualified personnel, usually requires 'back-up' control measures in case pond/basin overflows

7.6 Selection Considerations for Bio-engineering Methods

The following should be evaluated when bio-engineering methods are considered for use in an erosion and sediment control plan:

- **Transport of Weeds** The consultant and contractor responsible for design and implementation of bio-engineering methods must minimize the risk of damaging, invasive or foreign species of plants being introduced into a new area from an infested area. A Professional Agrologist should be consulted as to the suitability of plant species for use in bio-engineering methods.
- **Availability of Suitable Plants** An area where suitable plants for use in bio-engineering methods must be within an economical distance from the proposed construction site. Permission to harvest plants from other locations must be obtained if suitable species or quantities of plants are not available within the limits of the proposed construction site.
- **Mechanical and Hydrological Benefits of Plant Systems** The root systems strengthen with time and reduce available moisture, however when initially installed, the plants used in bio-engineering are usually dormant and provide no immediate mechanical or hydrological benefit. However, the process of installation (benching) helps reduce erosion and promotes plant growth.
- **Use of Indigenous Materials** The plants must be well suited to climate, soil and moisture conditions of a site. Harvest sites should have similar characteristics to the planting site. Large variations in the bio-geoclimatic regimes such as elevation, drainage, soil type, slope aspect, and temperature will increase plant mortality and decrease the effectiveness of the bio-engineering system.
- **Labour / Skill Requirements** Crews can be easily trained to install bio-engineering systems and the capital / energy requirements are typically low. Bio-engineering can be installed using heavy equipment, however the harvesting and installation of the living plant material is conducive to a non-mechanized labour force working on sensitive sites that limit heavy equipment use.
- **Costs** The majority of bio-engineering costs are usually associated with labour. Labour costs can be substantial because plant material must be harvested, prepared, installed and tended, usually by hand. Transportation and storage, if required, of living plants is also a cost consideration. In some cases, large refrigerated facilities are required to properly store living plant material for extended periods between harvesting and planting.
- **Environmental Compatibility** Selected properly, the plants selected provide non-intrusive systems that enhance aesthetics as well as fish and wildlife habitat. It is important to recognize the site sensitivities before selecting plants to be used in bio-engineering. Harvesting plant species that are well climatized and appropriate to the installation site will provide the most effective bio-engineering results.

- **Access** Bio-engineering methods can be the most appropriate choice for sites with poor access such as riparian zones or sensitive stream embankments. Difficult sites can be accessed with minimal impact, however poor site access will increase costs associated with transportation and handling since machinery may not be able to support the labour force. For sites where access is good, heavy equipment can support bio-engineering installation by transportation of supplies and equipment and preparation of earthworks.
- **Timing** Bio-engineering methods are most effective when plant stock is harvested during the dormant seasons (late fall or early spring). Energy stored within the plant during dormancy provides the best opportunity for the plant to establish roots when it is placed in soil. Plants that are harvested while in a growth period suffer higher mortality since the plant has already gone into leaf production and harvesting shocks the plant system. Plants can effectively be harvested during a dormant period, cold stored and then planted when the soil has warmed.
- **Maintenance Requirements** Depending on the site, certain levels of maintenance are required. Supplemental plant stock may be required if minimum coverage of plant growth is not achieved by a certain time in the project schedule. Conversely, bio-engineering systems that experience heavy growth may require trimming particularly on projects where sight lines are important.

8.0 SELECTION OF BMP FOR EROSION AND SEDIMENT CONTROL

8.1 Preliminary Tasks

The following tasks should be completed before erosion and sediment control measures are selected for a given site:

- Conduct the Site Assessment (Section 5.0);
- Conduct the Site Evaluation (Section 6.5);
- Site Hazard Classification (Section 6.5.3); and
- Connectivity to Downstream Resources (Section 6.5.4).

The order in which these tasks should be completed is presented as a flow chart in Figure 8.1.

Conduct Site Assessment
(Section 5.0)

- Gather background information

⇩

Conduct Site Evaluation
(Section 6.5)

- Prepare slope analysis summary (Section 6.5.1)
- Prepare drainage analysis summary (Section 6.5.2)
- Estimate soil loss for each drainage catchment on the construction site (Section 6.2)
- Prepare Site Hazard classification for each drainage catchment on the construction site (Section 6.5.3)
- Prepare connectivity rating to aquatic resources (Section 6.5.4)

⇩

Select Appropriate Erosion and Sediment Control Measures
(Section 8.2)

- Based on results of Site Evaluation

Figure 8.1: Steps in Preparing an Erosion and Sediment Control Pan

8.2 Guidelines for Selecting Appropriate Erosion and Sediment Control Measures

Failure of erosion and sediment control measures can result in three types of potential consequences:

- Ecological consequences, related to the introduction of sediment to the aquatic environment. This is related to the connectivity to aquatic resources (see Table 6.2).

- Project consequences, related to the need to repair erosion damage and the implications for project schedule and cost; and
- Legal consequences, associated with the deposition of sediment in receiving waterbodies.

The aim in selecting, designing, and constructing the appropriate erosion and sediment control measures is to reduce the risk of these negative consequences.

Following the site assessment and evaluation, the information required to adequately select the erosion and sediment control measures for preparing an ESC Plan will be available. Selection of BMPs and other measures can be guided by a combination of the site erosion potential, the consequences of erosion and sediment control, as well as the experience and judgement of the designer.

A summary of the BMPs and other measures required based on site erosion potential and consequences of erosion and sedimentation is presented in Table 8.1.

Table 8.1: Required Levels of Erosion and Sediment Control

Erosion Potential	Consequences of Erosion and Sedimentation	Level of Erosion and Sediment Control (BMPs and Other Measures)					
		Procedural BMPs and Planning Strategy	ESC Plan and Structural BMPs	Water Management BMPs	Staged Construction and Progressive Rehabilitation	More Intensive Sediment Control BMPs	Water Quality Monitoring
Low	Low	Recommended[b]	-	-	-	-	-
	High	Required	Required	-	-	-	-
Moderate	Low[a]	Required	-	-	-	-	-
	High	Required	Required	Recommended[b]	Recommended[b]	Recommended[b]	Recommended[b]
High	Low[a]	Required	Required	Required	Required	Required	Recommended[b]
	High	Required	Required	Required	Required	Required	Required[c]
Reference in Manual Section		7.2	7.3, 7.4, 8.0	7.3	7.2, 7.2.1	7.5	9.9

Source: Transportation Association of Canada, 2005

Notes: (a) If economically justified, it may be acceptable to limit ESC measures for low-consequence projects, including those distant from sensitive areas, to procedural BMPs only.

(b) This level of ESC should be implemented where practical. For example, a small, short-duration project 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 runoff event.

(c) Water quality monitoring provides a quantitative measurement of the effectiveness of ESC measures. Monitoring may be required by regulatory agencies.

The information presented in Table 8.1 must be supplemented with the designers experience and judgement during the preparation of the erosion and sediment control strategy. Those responsible for the design and implementation of BMPs and other measures should continue to utilize innovative approaches which best address specific situations. Advances in technology will also continue to improve the methods and materials that are currently employed. Reference should be made to AT's Products List for the most up-to-date approved products (www.transportation.alberta.ca/689.htm).

Specific measures and BMPs are published in many manuals and standards, which describe criteria and specifications in detail. Many of the BMPs most commonly used in Alberta are presented in Appendix C. The BMPs are listed in terms of erosion control and sediment control, and the description, typical applications, advantages and limitations for each are provided. For each BMP, installation information and construction, maintenance and inspection considerations are provided. Where applicable, similar measures are also noted to provide the designer with options and flexibility in choice.

Other factors effecting the selection of erosion and sediment control BMPs include:

- Site Specific Design Requirements;
- Specific Construction Requirements including available space;
- Regulatory laws and guidelines; and
- Cost.

8.3 Construction Phase Activities

Erosion control considerations for various construction phase activities are presented as follows. These construction-related activities must be addressed in the contractor's ECO Plan.

Clearing and Grubbing

Clearing operations include slashing, cutting, stockpiling, and removal (or burning) of trees and brush. Clearing operations leave the stump and root mass intact, as well as the organic mat in the soil. Grubbing operations include the removal of the tree stumps and root masses left behind during clearing operations, however, the topsoil and the majority of the organic mat remains in place. Grubbing operations may cause localized soil exposure in areas where roots and stumps were removed.

Stripping

Stripping is the removal of the organic mat from the construction site to expose the underlying mineral soil. The exposed soil will be disturbed during the stripping operation, thereby increasing the erosion potential.

Borrow Excavations

These are excavations outside of the road right-of-way, made solely for the purpose of removing borrow material for:

- Roadway subgrade construction, or
- The construction of a dam, canal, dike, structure or erosion protection works associated with a provincial water management infrastructure project which may be connected with the borrow excavation.

Borrow excavations can either be landscape borrows or dugout borrows. Landscape borrows can be topographical highs such as hills or ridges, or if utilized on relatively flat terrain a maximum of 1m in depth and must be free draining. Dugout borrows are large excavations utilized for the extraction of construction material with the excavated area being returned to an "equivalent land capability" as required by Provincial Legislation, which may include holding water.

Development of borrow excavations may include clearing, stripping, grubbing and excavation. The development of borrow excavations and haul roads may cause soil disturbance, create exposed slopes and/or alter the natural drainage courses in the vicinity of the borrow excavation.

Stockpiles

Stockpiles may include material removed from excavations, stripping, clearing, and from borrow pits. The creation of stockpiles may disturb the vegetated soil surface, create exposed slopes, and/or alter the natural drainage courses.

Cut Slope Construction

Cut slopes are slopes created through the excavation and removal of native soil. Cut slopes may increase the slope angle, disturb the soil surface, create exposed slopes, and/or alter the natural drainage courses.

Fill Slope Construction

Fill (embankment) slopes are constructed by placing and compacting fill material. Embankments may create disturbed exposed slopes, create steep slope angles, and/or alter the natural drainage courses.

Ditch Construction

Where channels or ditches are constructed to direct and transport water along or transverse to the highway alignment, the original drainage pattern may be altered and concentration of flows created thereby increasing flow velocity and erosion potential. Ditch construction creates exposed slopes which can be eroded.

Culvert Installation

Culverts are installed to connect drainage courses and surface drainage flow. Installation of culverts may cause flow concentrations, create cut slopes, disturb the soil surface on slope faces, and create scour zones at the culvert inlet or outlet.

Temporary Access Road Construction

Temporary access roads are constructed to accommodate construction equipment on the project site. Construction of temporary haul roads may alter drainage courses and may include the construction of cut slopes, fill slopes, ditches or culvert installation.

8.4 Selection of Best Management Practice (BMP) According to Construction Activity

A large number of erosion and sediment control BMPs are available for use in an erosion and sediment control plan. The BMPs presented in this section have been proven to be effective when properly implemented. Since effective implementation of control measures is a site-specific operation, the BMPs have been grouped by typical construction activities that occur on highway construction sites in Table 8.2. BMPs typically used for streambank stabilization applications are summarized in Tables 8.3 and 8.4.

Site conditions may be such that the BMPs presented in this guideline are not appropriate. As such, modified methods and techniques may be required to meet the specific requirements of any given construction site. Erosion and sediment controls to be considered should be easy to design, implement, maintain and inspect.

Table 8.2: Application for BMPs Based on Construction Activities

BMP Name		Construction Activity								
		Clearing and Grubbing	Stripping	Borrow Pits	Stockpiles	Cut Slopes	Fill Slopes	Ditches/Channels	Culverts	Temporary Haul Roads
1.	Silt Fence	✓	✓	✓	✓	✓	✓		✓	✓
2.	Gabions							✓	✓	
4.	Continuous Perimeter Control Structures	✓	✓	✓	✓	✓	✓			✓
5.	Berm Interceptor	✓	✓	✓	✓	✓	✓			✓
6.	Storm Drain Inlet							✓	✓	
7.	Rock Check							✓		
10.	Synthetic Permeable Barrier							✓		
12.	Straw Bale Barrier			✓	✓	✓	✓			✓
13.	Rolled Erosion Control Products (RECP)				✓	✓	✓	✓		
14.	Riprap Armouring							✓	✓	
15.	Cellular Confinement System					✓	✓	✓		
17.	Energy Dissipators							✓	✓	
18.	Sediment Traps and Basins		✓					✓		
19.	Slope Drains					✓	✓			
20.	Groundwater Control			✓		✓	✓			
21.	Offtake Ditches		✓	✓	✓	✓	✓			
22.	Seeding			✓	✓	✓	✓	✓		
23.	Mulching			✓	✓	✓	✓	✓		
35	Straw Mulching and Crimping (Straw Anchoring)			✓		✓	✓			
24a.	Hydroseeding			✓	✓	✓	✓	✓		
24b.	Hydromulching			✓	✓	✓	✓	✓		
25.	Topsoiling			✓	✓	✓	✓	✓		
26.	Sodding			✓	✓	✓	✓	✓		

BMP Name		Clearing and Grubbing	Stripping	Borrow Pits	Stockpiles	Cut Slopes	Fill Slopes	Ditches/Channels	Culverts	Temporary Haul Roads
		Construction Activity								
27a.	Live Staking					✓	✓	✓		
30.	Riparian Zone Preservation	✓	✓	✓	✓	✓	✓	✓	✓	✓
31.	Pumped Silt Control Systems							✓	✓	
32.	Scheduling	✓	✓	✓	✓	✓	✓	✓	✓	✓
33.	Stabilized Worksite Entrances	✓	✓	✓	✓	✓	✓	✓	✓	✓
34.	Slope Texturing			✓	✓	✓	✓			✓
36.	Polyacrylamide (PAM)			✓		✓	✓	✓		
37.	Compost Blanket				✓	✓	✓			✓
38.	Rolls (Fibre)			✓	✓	✓	✓			

Table 8.3: BMPs for Streambank Applications

BMP #	BMP Name	Category	Also Known As
38.	Rolls (Fibre)	Bank Armour and Protection	Coir Rolls and Coir Mats
27a.	Live Staking	River Training	Live Staking
27b.	Brushlayering	River Training	Live Brushlayering
39.	Brush Mattress	Bank Armour and Protection	Live Brush Mattress, Brush Mat
40.	Live Siltation	River Training	Vertical Brushlayering
41.	Willow Posts & Poles	River Training	Pole Planting, Dormant Live Posts
42.	Rock Vanes	River Training	Rock Vanes, Upstream Angled Spurs
43.	Longitudinal Stone Toe	River Training	Longitudinal Peaked Stone Toe Protection (LPSTP), Stone Toe, Rock Toe, Stone Toe Buttress, Weighted Riprap Toe, Longitudinal Fill Stone Toe Protection (LFSTP)
44.	Vegetated Mechanically Stabilized Earth (VMSE)	River Training	Vegetated Geogrids, Brushlayering with Soil Wraps, Vegetated Geofabric Wrapped Soil
45.	Vegetated Riprap	Bank Armour and Protection	Vegetated Rock Revetment, Vegetated Rock Slope Protection (VRSP), Face Planting, Joint Planting

Note: Adapted from E-SenSS Software, 2005, Salix Applied Earthcare

Table 8.4: BMPs for Streambank Applications Based on Erosion Process

	BMP 38 Roll (Fibre)	BMP 27a Live Staking	BMP 27b Brushlayering	BMP 39 Brush Mattress	BMP 40 Live Siltation	BMP 41 Willow Posts & Poles	BMP 42 Rock Vanes	BMP 43 Longitudinal Stone Toe	BMP 44 VMSE	BMP 45 Vegetated Riprap
Erosion Process										
Toe erosion with upper bank failure	✓				✓		✓	✓		✓
Scour of middle and upper banks by currents		✓	✓	✓	✓	✓	✓		✓	✓
Local scour	✓	✓	✓	✓	✓	✓	✓			✓
Erosion of local lenses or layers of non-cohesive sediment	✓	✓	✓	✓	✓	✓			✓	✓
Erosion by overbank runoff			✓							
General Bed Degradation										
Headcutting										
Piping										
Erosion by navigation waves	✓	✓			✓	✓				✓
Erosion by wind waves	✓	✓			✓	✓				✓
Erosion by ice and debris gouging	✓							✓		✓
General bank instability or susceptibility to mass slope failure		✓	✓					✓	✓	
Spatial Application										
Instream							✓			
Toe	✓			✓	✓		✓	✓		✓
Midbank		✓	✓	✓		✓			✓	✓
Top of bank				✓						✓
Hydrologic / Geomorphic Setting										
Resistive	✓			✓				✓	✓	✓
Redirective							✓			
Continuous				✓	✓			✓	✓	✓
Discontinuous							✓		✓	
Outer Bend	✓			✓	✓		✓	✓	✓	✓
Inner Bend				✓					✓	
Incision								✓		
Lateral Migration	✓						✓			✓
Aggradation					✓		✓			
Complexity										
Low					✓	✓		✓		
Moderate	✓	✓	✓	✓			✓			✓
High									✓	

Note: Adapted from E-SenSS Software, 2005, Salix Applied Earthcare

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9.0 THE PERMANENT EROSION AND SEDIMENT CONTROL PLAN (PESC PLAN)

9.1 General

The Permanent Erosion and Sediment Control (PESC) Plan constitutes the measures designed by the consultant to be implemented by the contractor as part of the construction contract to address long term post construction erosion and sedimentation issues. The PESC Plan should be designed using an engineering approach based on acceptable principles of soil mechanics and open channel flow hydraulics. The PESC Plan will also be referenced by the construction contractor in the development of the Environmental Construction Operations (ECO) Plan.

A PESC Plan should be prepared for all construction projects. For sites smaller than 2 ha (and not connected to an environmentally sensitive area), this consists of identifying minimum requirements for an erosion and sediment control strategy, and where practical, implementing erosion and sediment controls to reduce on-site runoff and erosion. Sites larger than 2 ha require the development of a comprehensive PESC Plan and associated documents. During construction, the PESC Plan should be reviewed by the consultant and modified as required as field conditions change.

9.2 Consultant Responsibility

The consultant is required to prepare and submit:

- A PESC Plan Report;
- Design and Construction Drawings showing PESC measures where appropriate;
- Contract special provisions which may be necessary to identify and address special areas of concern or types of work; and
- As-Built drawings showing the type, quantity and location of PESC measures installed.

The consultant is also responsible to monitor construction and confirm that the permanent erosion control works are installed according to the requirements of the PESC Plan.

The required qualifications of the Consultant are provided in Section 3.1.3.

9.3 PESC Plan Documentation

The PESC Plan must include a report and drawings. Reference should be made to Alberta Transportation's Engineering Consultant Guidelines for Highway and Bridge Projects. As a minimum the following should be addressed in the PESC Plan:

- Site Assessment;
- Design of the PESC Plan including highlighting procedural or minimum requirements, required BMPs and site specific designs;
- Shut Down considerations;
- Inspection, Monitoring and Maintenance Requirements;

- Emergency Response Plan and incident reporting requirements; and

A checklist for the development of the PESC Plan is included in Appendix D.

9.4 Design and Construction Drawings

The Design and Construction Drawings must show the PESC measures (where appropriate) and reference the PESC Plan report.

9.5 Contract Special Provisions

Contract Special Provisions shall discuss other special or site specific items not included in the Standard Specifications for Highway Construction. Information which may be included in the Special Provisions are design location of the devices, quantities and special regulatory requirements, or reference to special instructions on installing the erosion and sediment control devices.

9.6 Site Inspection During Construction

Once the PESC measures have been installed, it is important that their effectiveness is monitored and necessary maintenance be carried out. The success of the entire erosion and sediment control strategy will depend upon this, and its importance cannot be overemphasized.

All PESC measures must be inspected by the contractor daily and following heavy rainstorms or snowmelt events during the construction phase. Immediate action must be taken by the contractor when the need for maintenance or repair of PESC measures is identified for the ongoing performance of the measures.

The Consultant should inspect the PESC measures every 7 days and following heavy rainstorms or snowmelt events and advise the contractor immediately of any areas of concern. As site work progresses, the PESC Plan should be modified when necessary by the Consultant to reflect changing site conditions or new information which has been identified during construction.

A copy of the PESC Plan, along with a copy of the Construction Drawings, must be kept by the Contractor at the construction site for use by construction and inspection personnel.

9.7 Inspection and Incident Records

The Contractor and Consultant must both maintain separate records of their inspection of all ESC measures at the frequencies noted above, including notes regarding damage and deficiencies observed. The same document can be used to record maintenance and repairs undertaken after the inspection.

The Consultant must submit their inspection report of ESC measures to AT on a weekly basis. The contractor must maintain records of their daily inspection and provide copies to the consultant if and when requested.

Sample inspection report forms are presented in Appendix D.

9.8 As-Built Drawings and Project Records

A complete summary of the PESC measures installed must be documented by the Consultant during construction and updated as various measures modified. As-built drawings and supporting records must include a plan view drawing showing the type, quantity and location of PESC measures installed.

Supplemental information which should be included in the Final Details includes:

- Inspection and Maintenance Reports;
- Modifications to the PESC Plan;
- Photos of the installed PESC measures; and
- Incident Reports.

9.9 Post Construction

After final acceptance, the inspection and maintenance responsibilities of the PESC measures will be transferred from the construction contractor to the Maintenance Contract Inspector (MCI) and AT's Maintenance Contractor.

The respective maintenance responsibilities at the Construction Phase and Post Construction Phase are described in Construction Bulletin #12, which is available on Alberta Transportation’s website at www.transportation.alberta.ca/920.htm.

Inspection and maintenance of PESC measures must continue regularly so that the measures remain effective in the long term. The following circumstances and conditions will permit BMPs to be removed:

- Revegetation of bare soil is successful;
- No obvious erosion scour is observed;
- No obvious bed load of silt and sediment laden runoff is observed;
- Inspection and maintenance report indicates satisfactory performance for past 3 years; and
- AT maintenance staff will assess and decide on performance of the structures and requirement for necessary removal.

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10.0 THE TEMPORARY EROSION AND SEDIMENT CONTROL PLAN (TESC PLAN)

10.1 General

The temporary erosion and sediment control plan (TESC Plan) constitutes the measures designed and installed by the contractor to address matters of erosion and sediment control which the contractor anticipates during the construction contract and includes activities up to the point of final acceptance of the construction work. The TESC Plan is prepared by the contractor and forms one component of the ECO Plan which is also prepared by the contractor.

10.2 Contractor's Responsibility

The contractor is required to prepare and submit an ECO Plan to the consultant prior to construction. In order to develop a proper TESC Plan, the contractor should incorporate recommendations of the consultant's PESC Plan and Environmental Risk Assessment.

Responsibilities of the Consultant and Contractor as well as the guidelines on preparing an ECO Plan are outlined in the most current version of the ECO Plan Framework which can be found on Alberta Transportation's website at http://www.transportation.alberta.ca/571.htm.

10.3 TESC Plan Documentation

As a minimum, the following should be addressed in the TESC Plan:

- Design of the TESC Plan including addressing procedural or minimum requirements, required BMPs and site specific designs;
- Shut Down considerations;
- Inspection, Monitoring and Maintenance requirements; and
- Emergency Response Plan and incident reporting requirements.

10.4 Site Inspection During Construction

During construction, before final acceptance of the construction contract works, the responsibility for the inspection, maintenance and repair of all TESC measures lies with the contractor. A schedule of planned maintenance activities is required with the submission of the ECO Plan. When implemented controls are insufficient or not working as intended, changes to the TESC Plan component must be made by the contractor to ensure continued compliance.

All erosion and sediment control measures must be inspected daily by the contractor and following heavy rainstorms or snowmelt events. Some measures will require periodic replacement and/or removal of accumulated sediment.

Damage or deficiencies to control measures should be corrected immediately.

Details on inspection, maintenance and repair activities shall be recorded on the "Inspection and Maintenance Form" presented in Appendix D.

10.5 Shutdown Considerations

The TESC Plan must include provisions for erosion and sediment control during shutdown periods. Shutdowns are considered any extended period of time during which the contractor is not actively developing the project site and may no longer have personnel or equipment on-site. Shutdowns may or may not be planned and may result from seasonal work stoppages, adverse weather events, or contractual disagreements.

During a shutdown, erosion and sediment control measures must still be inspected and maintained. This will include during winter shutdown and more importantly, during spring snow melt prior to construction re-start when the contractor must provide timely, regular monitoring and maintenance as well as install additional measures as necessary.

10.6 Emergency Response Plan

The TESC Plan must show preparedness for an emergency response to erosion and sediment related problems. The contractor should reference the most current versions of the ECO Plan Framework and EMS Manual and should also reference the consultant's PESC Plan for information on requirements and procedures.

10.7 Inspection and Incident Reports

All inspection, maintenance and repairs performed on erosion and sediment control measures should be recorded on the "Inspection and Maintenance Form" presented in Appendix D. Inspection and maintenance report and repair records must be kept at the construction site for review by construction personnel, inspectors, consultants and AT.

10.8 Post Construction

After final acceptance, the inspection and maintenance responsibilities of any installations that must remain in operation will be transferred from the construction contractor to the Maintenance Contract Inspector (MCI) and AT's Maintenance Contractor in the post construction phase. The respective maintenance responsibilities at the Construction Phase and Post Construction Phase are described in Construction Bulletin #12, which is available on Alberta Transportation's website at www.transportation.alberta.ca/920.htm.

Inspection and maintenance must continue until the BMP is no longer required, at which time the BMP will have to be properly removed. The following circumstances and conditions will permit BMPs to be removed:

- Revegetation of bare soil is successful;
- No obvious erosion scour is observed;
- No obvious bed load of silt and sediment laden runoff is observed; and
- AT maintenance staff will assess and decide on performance of the structures and requirement for necessary removal.

11.0 GUIDELINES FOR ESTIMATING RUNOFF FROM SMALL WATERSHEDS AND DESIGN OF OPEN CHANNELS

11.1 General

The design of erosion and sediment control measures should consider the peak flow rate of surface runoff to ensure channels and sedimentation containment systems are adequately sized. Furthermore, these structures must be protected from erosion due to concentrated water flow.

Channelized flow requires provision of erosion control measures to prevent concentrated water flow from causing erosion. The amount of runoff laden with sediment will influence the design requirements for sediment control. The estimate of runoff from small watersheds and the design of channel lining are presented below.

11.2 Estimating Runoff from Small Watersheds

The amount of runoff from each catchment on a highway construction project site is related to the design rainfall storm and catchment area affected by construction. The highway drainage design generally includes ditches and cross-drainage culverts as well as stormwater storage/treatment areas and floodplain considerations.

For the design of erosion and sedimentation protection measures, the understanding of runoff estimation is an important design consideration. The runoff assessment should be provided by a qualified hydrology professional or engineer. For small catchment areas, the guidelines for the estimate of runoff are presented in Appendix E. These guidelines should only be used in conjunction with professional judgement and experience. For major watercourse crossings, the drainage assessment is generally provided by a qualified hydrotechnical bridge engineer.

11.3 Design of Open Channels

Open channels are the system of culverts, ditches and swales that convey concentrated drainage on a highway construction site. These channels must be designed to contain design runoff flow without overtopping. Furthermore, open channels must be able to convey the concentrated flows without promoting additional erosion within the channel. Open channel design should be provided by a qualified hydrology professional or engineer.

The use of permissible tractive resistance has been adopted for the design of channel lining instead of the permissible velocity concept which was historically used by some designers. For highway ditch/channel and a simplified flow regime, the channel design is a function of runoff, geometric channel properties and channel roughness (n).

The channel roughness (n) is dependent on the degree of irregularity of the wetted perimeter of open channel flow which may be influenced by erosion control BMPs in the channel. The protective linings for channels can include soft armour linings of different materials (i.e., vegetation, mulch, soil coverings or erosion protection matting, etc.) and hard armour linings (i.e., gabion, riprap, concrete lining, pipe, etc.), all of which will affect “n”.

Simplified guidelines for design of highway channels and channel roughness (n) values for various protective channel lining materials are presented in Appendix F. These guidelines should only be used in conjunction with professional judgement and experience.

12.0 GUIDELINES FOR THE DESIGN OF SEDIMENT CONTAINMENT

12.1 General

The function of a sediment containment system is to provide storage capacity to runoff volume and to slow the flow velocity of runoff to allow the sedimentation of suspended soil particles to occur. When designed correctly, most sediment containment systems do one or more of the following:

- Provide containment storage volume for incoming runoff waters;
- Create uniform flow zones, increased flow path length and width and increased sedimentation times to facilitate sedimentation of suspended particles; and
- Discharge water at a controlled rate that permits adequate detention time for sedimentation of suspended particles.

It is important to note that 100% reduction of all incoming suspended particles is not feasible due to practical limits of storage space and available settling time. Therefore, the efficiency of a containment system is based on the efficiency of sedimentation of a target soil grain size.

The sediment containment system should be designed so that the outflow rate during the design rainfall event is equal to or smaller than the inflow rate of sediment-laden runoff. Coarse to medium size silt particles (particle size range 75 μm to 20 μm) can be realistically targeted for sedimentation. Finer size particles (i.e., clay and fine silt) will require a long time to settle and therefore may not be deposited in the sediment containment facility during the time of retention. As such, targeting clay, fine silt particles and organic silts for sedimentation is generally not practical.

The design capacity of a sediment containment system should be sufficient to impound the runoff volume collected from an area of disturbed land (bare soil) for a 1:2 year storm event of 24 hour rainfall intensity or a recommended runoff volume of 250 m^3 per hectare of disturbed land. Under conditions of land constraints, a minimum runoff volume of 150 m^3 per hectare can be considered. The designer of a sediment containment system should consider the flow rate at which sediment laden runoff enters the system and ensure that sufficient geometry exists to permit adequate sedimentation to occur before the flow exits the system.

12.2 Containment Systems (Type I, II and III)

The type of containment system should be selected based on site specific conditions. The selection should generally be based on the following:

- Site erosion potential classification;
- Area of upstream soil exposure;
- Terrain conditions and space constraints; and
- Method of construction.

Construction of the containment system should be completed at high risk areas prior to any land disturbance and construction.

The selection of the location and type of sediment containment system should be based on the experience and judgement of the designer. The criteria for selection of the type of sediment containment systems are presented in Table 12.1.

Table 12.1: Containment System Types

Containment System *	Site Erosion Potential Classification	Design Particle Size *	Affected Land Area *
Type I (Sediment Basin)	High to Very High	Particle size ≤ 0.045 mm (medium silt and finer)	>2.0 ha
Type II (Sediment Trap)	Moderate	0.045 mm < Particle size ≤ 0.014 mm (fine sand, coarse to medium silt)	<2.0 ha
Type III (Sediment Barrier)	Low to Very Low	Particle size >0.14 mm (medium to fine sand, coarse silt)	Grade break and velocity retarder for construction and intermediate areas

*Source: Fifield, 2001

The three types of sediment containment systems are discussed in the following sections.

<u>Type I (Sediment Basin)</u>

Type I sediment containment system requires development of a structure to capture coarse to medium silt and a portion of smaller suspended particles. Since particles of this size have low settling velocities, large storage volumes, long flow-path lengths, and controlled discharges are required. As such, the containment basin will be configured accordingly to provide sufficient retention time and flow velocity reduction to permit sedimentation. Type I systems are designed to have the highest possible net efficiency and are best represented by the traditional sediment basin.

In general, sediment basins should be sized for a minimum recommended storage volume of 250 m^3/ha where possible over the contributing disturbed bare soil area. Length (L) to width (W_e) ratio should be between 4:1 and 8:1. A practical width (W_e) can be 6 to 8 m. Generally, a practical pond depth is 1.2 m. The maximum pond depth should not exceed 1.5 m. An illustration of the Type I structure is presented in Figure 12.1.

<u>Type II (Sediment Trap)</u>

The Type II sediment containment system will capture suspended particles (fine sand to coarse silt) having higher settling velocities than particles requiring Type I structure. Consequently, small storage volumes and shorter flow-path lengths in comparison to widths can be used. As with a Type I structure, these sediment control systems will also have controlled discharges. Whereas their net effectiveness for the inflow and sedimentation of all suspended particles may be low, Type II systems will still have an effective sediment control measure.

In general, sediment traps should be sized for a recommended storage volume of 250 m^3/ha over the contributing area, where possible; or a minimum storage volume of

150 m^3/ha under conditions of land constraints. Length (L) to width (W_e) ratio should be between 2:1 to 3:1. A practical pond depth can be 1 m and the maximum pond depth should not exceed 1.5 m. Illustrations of Type II structures are presented in Figure 12.1 and Figure 12.2.

Type III (Sediment Barrier)

The least effective method to control suspended particles in runoff waters is represented by the Type III sediment containment systems. These are not necessarily design structures, as found with Type I and Type II systems, but are often BMPs (such as drainage ditch check structures). Whenever significant runoff occurs, all Type III systems have very low net and apparent effectiveness to control suspended particles. However, when runoff is low, the Type III sediment control systems can be effective in reducing flow velocity and suspended particles (coarse silt to fine sand) along gentle grade areas as long as they are regularly maintained.

12.3 Design Considerations

The design of a sedimentation pond can be a challenge as design parameters are difficult to define (e.g., storm events, runoff, soil erodibility and distribution of erodible soil). Thus, the evaluation of the effectiveness of pond performance is difficult to quantify. Therefore, the design of sediment pond or review of its performance should be undertaken by a qualified engineer with a practical perspective in experience and judgement. A suggested design rationale for the design of sediment containment systems is presented in Appendix G.

The focus of sediment control should be placed on capturing silt and larger sized soil particles. It is not practical to design for clay particles or colloidal organic particles due to the significant amount of time required for them to settle. Therefore, the emphasis for preventing release of water containing clay particles or colloidal organic particles from a construction site should be placed as erosion control.

Methods that estimate the efficiency of a given sediment containment system should be used with caution as there are several variables that affect the effectiveness of these systems. Estimating the efficiency of a sediment containment system should be used as a preliminary means of evaluating various options. However, the final selection should be based on the site conditions and the experience and judgement of the designer.

Care should be taken when designing embankments, since these may have to be designed according to dam design guidelines and regulatory requirements. Regardless of the height of an embankment, the consequences of failure will determine the level of effort during design and construction. A qualified engineer should design the foundation and embankment, and provide inspection during and after construction. Similarly, the optimization of pond areas and depth to obtain maximum efficiency should be undertaken by a qualified engineer.

12.4 Design Examples

A design example for a sediment pond is presented in Appendix H as Example H.16.

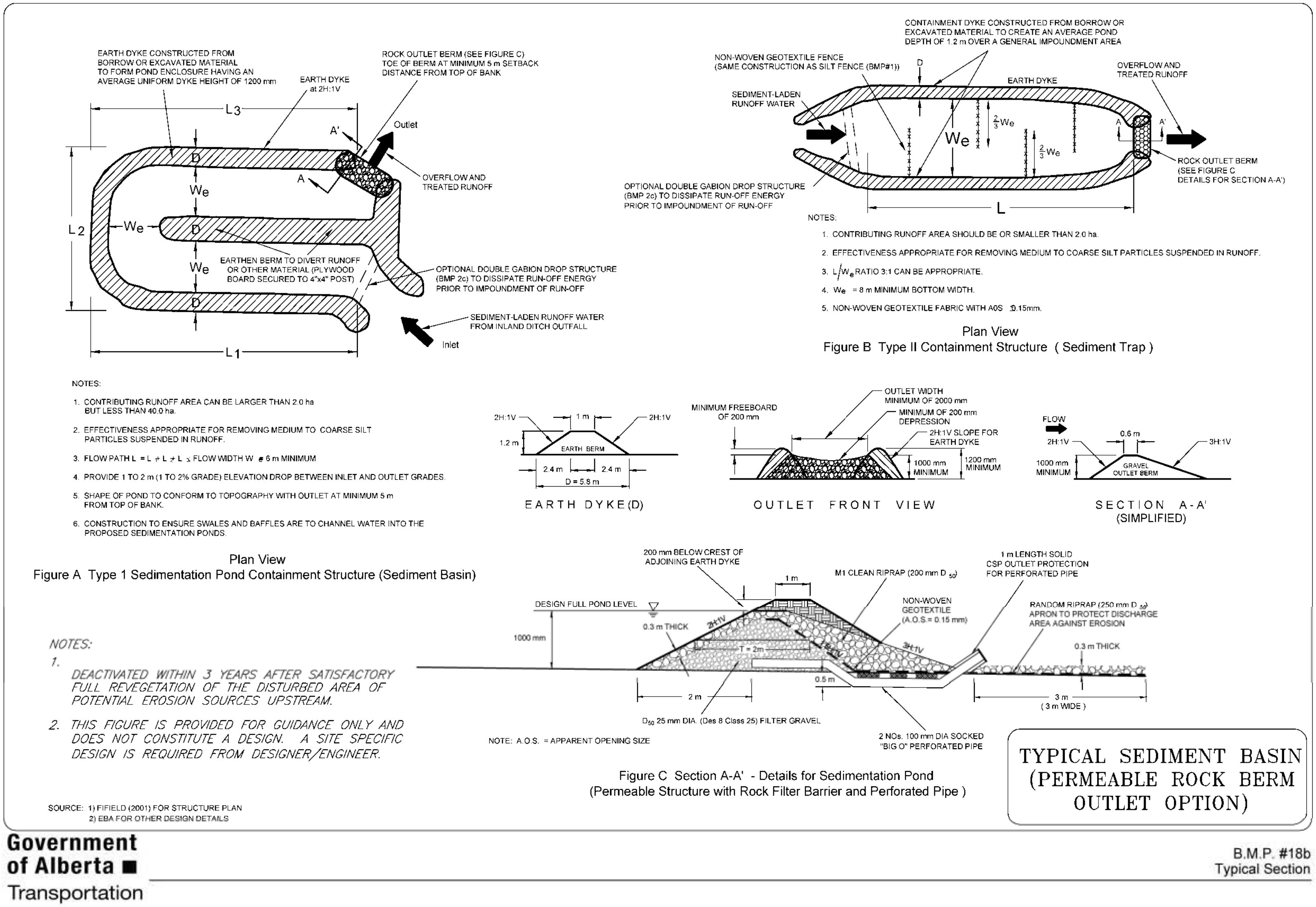

Figure 12.1: Type I and II Typical Sediment Containment Systems

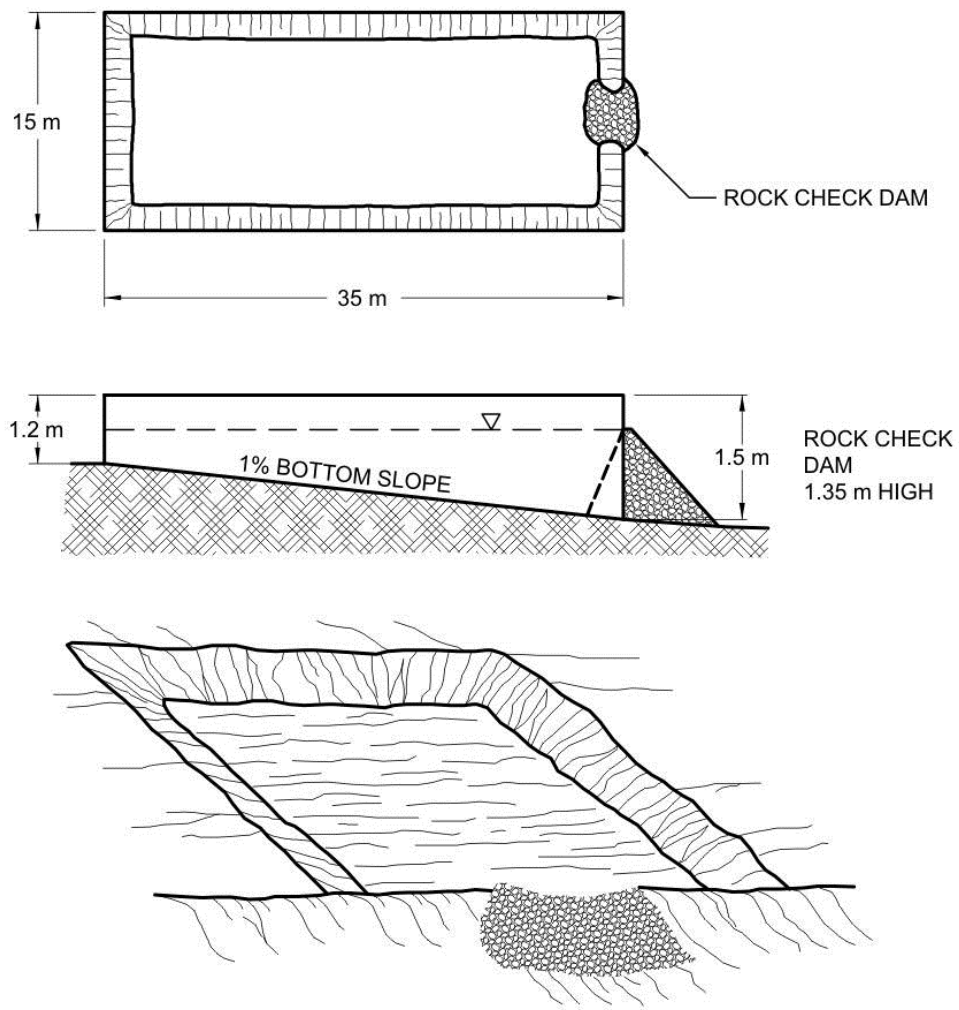

Figure 12.2: Type II Sediment Containment System (Sediment Trap) – Excavation Option

Source: City of Calgary, 2001

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APPENDIX A

EXAMPLE SOIL TEST DATA FOR
DIFFERENT PARTS OF ALBERTA
AND RESPECTIVE SOIL ERODIBILITY RATING
PRELIMINARY ASSESSMENT

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Table No.	Soils from the Area of:
A.1	Hotchkiss and Keg River
A.2	Grimshaw and Notikewin
A.3	Cherry Point and Hines Creek
A.4	Sand River
A.5	Waterton National Park
A.6	Waterton National Park

Table A.1: Test Data from Soil Samples in the Hotchkiss and Keg River Areas

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition		
					Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Lacustrine	CH	56	25	31	5	26	69
	CH	51	21	30	2	45	53
	CI	45	20	25	13	44	43
	CH	61	21	40	10	29	61
	CH	60	21	39	5	43	52
	CH	84	36	48	0	21	79
Fluvial	CH	52	24	28	8	57	43
Residual	SM			TR	78	10	12
	MH	51	30	21	1	45	54

Table A.2: Test Data from Soil Samples in Grimshaw and Notikewin Areas

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition		
					Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Till	CI	43	20	23	18	39	43
	CI	41	19	22	19	41	40
	CI	36	18	18	27	33	40
	CI	43	18	25	22	42	36
	CI	41	20	21	21	48	38
	CI	44	20	24	20	37	43
	CI	44	18	26	25	34	41
	CI	43	19	24	21	41	38
	CI	37	18	19	23	35	32
Lacustrine	CI	40	18	22	20	46	34
	CH	58	24	34	3	19	78
	CI	44	18	26	0	25	75
	CH	61	28	33	2	40	58
	CH	57	24	33	2	44	56
	CH	66	27	39	0	40	60
	CH	64	28	36	3	19	78
	CH	69	26	43	6	20	74
	CI-CH	50	21	29	3	35	62
	CI	43	20	23	7	44	49
Fluvial	CI	42	21	21	22	45	33
	CI	38	19	19	20	50	30

Table A.3: Test Data from Soil Samples in Cherry Point and Hines Creek Area

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition		
					Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Till	CI	39	18	21	20	38	42
	CH	51	23	28	12	33	55
	CI	43	20	23	20	42	38
	CI	41	20	21	17	49	34
	CI	40	19	21	15	41	44
	CH	67	30	37	2	15	83
	MH	78	38	40	5	9	86
	CH	55	25	30	1	41	58
	CI	45	26	19	6	60	34
Lacustrine	CH	55	24	31	10	23	67
	CH	69	30	39	1	19	80
	CH	51	21	30	17	40	43
	CH	69	28	41	3	27	70
Fluvial	CI	43	23	20	15	32	53
	CI	41	19	22	21	43	36
	CI	39	19	20	29	38	33
	CI	41	22	19	16	51	33
	CI	33	21	12	2	32	65
	CI	35	23	12	32	49	19
	ML	32	23	9	59	25	16
	CL-MI	22	17	5	84	14	2
	MH	51	30	21	8	19	73
	MH	41	27	14	8	42	50

Note: Potential soil erodibility: moderate to high

Table A.4: Test Data from Soil Samples in Sand River Area

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition			
					Gravel (>2) (mm)	Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Till	CI-CH	49	26	23		22	35	43
	CI	35	20	15	1	29	32	38
	CI	36	21	15	3	38	27	37
	CI	31	17	14	2	34	27	37
	CI	32	19	13	1	30	34	35
	CI	38	19	19	1	31	33	35
	CL	27	15	12	1	38	29	32
	CL-CI	30	15	15	10	30	30	30
	CI	33	17	16	1	30	39	30
	CI	33	17	16	2	40	28	30
	CL-CI	28	15	13	3	40	27	30
	CI	27	14	13	1	42	28	29
	CI	31	17	14			34	28
	CL-CI	29	16	13	18	20	34	28
	CL-CI	31	18	13	18	20	34	28
	CL	24	16	8	1	40	31	28
	CI	32	17	15	2	30	42	26
	CL-CI	29	16	13	2	41	31	26
	CL	27	15	12	2	42	30	26
	ML	19	16	3	7	37	30	26
	CL	23	14	9	1	47	27	25
	CL	29	13	16	5	45	25	25
	CL	27	16	11			37	25
	CL	28	17	11	3	39	34	24
	CL-CI	30	16	14	2	46	28	24
	CL	24	14	10	3	47	26	24
	CL	24	14	10	2	52		
	SM			NP	4	53	29	14
Lacustrine	CH-CL	51	24	27		2	46	52

Note: Potential soil erodibility: moderate to high

Table A.5: Test Data from Soil Samples in Waterton National Park Area

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition		
					Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Till	CL-ML	27	21	6	49	28	23
	CI	30	18	12	18	61	21
	CI	37	23	14	18	34	31
	CI	38	23	15	35	3	32
Lacustrine	CI	39	24	15	36	32	32
	MH	72	39	33	1	39	67
	MH	68	39	29	1	39	60
Fluvial	SM			NP	88	6	6
--------	SP-SM			NP	88	10	2
Acadian	SM			NP	58	23	19
	SW			NP	96	4	0
	SM			NP	87	6	7

Note: Potential soil erodibility: moderate to high

Table A.6: Test Data from Soil Samples in Waterton National Park Area

Material Type	Classification (USCS)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Composition			
					Gravel (>2) (mm)	Sand (2.0-0.05) (mm)	Silt (0.05-0.002) (mm)	Clay (<0.002) (mm)
Till	CH	50	22	28	18	12	38	32
	CL-ML	27	21	6	38	26	27	9
	GM	17	15	2	43	23	27	7
	GM-GC	25	20	5	55	22	19	4
	ML	19	15	4	3	41	46	10
	GC	47	37	10	77	6	9	8
	GM			NP	60	26	9	5
	SC	36	18	18	35	27	27	11
	CI	37	20	17	5	8	72	15
	GM	18	16	2	48	39	10	3
Fluvial	GP-GM			NP	76	18	4	2
	ML			NP		28	70	2
	GP-GM			NP	59	33	5	3
	MH	53	30	23		3	67	30
	ML	35	25	10		7	71	22
	ML-CL	42	27	15		15	58	27
	GC	22	14	8	76	7	9	8
	GD			NP	84	12	3	1
	GM	28	22	6	83	5	7	5
	SM			NP	43	45	10	7
	SM	27	22	5	55	33	8	4
	ML	37	28	9	2	25	54	19
	GP-GM			NP	78	14	6	2
	GP-GM			NP	79	14	5	2
	GP-GM	16	14	2	78	15	5	2
	GM			NP	58	25	13	4
	ML	36	19	17	4	29	50	17
	ML	26	23	3	7	44	38	11
	SM			NP		75	22	3
	SM			NP		64	27	11
	SM-SC	25	19	6	42	40	13	5
	GM-GC	25	20	5	74	17	7	4
	GC	43	20	23	55	13	20	12
	GM	19	16	3	78	8	10	4
	SM	21	19	2	40	46	10	4
	GP-GC	25	10	15	80	11	6	3
	GM			NP	71	18	9	2

Note: Potential soil erodibility: moderate to high

APPENDIX B

SUPPORTING INFORMATION FOR RUSLE

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Supporting Information for RUSLE

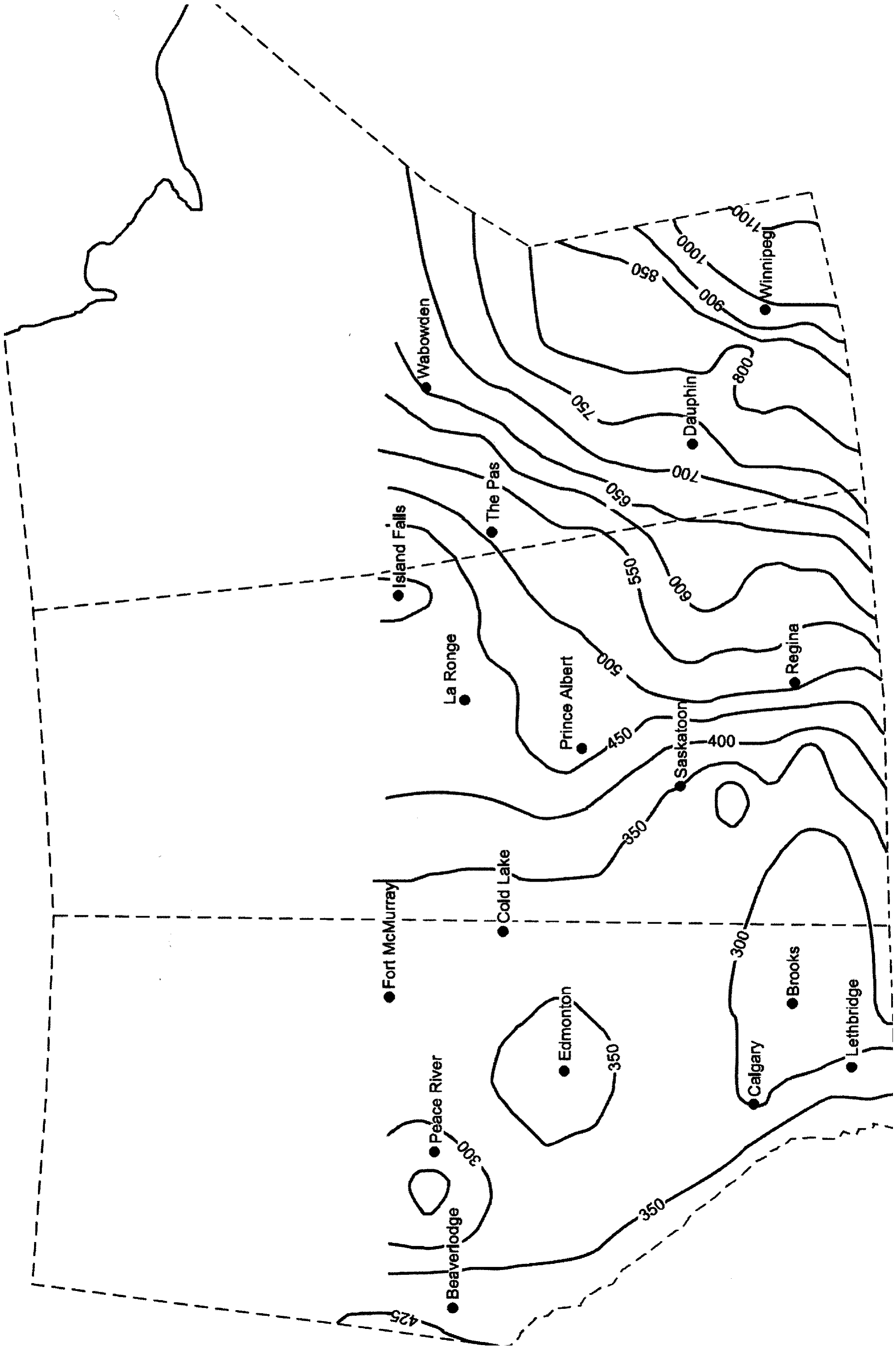

Figure B-1: Isoerodent map showing R_t values for the Prairie Region (whole year)

(Source: Wall et al, 1997)

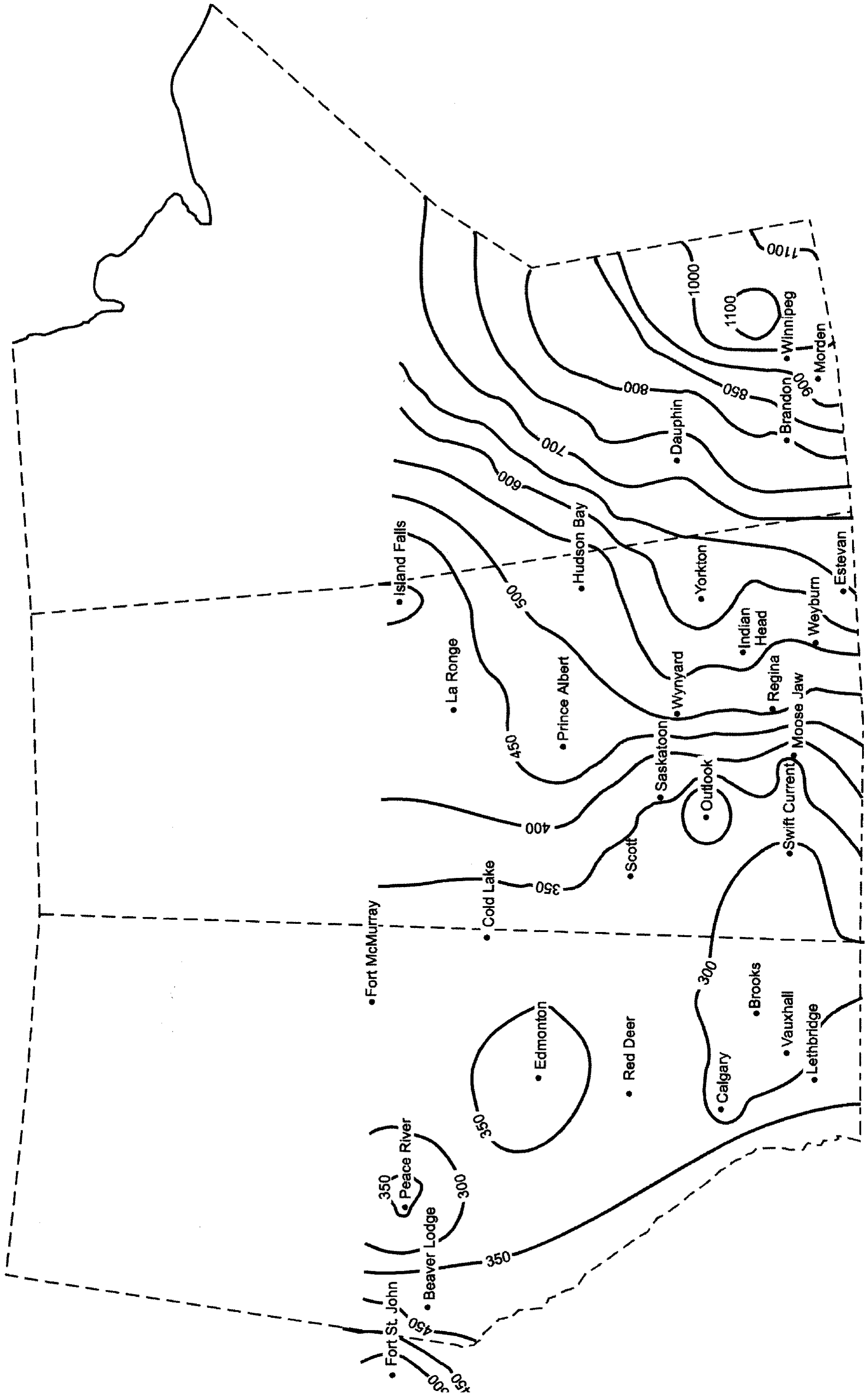

Figure B-2: Isoerodent map showing R values for the Prairie Region (spring to fall)

(Source: Wall et al, 1997)

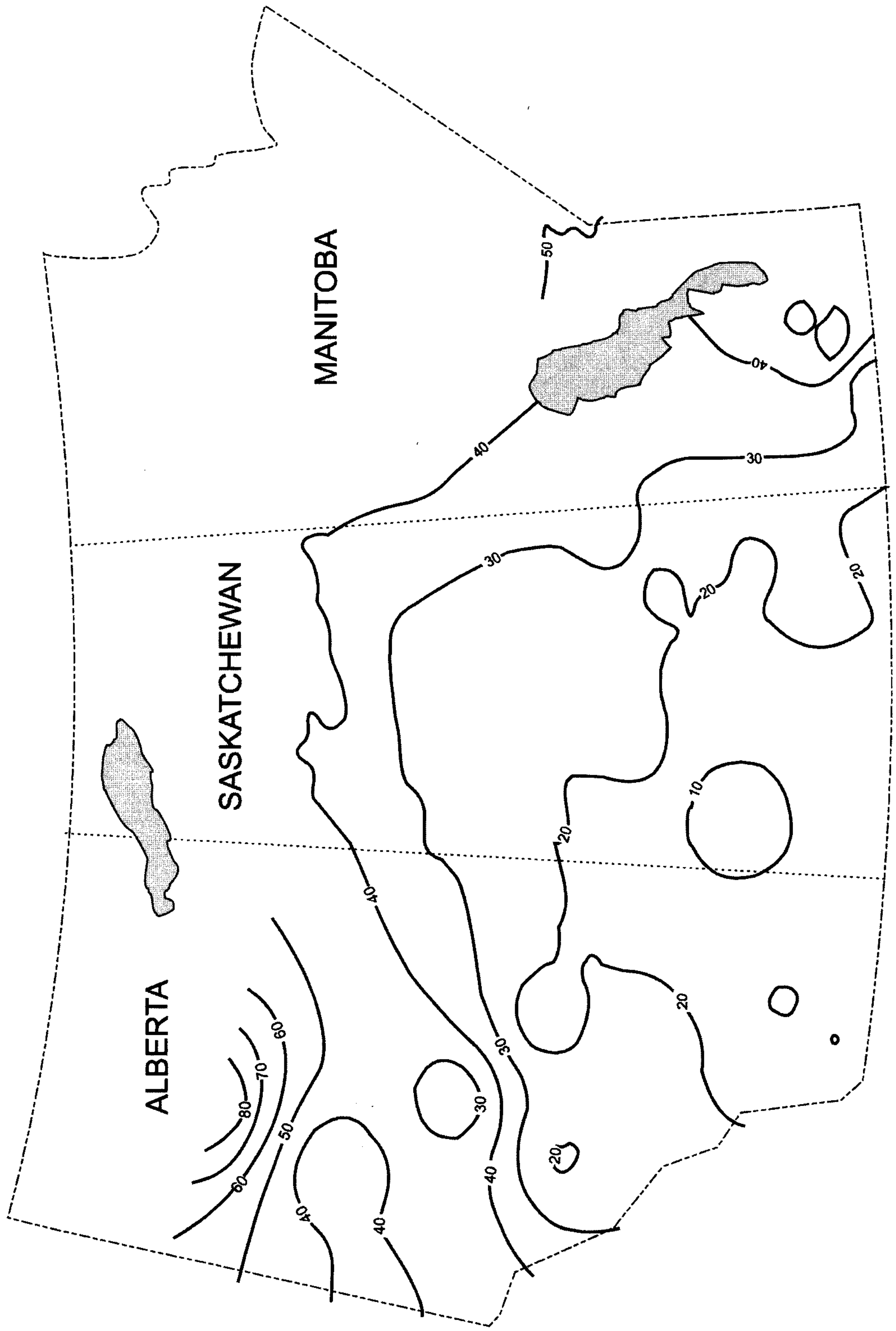

Figure B-3: Adjustment for winter conditions. R_s for the Prairie Region (winter)

(Source: Wall et al, 1997)

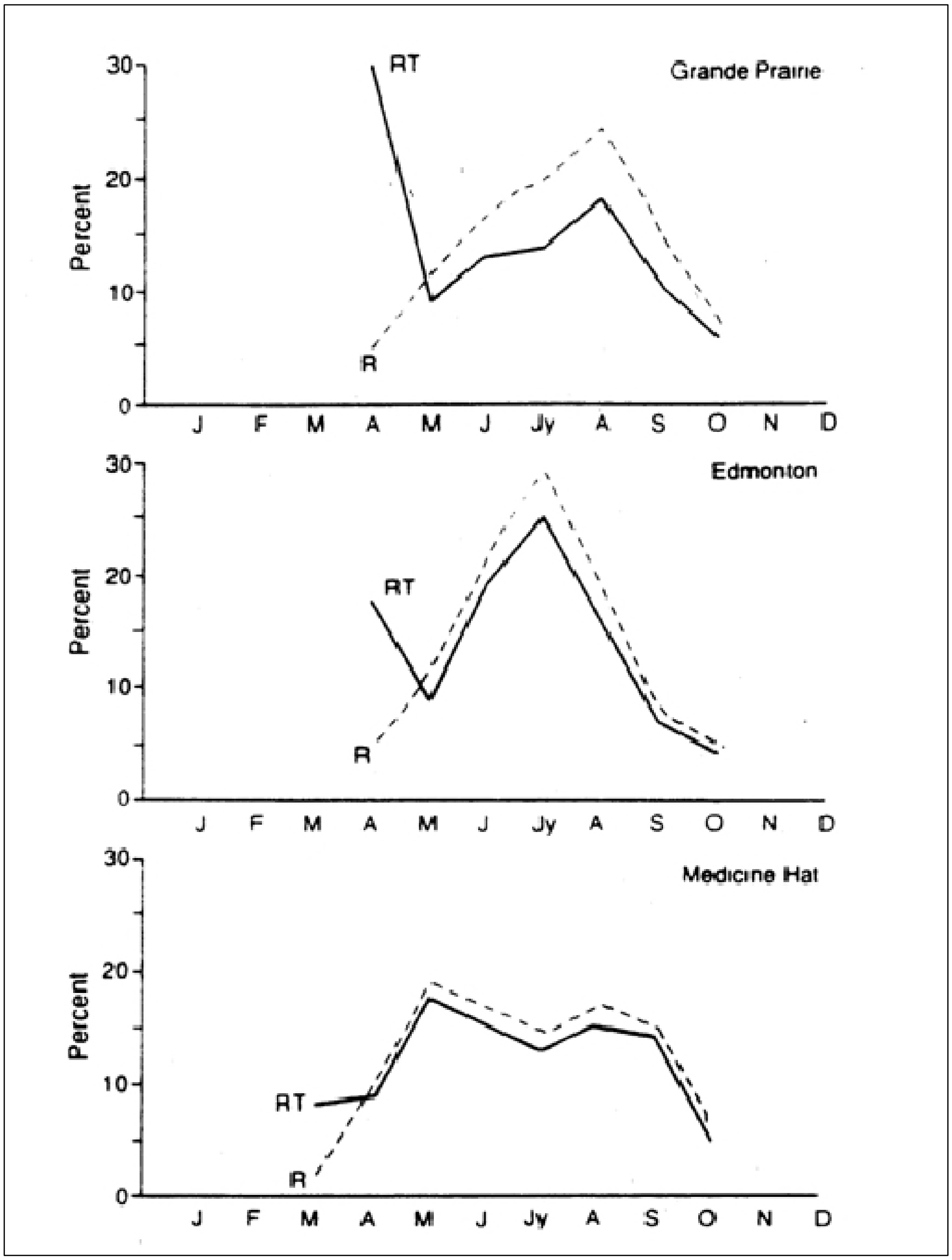

Figure B-4: Monthly Distribution Patterns of R_t for Selected Stations in Alberta

From: Water Erosion Potential of Soils in Alberta (1985). Agriculture Canada

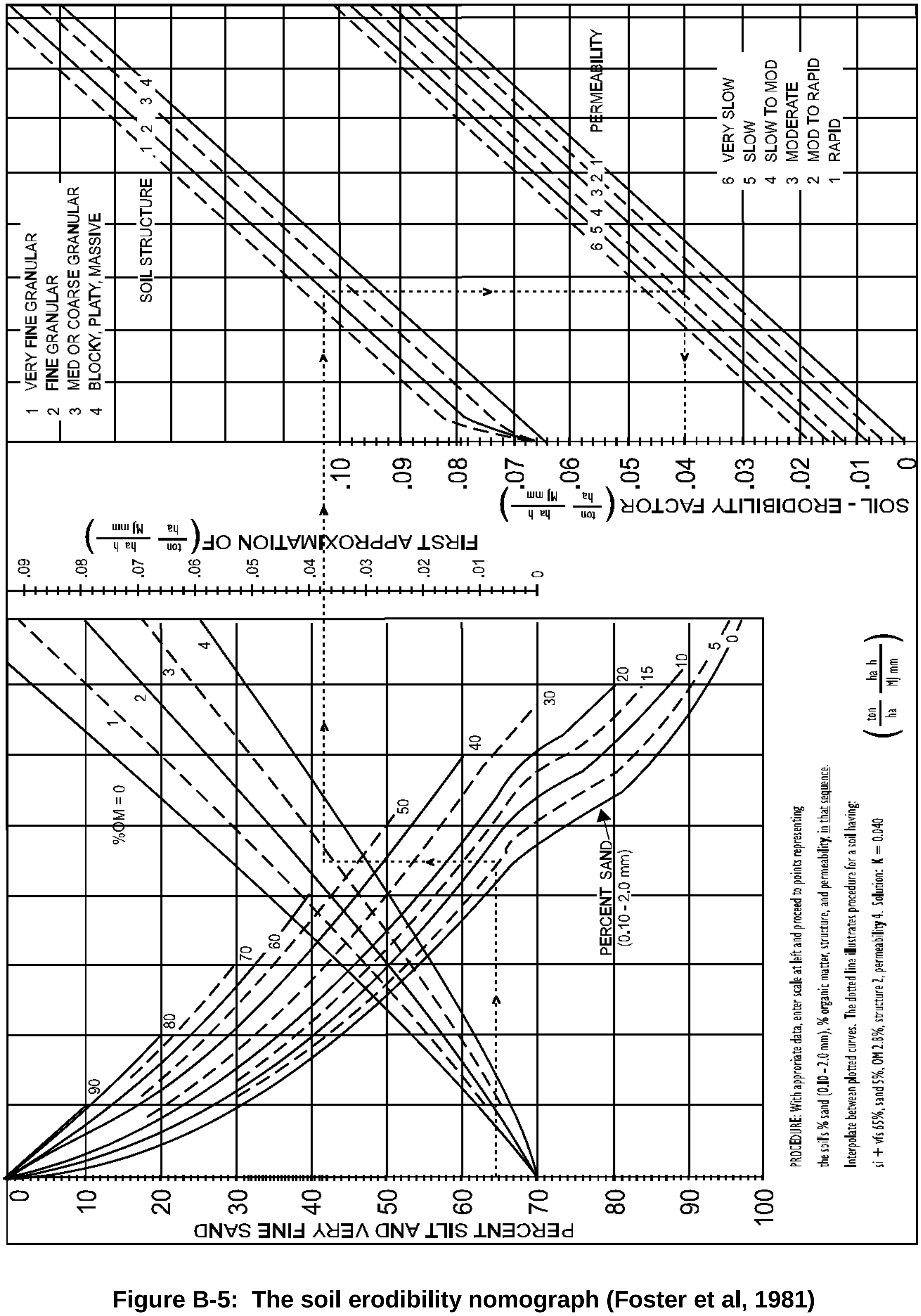

Figure B-5: The soil erodibility nomograph (Foster et al, 1981)

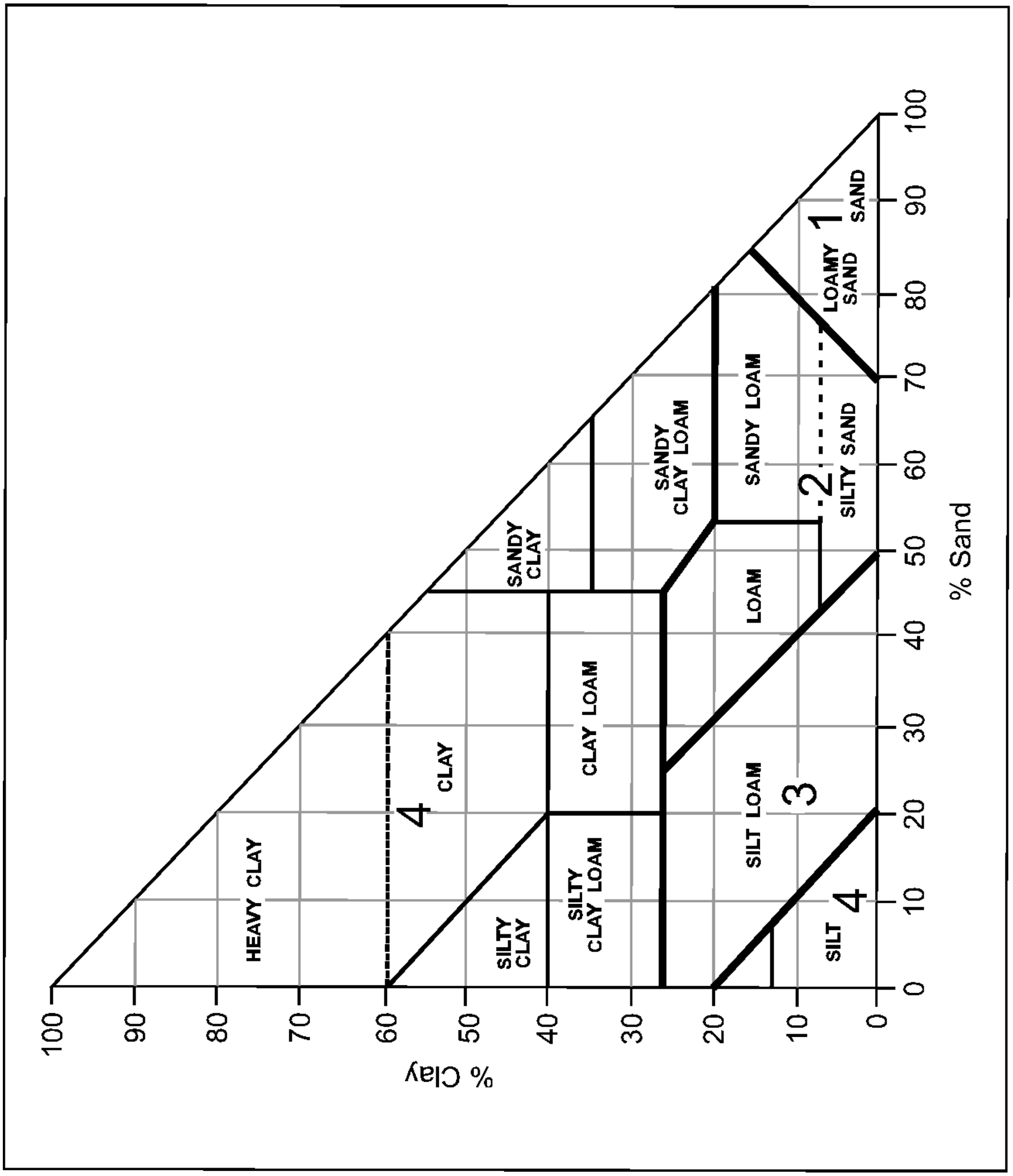

Figure B-6: Structure code based on textural classification

Source: 1) Ontario Centre for Soil Resource Evaluation, 1993
2) Wall et al, 1997

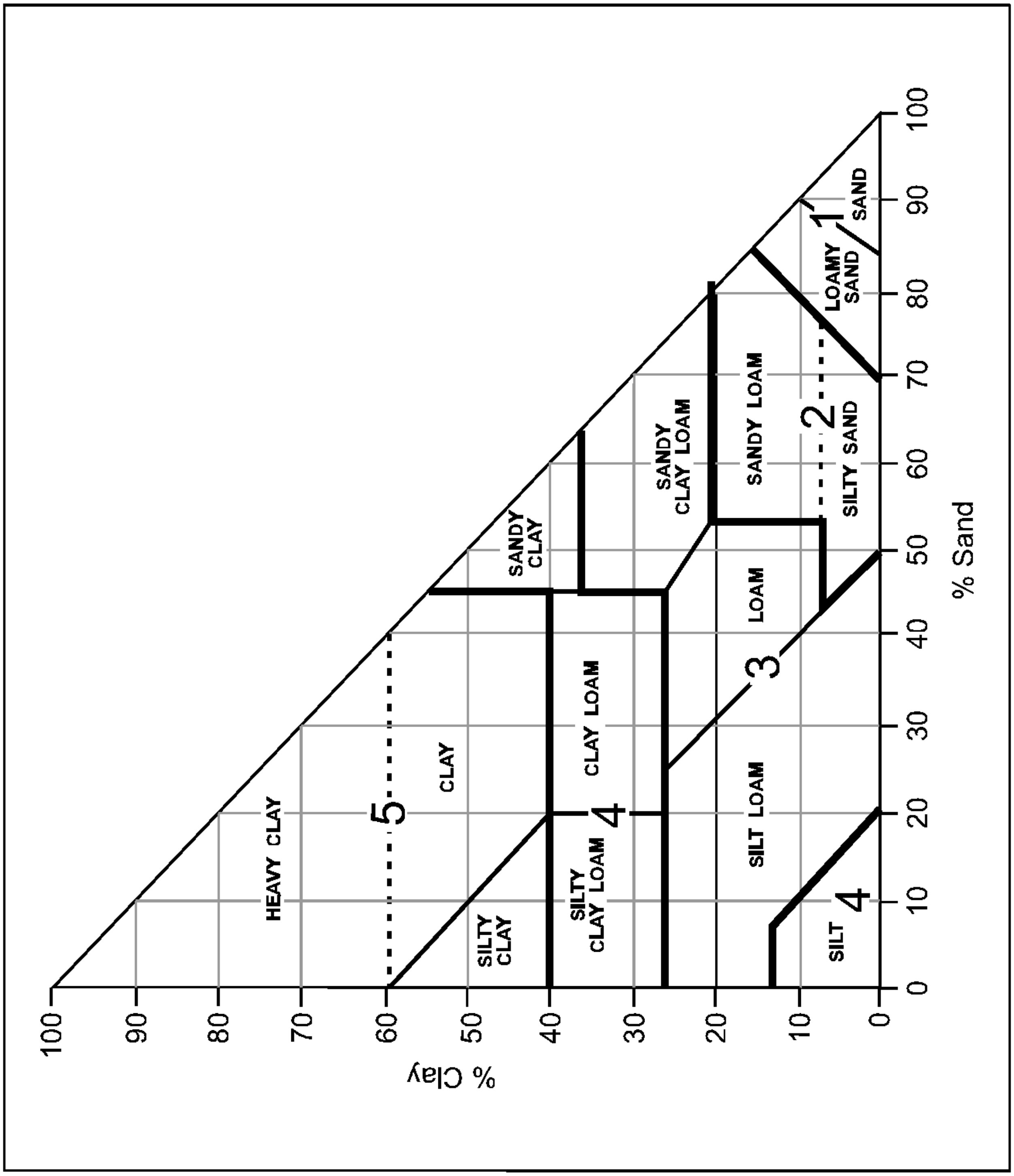

Figure B-7: Permeability code based on textural classification

(Source: Ontario Centre for
Soil Resource Evaluation, 1993)

Site	R_t	Monthly percentage of erosivity index (R)											
		J	F	M	A	M	J	J	A	S	O	N	D
Beaverlodge, B.C.	378	0	0	4	9	3	20	23	34	7	0	0	0
Lethbridge, Alta.	346	0	0	1	4	11	22	37	16	10	0	0	0
Peace River, Alta.	226	0	0	4	10	5	17	41	17	7	1	0	0
Vauxhall, Alta.	270	0	0	2	13	9	24	24	16	11	0	0	0
Broadview, Sask.	342	0	0	2	7	8	12	24	31	15	2	0	0
Estevan, Sask.	680	0	0	1	2	8	22	41	18	9	1	0	0
Outlook, Sask.	261	0	0	1	4	8	39	32	12	5	0	0	0
Saskatoon, Sask.	348	0	0	2	6	13	38	33	5	3	0	0	0
Swift Current, Sask.	268	0	0	1	3	7	43	25	16	5	0	0	0
Wynyard, Sask.	572	0	0	1	2	13	18	39	22	4	1	0	0
Yorkton, Sask.	663	0	0	1	2	7	23	26	28	10	2	0	0
Hudson Bay	510	0	0	2	5	5	22	37	18	10	1	0	0
Glenlea	1029	0	0	2	5	11	23	31	20	6	3	0	0
Gimli, Man.	848	0	0	1	4	6	25	24	27	11	3	0	0
Winnipeg, Man.	1093	0	0	1	3	12	18	21	32	12	2	0	0
White River, Ont.	1075	0	0	0	2	8	16	17	26	23	5	3	0
Windsor, Ont.	1615	2	3	5	9	6	15	20	18	9	5	4	4
London, Ont.	1330	3	3	3	9	7	14	18	15	11	7	6	4
Montreal, Que.	920	0	0	0	6	5	17	19	22	15	9	7	0
Moncton, N.B.	1225	3	4	4	4	8	10	14	15	10	12	11	5
Halifax, N.S.	1790	*	*	*	2	11	16	19	24	19	8	1	0
Kentville, N.S.	1975	4	6	7	6	3	12	12	15	10	10	7	8
Nappan, N.S.	1900	3	3	3	9	7	14	18	15	11	7	6	4
Truro, N.S.	2000	4	8	5	5	5	7	6	13	11	11	15	10
Charlottetown, P.E.I.	1520	4	4	4	9	7	13	17	14	11	7	5	5
St. John's, Nfld.	1700	4	8	5	5	5	7	6	13	11	11	17	8

* Data not available
Units for R = MJ mm ha^{-1} h^{-1}

Table B-1: Erosivity index and monthly distribution for sites in the Prairie Region and Eastern Canada

(Source RUSLEFAC)

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

Table B-2: Soil erodibility values (K) for common surface textures

These K estimations are based on the information obtained on approximately 1600 samples collected in Southern Ontario by Ontario Institute of Pedology surveyors.

If the organic matter content of a soil is unknown, use the value in the ‘average’ column. The other two columns refer to the values which can be used if the approximately organic matter content of a particular texture is known to be either greater or less than 2 percent.

(Source: Wall et al, 1997)

Slope (%)	Slope length in meters											
	2	5	10	15	25	50	75	100	150	200	250	300
0.2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
0.5	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
1	0.11	0.12	0.13	0.13	0.14	0.15	0.15	0.16	0.16	0.16	0.17	0.17
2	0.18	0.20	0.22	0.23	0.25	0.28	0.29	0.30	0.32	0.33	0.35	0.35
3	0.23	0.27	0.31	0.33	0.36	0.41	0.44	0.47	0.50	0.53	0.55	0.57
4	0.27	0.33	0.39	0.42	0.47	0.55	0.60	0.64	0.70	0.74	0.78	0.81
5	0.31	0.39	0.47	0.52	0.59	0.70	0.77	0.83	0.92	0.99	1.05	1.10
6	0.35	0.45	0.54	0.61	0.70	0.84	0.94	1.02	1.14	1.24	1.32	1.39
8	0.41	0.55	0.69	0.78	0.92	1.15	1.31	1.43	1.63	1.79	1.92	2.03
10	0.48	0.66	0.84	0.96	1.15	1.47	1.69	1.87	2.15	2.38	2.57	2.74
12	0.61	0.86	1.11	1.29	1.57	2.03	2.37	2.64	3.07	3.42	3.72	3.99
14	0.70	1.01	1.33	1.56	1.91	2.52	2.96	3.31	3.89	4.36	4.77	5.12
16	0.79	1.16	1.54	1.82	2.25	3.00	3.55	4.00	4.74	5.33	5.85	6.31
20	0.96	1.44	1.96	2.34	2.94	4.00	4.79	5.44	6.51	7.39	8.16	8.85
25	1.15	1.77	2.45	2.96	3.77	5.22	6.31	7.23	8.74	10.01	11.12	12.11
30	1.33	2.08	2.92	3.56	4.57	6.42	7.84	9.03	11.01	12.68	14.15	15.47
40	1.64	2.64	3.78	4.67	6.08	8.72	10.76	12.50	15.43	17.91	20.12	22.11
50	1.91	3.13	4.55	5.66	7.45	10.83	13.47	15.73	19.57	22.85	25.77	28.43
60	2.15	3.56	5.22	6.54	8.67	12.71	15.91	18.65	23.34	27.36	30.95	34.23

Table B-3: Values for topographic factor, LS, for low ratio of rill:interill erosion, such as consolidated soil conditions with cover and rangeland (applicable to thawing soils where both inter-rill and rill erosion are significant

(Source: Wall et al, 1997)

Slope Steepness (%)	Slope Length Exponent, m Rill/Interrill Ratio â Low*	Moderate†	High‡
0.2	0.02	0.04	0.07
0.5	0.04	0.08	0.16
1	0.08	0.15	0.26
2	0.14	0.24	0.39
3	0.18	0.31	0.47
4	0.22	0.36	0.53
5	0.25	0.40	0.57
6	0.28	0.43	0.60
8	0.32	0.48	0.65
10	0.35	0.52	0.68
12	0.37	0.55	0.71
14	0.40	0.57	0.72
16	0.41	0.59	0.74
20	0.44	0.61	0.76
25	0.47	0.64	0.78
30	0.49	0.66	0.79
40	0.52	0.68	0.81
50	0.54	0.70	0.82
60	0.55	0.71	0.83

* conditions where rill erosion is slight with respect to interill erosion; generally C factors would be less than 0.15

† conditions where rill and interill erosion would be about equal on a 22.1 m long slope in seedbed condition on a 9% slope

‡ conditions where rill erosion is great with respect to interill erosion; generally C factors would be greater than 7.0

Table B-4: Slope length exponents (m) for a range of slopes and rill/interill erosion classes

(Source: McCool et al, 1989)

# of Segments	Sequence # of Segment (i)	Soil Loss Factor (SLF) value of m																		
		0.02	0.06	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.64	0.7	0.75	0.8	0.85	0.9
2	1	0.99	0.96	0.93	0.90	0.87	0.84	0.81	0.78	0.76	0.73	0.71	0.68	0.66	0.64	0.62	0.59	0.57	0.55	0.54
	2	1.01	1.04	1.07	1.10	1.13	1.16	1.19	1.22	1.24	1.27	1.29	1.32	1.34	1.36	1.38	1.41	1.43	1.45	1.46
3	1	0.98	0.94	0.90	0.85	0.80	0.76	0.72	0.68	0.64	0.61	0.58	0.55	0.52	0.50	0.46	0.44	0.42	0.39	0.37
	2	1.01	1.02	1.02	1.03	1.04	1.05	1.05	1.05	1.06	1.06	1.06	1.05	1.05	1.05	1.04	1.04	1.03	1.02	1.02
	3	1.02	1.05	1.08	1.12	1.16	1.19	1.23	1.26	1.30	1.33	1.37	1.40	1.43	1.46	1.49	1.52	1.55	1.58	1.61
4	1	0.97	0.92	0.87	0.81	0.76	0.71	0.66	0.62	0.57	0.54	0.50	0.47	0.44	0.41	0.38	0.35	0.33	0.31	0.29
	2	1.00	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.91	0.90	0.88	0.87	0.85	0.84	0.82	0.80	0.78
	3	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.14	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.23	1.24	1.24
	4	1.02	1.05	1.09	1.13	1.17	1.21	1.25	1.29	1.33	1.36	1.40	1.44	1.48	1.50	1.55	1.58	1.62	1.65	1.68
5	1	0.97	0.91	0.85	0.79	0.72	0.67	0.62	0.57	0.53	0.48	0.45	0.41	0.38	0.36	0.32	0.30	0.28	0.25	0.23
	2	1.00	0.99	0.97	0.96	0.94	0.92	0.90	0.88	0.86	0.84	0.82	0.80	0.77	0.76	0.73	0.71	0.69	0.66	0.64
	3	1.01	1.02	1.03	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.05	1.05	1.05	1.04	1.03	1.03	1.02
	4	1.01	1.04	1.06	1.09	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.27	1.29	1.30	1.32	1.34	1.35	1.37	1.38
	5	1.02	1.05	1.09	1.13	1.17	1.22	1.26	1.30	1.34	1.38	1.42	1.46	1.50	1.53	1.58	1.62	1.65	1.69	1.73

Table B-5: Soil loss factors (SLF) for irregular slopes

(Source: Wall et al, 1997)

Type of mulch	Mulch rate tons/acre	Land slope percent	C Factor	Length limit (feet)
None	0	all	1	-
Straw or hay, tied down by anchoring and tacking equipment	1	1.5	0.20	200
	1	6-10	0.20	100
	1.5	1.5	0.12	300
	1.5	6-10	0.12	150
	2	1.5	0.06	400
	2	6-10	0.06	200
	2	11-15	0.07	150
	2	16-20	0.11	100
	2	21-25	0.14	75
	2	26-33	0.17	50
	2	34-50	0.20	35
Crushed stone, 1/4 to 1 1/2 inch	135	<16	0.05	200
	135	16-20	0.05	150
	135	21-33	0.05	100
	135	34-50	0.05	75
	240	<21	0.02	300
	240	21-33	0.02	200
	240	34-50	0.02	150
Wood chips	7	<16	0.08	75
	7	16-20	0.08	50
	12	<16	0.05	150
	12	16-20	0.05	100
	12	21-33	0.05	75
	25	<16	0.02	200
	25	16-20	0.02	150
	25	21-33	0.02	100
	25	34-50	0.02	75

Table B-6a: C-Factors for mulch placement and respective slope length limits

(Source: Wall et al, 1997)

Treatment	C-Factor
Sod Grass	0.01
Temporary Vegetation/Cover Crop	0.45[1]
Hydraulic Mulch at 4.5 tonnes/ha	0.10[2]
Soil Sealant	0.10 – 0.60[3]
Rolled Erosion Control Products	0.10 – 0.30[3]

Notes: [1] Assumes planting occurs within optimal climatic conditions

[2] Some limitation on use in arid and semiarid climates

[3] Value used must be substantiated by documentation.

Table B-6b: C-Factors for Other Treatments

Treatment			P- Factor
Bare Soil			
Packed and smooth			1.00
Freshly disked or rough, irregular			0.90
Sediment Containment Systems (a.k.a. Sediment Trap / Basin)			0.10-0.90[A]
Bale or Sandbag Barriers			0.90
Rock (Diameter = 25 - 50 mm) Barriers at Sump Location			0.80
Silt - Fence Barriers			0.60
Contour Furrowed Surface			
	Must be maintained throughout construction activities, otherwise P-Factor =1.0, Maximum length refers to downslope length		
	Slope (%)	**Max. Length (m)**	
	1 to 2	120	0.60
	3 to 5	90	0.50
	6 to 8	60	0.50
	9 to 12	40	0.60
	13 to 16	25	0.70
	17 to 20	20	0.80
	>20	15	0.80
Terracing			
	Must contain 2-year runoff volumes without overflowing, otherwise P-Factor = 1.00		
	Slope (%)		
	1 to 2		0.12
	3 to 8		0.10
	9 to 12		0.12
	13 to 16		0.14
	17 to 20		0.16
	>20		0.18
Grass Buffer Strips to Filter Sediment-laden Sheet Flows			
	Strips must be at least 15 m (50 ft) wide and have a groundcover value of 65% or great, otherwise P-Factor =1.00		
	Basin Slope (%)		
	0 to 10		0.60
	11 to 24		0.80

A. Should be constructed as the first step in over lot grading.

Note: Use of P-Factor values not in this table must be supported by documentation.

Table B-7: P-Factor Values for Construction Site

(Source: Fifield 2001) (part)
(Source: Wall et al, 1997) (part)

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APPENDIX C

EROSION AND SEDIMENTATION CONTROL BEST MANAGEMENT PRACTICES (BMPs)

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INTRODUCTION

A revised List of Tables and List of BMPs have been included in this 2011 edition of the Erosion and Sediment Control Manual. New items have been **bolded** in this list.

Items which have undergone change from the 2003 edition are:

2003 BMP Number	2003 BMP Name	Type of Change
3.	Brush or Rock Filter Berm	Removed
4.	Continuous (earth-filled geotextile) Berm	Revised
5.	Earth Dyke Barrier	Revised
8.	Aggregate Filled Sand Bag Check Dam	Removed
9.	Log Check Dam	Removed
10.	Synthetic Permeability (Ditch) Barrier	Revised
11.	Straw Bale Check Dam	Removed
16.	Gravel Blankets	Removed
24.	Hydroseeding-Hydromulching	Revised
28.	Fibre Rolls and Wattles	Revised
29.	Chemical Stabilization (Tackifiers)	Removed

All BMPs had a general review. However, the major changes to the 2011 edition of the ESC Manual are:

- Adding new Streambank Stabilization Techniques
- Categorizing BMPs into Erosion Control, Sediment Control and Streambank Stabilization Techniques
- Removing, adding, and revising various BMPs

Users of this manual are cautioned that these BMPs are for guidance only and that a specific site design is required by the engineer or designer.

LIST OF TABLES

LIST OF BMPs

Erosion Control

BMP #	BMP Description
13	Rolled Erosion Control Products (RECP)
14	Riprap Armouring
15	Cellular Confinement System
21	Offtake Ditch
22	Seeding
25	Topsoiling
26	Sodding
34	Slope Texturing
36	**Polyacrylamide (PAM)**
37	**Compost Blanket**

Sediment Control

BMP #	BMP Description
1	Silt Fence
4	Continuous Perimeter Control Structures
5	Berm Interceptor
6	Storm Drain Inlet Sediment Barrier
12	Straw Bale Barrier
17	Energy Dissipators
18	Sediment Traps and Basins
19	Slope Drains
20	Groundwater Control
38	**Rolls**
38	Wattles (Live Fascine)

Erosion and Sediment Control

BMP #	BMP Description
2	Gabions
7	Rock Check Dam
10	Synthetic Permeable Barrier
23	Mulching
24a	Hydroseeding
24b	Hydromulching
30	Riparian Zone Preservation
31	Pumped Silt Control Systems
32	Scheduling
33	Stabilized Worksite Entrances
35	**Straw Mulching & Crimping**

Streambank Stabilization Techniques

BMP #	BMP Description
27a	**Live Staking**
27b	**Brushlayering**
38	**Rolls**
39	**Brush Mattress**
40	**Live Siltation**
41	**Willow Post and Poles**
42	**Rock Vanes**
43	**Longitudinal Stone Toe**
44	**Vegetated Mechanical Stabilized Earth (VMSE)**
45	**Vegetated Riprap**

DRAWING LISTING

BMP Drawing #	Drawing Description
1	Silt Fence
2a	Gabions (Slope and Bank)
2b	Gabions (Single Gabion) Drop Structure for Ditch Channel
2c	Gabions (Double Gabion) “Energy Dissipator” Drop Structure for Ditch Channel
5	Berm Interceptor
6a	Storm Drain Drop Inlet Sediment Barrier (Block and Gravel – Option 1)
6b	Storm Drain Curb Inlet Sediment Barrier (Block and Gravel – Option 2)
6c	Storm Drain Curb Inlet Sediment Barrier (Sandbags – Option 1)
6d	Storm Drain Curb and Gutter Sediment Barrier (Sandbags – Option 2)
6e	Storm Drain Drop Inlet Sediment Barrier (Straw Bale/Gravel Option)
6f	Storm Drain Drop Inlet Sediment Barrier (Silt Fence – Option)
7	Rock Check Dam
10	Synthetic Permeable Barriers
12	Straw Bale Barrier

BMP Drawing #	**Drawing Description**
13a	Rolled Erosion Control Product (RECP) Channel Installation
13b	Rolled Erosion Control Product (RECP) Slope Installation
14a	Riprap Armouring for Slope
14b	Riprap Armouring for Channel
15	Cellular Confinement System for Slope Stabilization
17a	Energy Dissipator for Culvert Outlet
17b	Energy Dissipator for Semi-Circular Trough Drain Terminal Protection for Bridge Headslope
18a	Typical Sediment Basin (Riser Outlet Option)
18b	Typical Sediment Basin (Permeable Rock Berm Outlet Option)
19a	Slope Drain
19b	Overside Drain
21	Offtake Ditch (Intercept Ditch)
27a	**Live Staking**
27b1	**Brushlayering with Rock Toe Protection**
27b2	**Brushlayering**
27b3	**Brushlayering**
28	Wattle (Live Fascine)
31	Pumped Silt Control System
33	Temporary Gravel Construction Entrance/Exit
34a	Surface Roughening
34b	Grooved or Serrated Slope
34c	Benched Slope
35	**Straw Mulching and Crimping (Straw Anchoring)**
38a	**Coir Roll with Brushlayering**
38b	**Coir Roll / Coir Mats**
38c	**Straw Rolls**
39	**Brush Mattress**
40	**Live Siltation**
41	**Willow Posts and Poles**
42a	**Rock Vanes**
42b	**Typical Vane Bank Key Detail (With Pole Planting)**
43	**Longitudinal Stone Toe**
44	**Vegetated Mechanically Stabilized Earth (Step by Step)**
45a	**Vegetated Riprap with Brushlayering and Pole Planting**
45b	**Vegetated Riprap Willow Bundle Method (Horizontal)**
45c	**Vegetated Riprap Bent Pole Method (Horizontal)**
45d	**Vegetated Riprap During Construction Summary of Techniques**

Table C-1: Erosion Control Measures - Source Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
25	Topsoiling	✓	✓	✓	✓	Placing topsoil provides excellent medium for vegetation root structure development, organic content promotes plant growth, reuse organics (topsoil or peat) stripped from the site at start of grading; absorbs raindrop energy to minimize erosion potential	Cannot be effective without seeding and allowing time for plant growth; not appropriate for slopes steeper than 2H:1V (steep slopes will require soil covering over topsoil and specialized design); dry topsoil susceptible to wind erosion, susceptible to erosion prior to establishment of vegetation
22	Seeding	✓	✓	✓	✓	Inexpensive and relatively effective erosion control measure, effectiveness increases with time as vegetation develops, aesthetically pleasing, enhances terrestrial and aquatic habitat	Must be applied over prepared surface (topsoiled), grasses may require periodic maintenance (mowing), uncut dry grass may be a fire hazard, seeding for steep slopes may be difficult, seasonal limitations on seeding effectiveness may not coincide with construction schedule, freshly seeded areas are susceptible to runoff erosion until vegetation is established, reseeding may be required for areas of low growth
23	Mulching	✓	✓	✓	✓	Used alone to protect exposed areas for short periods, protects soil from rainsplash erosion, preserves soil moisture and protects germinating seed from temperature extremes, relatively inexpensive measure of promoting plant growth and slope protection	Application of mulch on steep slopes may be difficult, may require additional specialized equipment May deplete available nitrogen Nitrogen rich fertilizer may need to be added
24a 24b	Hydroseeding / Hydromulching	✓	✓	✓	✓	Economical and effective on large areas, mulch tackifier may be used to provide immediate protection until seed germination and vegetation is established, allows re-vegetation of steep slopes where conventional seeding/mulching techniques are very difficult, relatively efficient operation, also provides wind erosion control	Site must be accessible to hydroseeding / hydromulching equipment (usually mounted on trucks with a maximum hose range of approximately 150 m), may require subsequent application in areas of low growth as part of maintenance program

Table C-1: Erosion Control Measures - Source Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
26	Sodding	✓	✓	✓	✓	Provides immediate vegetation and protection, instant buffer strip and/or soft channel lining, can be used on steep slopes, relatively easy to install, may be repaired if damaged, aesthetically pleasing	Expensive, labour intensive to install, sod may not be readily available in all areas of the province, relatively short 'shelf-life' (sod can't be stored on-site for excessive periods of time)
14	Riprap Armouring	✓	✓			Most applicable as channel lining with geotextile underlay, used for soils where vegetation not easily established, effective for high velocities or concentrations, permits infiltration, dissipates energy of flow from culvert inlets/outlets, easy to install and repair, very durable and virtually maintenance free	Expensive, may require heavy equipment to transport and place rock, may not be feasible in areas of the province where rock is not readily available, may be labour intensive to install (hand installation); generally thickness of riprap is higher when compared to gabion mattress
13	Rolled Erosion Control Products (RECP)	✓	✓			Provides a protective covering to bare soil or topsoiled surface where need of erosion protection is high, can be more uniform and longer lasting than mulch, wide range of commercially available products	RECP use is labour intensive to install, temporary blankets may require removal prior to restarting construction activities, RECP not suitable for rocky slopes, proper site preparation is required to seat RECP onto soil correctly; high performance is tied to successful vegetation growth
15	Cellular Confinement System	✓	✓		✓	Lightweight cellular system and easily installed, uses locally available soils or grout for fill to reduce costs	Not commonly used in Alberta highway construction, expensive, installation is labour intensive (hand installation), not suitable for slopes steeper than 1H:1V
27a	Live Staking	✓		✓	✓	Establishes vegetative cover and root mat, reduces flow velocities on vegetative surface, traps sediment laden runoff, aesthetically pleasing once established, grows stronger with time as root structure develops, usually has deeper root structure than grass	Expensive, may be labour intensive to install, not commonly used in Alberta highway construction projects, revegetated areas are subject to erosion until plants are established, plants may be damaged by wildlife, watering is usually required until plants are established

Table C-1: Erosion Control Measures - Source Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
30	Riparian Zone Preservation	✓	✓	✓	✓	Preserve a native vegetation buffer to filter and slow runoff before entering sensitive (high risk) areas, most effective natural sediment control measure, slows runoff velocity, filters sediment from runoff, reduces volume of runoff on slopes	Freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment
32	Scheduling	✓	✓	✓	✓	Identifies protection issues and plans for efficient, orderly construction of BMPs; minimizes bare soil exposure and erosion hazard; allows early installation of perimeter control for sediment entrapment; and early installation of runoff control measures	
34	Slope Texturing	✓			✓	Roughens slope surface to reduce erosion potential and sediment yield; suitable for clayey soils	Additional cost; not suitable for silty and sandy soils; not practical for slope length <8 m for dozer operation up/down slope
36	Polyacrylamide (PAM)	✓	✓		✓	Increase cohesion of soil particles, thus enhancing terrestrial and aquatic habitat and improving water quality	Not for application to surface waters. Not commonly used in highway construction projects and may be expensive. Treatment area must be accessible to spray equipment. Temporary measure only. Performance decreases due to exposure to UV light and time
35	Straw Mulching & Crimping (Straw Anchoring)	✓			✓	Economical method of promoting plant growth and slope protection	Availability of straw. “Punching” of straw does not work on sandy soils. Application of straw by hand is labour intensive. If using straw blowers, treatment area must be accessible to trucks for transport of weeds
37	Compost Blanket	✓		✓	✓	Economical. Appropriate on slopes 2H:1V to level surface.	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks

Table C-2: Erosion Control Measures - Runoff Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
34	Slope Texturing	✓		✓	✓	Contouring and roughening (tracking) of slope face reduces runoff velocity and increases infiltration rates; collects sediment; holds water, seed and mulch better than smooth surfaces; promotes development of vegetation, provides loss of soil reduction in soil erosion compared with untracked slopes	May increase grading costs, may cause sloughing in sensitive (wet) soils, tracking may compact soil, provides limited sediment and erosion control and should not be used as primary control measure
21	Offtake Ditch	✓		✓	✓	Collects and diverts sheet flow or runoff water at the top of a slope to reduce downslope erosion potential, incorporated with permanent project drainage systems	Channel must be sized appropriately to accommodate anticipated flow volumes and velocities, lining may be required, may require design by qualified personnel, must be graded to maintain positive drainage to outlets to minimize ponding
17	Energy Dissipator	✓	✓			Slows runoff velocity and dissipate flow energy to non-erosive level in relatively short distances, permits sediment collection from runoff	Small diameter rocks/stones can be dislodged; grouted riprap armouring may breakup due to hydrostatic pressures, frost heaves, or settlement; may be expensive, may be labour intensive to install; may require design by qualified personnel for extreme flow volumes and velocities
19	Slope Drains	✓				Directs surface water runoff into drain pipe instead of flowing over and eroding exposed soils of slope face	Must be sized appropriately to accommodate anticipated flows, erosion can occur at inlet/outlet if protection is not incorporated into design, slope drain must be anchored to slope

Table C-2: Erosion Control Measures - Runoff Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
2	Gabions		✓			Relatively maintenance free, permanent drop structure, long lasting (robust), may be less expensive than riprap, allows smaller diameter rock/stones to be used, relatively flexible, commercially available products, commonly used in Alberta highway construction projects; suitable for resisting high flow velocity	Construction may be labour intensive (hand installation), extra costs associated with gabion basket materials
7	Rock Check Dam		✓		✓	Permanent drop structure with some filtering capability, cheaper than gabion and armouring entire channel, easily constructed, commonly used in Alberta highway construction projects	Can be expensive in areas of limited rock source, not appropriate for channels draining areas larger than 10 ha (4 acres), requires extensive maintenance after high flow storm events, susceptible to failure if water undermines or outflanks structure
10	Synthetic Permeable Barriers		✓			Reusable/moveable, reduces flow velocities and dissipate flow energy; retains some sediments; used as grade breaks in conjunction with sturdy permanent drop structures along steep grades	Not to be used as check structures, must be installed by hand in conjunction with RECP, become brittle in winter and are easily damaged by construction equipment or recreational vehicles, only partially effective in retaining some sediment, primarily used for reducing flow velocities and energy dissipation
20	Groundwater Control (Subsurface Drain)	✓				Relief subsurface groundwater seepage and winter ice build-up; lower groundwater table to minimize piping erosion; enhance slope stability performance	Requires design by a qualified person; can be a slope instability issue

Table C-2: Erosion Control Measures - Runoff Control

No.	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
38 28	Rolls (Fibre) Wattles	✓				Function well in freeze-thaw conditions, low cost solution to sheet flow and rill erosion on slopes, low to medium cost flow retarder and silt trap, can be used on slopes too steep for silt fences or straw bale barriers, biodegradable	Labour intensive to install (hand installation), designed for slope surfaces with low flow velocities, designed for short slope lengths with a maximum slope of 2H:1V, not widely used on Alberta highway construction projects
37	Compost Blanket	✓		✓	✓	Economical. Appropriate on slopes 2H:1V to level surface	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks

Table C-3: Sediment Control Measures

No.	BMP Name		Applications				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
30	Filtering and Entrapment	Riparian Zone Preservation	✓	✓	✓	✓	Preserve a native vegetation buffer to filter and slow runoff before entering sensitive (high risk) areas, most effective natural sediment control measure, slows runoff velocity, filters sediment from runoff	Freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment
12	Filtering and Entrapment	Straw Bale Barrier		✓	✓	✓	Relatively inexpensive if bales are locally available, biodegradable, cheaper and easier to install than other barriers	Short service life due to biodegradation, straw bales may not be readily available in all areas of the province, maximum barrier height of one straw bale, require extensive maintenance after high flow storm events, require proper keying and staking
38 28	Filtering and Entrapment	Rolls (Fibre) Wattles	✓				Function well in freeze-thaw conditions, low cost solution to sheet flow and rill erosion on slopes, low to medium cost flow retarder and silt trap, can be used on slopes too steep for silt fences or straw bale barriers, biodegradable	Labour intensive to install (hand installation), designed for slope surfaces with low flow velocities, designed for short slope lengths with a maximum slope of 2H:1V, not widely used on Alberta highway construction projects
31	Filtering and Entrapment	Pumped Silt Control Systems (Silt Bags)		✓			Filter bag is lightweight and portable, simple set up and disposal, sediment-laden water is pumped into this filter bag, different aperture opening sizes (AOS) available from several manufacturers; normally for emergency use only	May be expensive, requires special design, not usually readily used in Alberta highway construction projects, requires a pump and power source for pump, suitable for only short periods of time and small volumes of sediment laden water, can only remove particles larger than aperture opening size (AOS)
1	Filtering and Entrapment	Silt Fence	✓		✓	✓	Economical, most commonly used sediment control measure allows water to pond and settle out coarse grained sediment, more effective than straw bale barriers	May fail under high runoff events, applicable for sheet flow erosion only, limited to locations where adequate space is available to pond collected runoff, sediment build up needs to be removed on a regular basis, damage to silt fence may occur during sediment removal, usable life of approximately one year

Table C-3: Sediment Control Measures

No.	BMP Name		Applications				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
5	Filtering and Entrapment	Berm Interceptor	✓		✓	✓	Easy to construct, relatively inexpensive as local soil and material is used	Geotechnical design required for fill heights in excess of 3 m, may not be suitable for all soil types or sites; riprap spillway and/or permeable outlet may be required
2		Gabions		✓			Relatively maintenance free, permanent drop structure, long lasting (robust), may be less expensive and thickness than riprap, allows smaller diameter rock/stones to be used, relatively flexible, commercially available products, commonly used in Alberta highway construction projects; suitable for resisting high flow velocity	Construction may be labour intensive (hand installation), extra costs associated with gabion basket materials
7		Rock Check Dam		✓		✓	Permanent drop structure with some filtering capability, cheaper than gabion and armouring entire channel, easily constructed, commonly used in Alberta highway construction projects	Can be expensive in areas of limited rock source, not appropriate for channels draining large areas, requires extensive maintenance after high flow storm events, susceptible to failure if water undermines or outflanks structure
10	Filtering and Entrapment	Synthetic Permeable Barriers		✓			Reusable/moveable, reduces flow velocities and dissipates flow energy; retains some sediments; used as grade breaks in conjunction with sturdy permanent drop structures along steep grades	Partially effective as check dam structure, must be installed by hand in conjunction with RECP, become brittle in winter and are easily damaged by construction equipment or recreational vehicles, only partially effective in retaining some sediment, primarily used for reducing flow velocities and energy dissipation
4		Continuous Perimeter Control Structures	✓		✓	✓	Temporary measure; divert and intercept sheet or overlaid flow to form pond and allow sedimentation; ;flexibility of shape of construction; no trenching	Require specialized continuous berm machine to manufacture earth-filled geotextile berm on site; sandy/gravel soil is preferable fill material
6		Storm Drain Inlet/Sediment Barrier			✓		Temporary measure; easy to install and remove	Limited sediment entrapment capacity; requires regular clean-out maintenance

Table C-3: Sediment Control Measures

No.	BMP Name		Applications: Slopes	Applications: Ditches and Channels	Applications: Large Flat Surface Areas	Applications: Borrow and Stockpile Area	Comments: Advantages	Comments: Limitations
37		Compost Blanket	✓		✓	✓	Economical. Appropriate on slopes 2H:1V to level surface	Application on steep slopes may be difficult. Treatment area should be accessible to blower trucks
32	All BMPs	Scheduling	✓	✓	✓	✓	Identifies protection issues and plans for efficient, orderly construction of BMPs; early installation of perimeter control for sediment entrapment; early dimension planning of runoff control measures	
18	Impoundment	Sediment Traps/Basins		✓		✓	May be constructed of a variety of materials, collects sediment laden runoff and reduces velocity of flow and deposition of sediment, can be cleaned and expanded as needed, capable of handling large volumes of sediment laden runoff	"Last resort" measure. Normally requires 250 m^3/ha storage volume per area of exposed soil, Can require large areas of land, requires periodic maintenance to remove sediment build up, requires design by qualified personnel, usually requires 'back-up' control measures in case pond/basin overflows

Table C-4: Streambank Applications

BMP # and Name	Comments	
	Advantages	**Limitations**
#27a Live Staking	Establishes vegetative cover and root mat, reduces flow velocities on vegetative surface, traps sediment laden runoff, aesthetically pleasing once established, grows stronger with time as root structure develops, usually has deeper root structure than grass	Expensive, may be labour intensive to install, not commonly used in Alberta highway construction projects, revegetated areas are subject to erosion until plants are established, plants may be damaged by wildlife, watering is usually required until plants are established
#27b Brushlayering	Provide immediate soil stability and habitat Can be used with other toe protection such as, rootwads, coir rolls, and log toes. Combining live brushlayering with rock toes is an effective and relatively low cost technique for revegetating and stabilizing streambanks. Provides a source of shade and nutrients, while slowing velocities along the bank during flooding flows. They provide a flexible strengthening system to fill slopes. Act as horizontal drains and favourably modify the soil water flow regime	Live cuttings are most effective when implemented during the dormancy period of chosen plant species. Brushlayers are vulnerable to failure before rooting occurs, and they are not effective at counteracting failure along very deep-seated failure planes
#39 Brush Mattress	Provides a dense network of branches that quickly stabilize a slope or streambank. Will trap sediments during high water and eventual plant growth will enhance aquatic habitat. Well suited for combined installation with many other streambank or slope stabilization techniques such as Vegetated Riprap, Live Stakes, Live Fascines, Rootwad Revetment, Live Siltation, and Coconut Fibre Rolls. Provides immediate surface protection against floods, greatly reducing water velocity at the soil surface. Cuttings are usually available locally. Relatively economical technique. Captures sediment during floods, assisting in rebuilding of bank. Produces riparian vegetation rapidly and enhances wildlife habitat value	Does not show high success on streams where basal ends cannot be kept wet for the duration of the growing season. They should be installed during the dormant season for woody vegetation and Installation is labour intensive
#40 Live Siltation	A very effective and simple conservation method using local plant materials. Can be constructed in combination with rock toes, Rootwad Revetments, Coconut Fibre Rolls, Live Fascines, and Brush Mattresses. Valuable for providing immediate cover and fish habitat while other revegetation plantings become established. The protruding branches provide roughness, slow velocities, and encourage deposition of sediment. The depositional areas are then available for natural recruitment of native riparian vegetation	If using a living system, cuttings must be taken during the dormancy period
#41 Willow Posts and Poles	Willow posts and poles are inexpensive to acquire, install, and maintain, provide long-term protection. They may be inserted into stone or soil backfill and thus become incorporated with the structure as they root. They can also be incorporated into many techniques during construction (e.g., Vegetated Riprap, Vegetated Gabions), and can be planted in the keyways of many structures. Aquatic and terrestrial habitat is provided and/or improved. Willows act as pioneer species, and allow other plant species to colonize the area after the willows have become established	Willow posts and poles have higher survival rates when planted during their dormant season, so planning should be adjusted accordingly. Optimum stabilization is not achieved until the willows become established, typically at least one season after installation, although they provide some reinforcement immediately following installation

Table C-4: Streambank Applications

BMP # and Name	Comments	
	Advantages	**Limitations**
#42 Rock Vanes	Rock vanes can successfully reduce near-bank velocities and shear stress, vegetation establishment is greatly improved. Vanes are often combined with other biotechnical soil stabilization measures for bank areas between the vanes. Provide aquatic habitats superior to resistive, continuous structures like Riprap and Longitudinal Stone Toe. Controlled scour at the vane tip, the creation of pool/riffle bed complexity, and increased deposition of the upstream end are the major environmental benefits of vanes. Vanes provide fish rearing and benthic habitat, creates or maintains pool and riffle habitat, provides cover and areas for adult fish, and velocity refugia. The redirection of impinging flows away from the bank and the sedimentation on the upstream side of the vane creates areas where vegetation can effectively re-establish. Areas of active bank erosion become depositional, vegetate, and subsequently, become permanently stable. The technique is appropriate under a range of flow conditions and bed materials and can be used in series to redirect flows around bends. Vane installation does not require extensive bank reshaping, and most heavy equipment work can be done from the top of the bank, further reducing site disturbance. Vanes require less rock and heavy equipment than riprap for a similar length of protected bank.	Unintended impacts can result from improper design and construction. If the vane is not properly keyed into the bank, it is likely to fail, creating new localized erosion problems. Improper vane angle and crest elevation can redirect flow in unintended directions, triggering downstream erosion
#43 Longitudinal Stone Toe	Willow posts and poles may be incorporated into key sections and used to revegetate the middle and upper bank above stone toe. May be combined with a number of other different techniques and the results enhance aquatic habitats. Longitudinal Stone Toe with Spurs is a variation on this technique. Bank grading, reshaping, or sloping is usually not needed (existing bank and overbank vegetation need not be disturbed or cleared), nor is a filter cloth or gravel filter needed. If stone is placed from the water side, existing bank vegetation need not be disturbed. It is very cost-effective and is relatively easy to design, specify and construct. It is easily combined with other bank stability techniques that provide superior habitat compared to pure riprap	Only provides toe protection and does not protect mid- and upper bank areas. Some erosion of these areas should be anticipated during long-duration, high energy flows, or until the areas become otherwise protected. Stone toe is not suitable for reaches where rapid bed degradation (lowering) is likely, or where scour depths adjacent to the toe will be greater than the height of the toe.

Table C-4: Streambank Applications

BMP # and Name	Comments	
	Advantages	**Limitations**
#44 Vegetated Mechanically Stabilized Earth (VMSE)	The presence of vegetation softens the stark visual appearance of conventional mechanically stabilized earth structures and provides potential habitat for riparian wildlife. Overhanging branches of the live brushlayers provide shade for fish and a substrate for insects and other organisms that the fish feed upon. They permit much steeper slopes to be constructed than would be possible with live brushlayers alone. Brushlayering treatment by itself is normally restricted to slopes no steeper than 1V:2H. VMSE can be constructed with a slope as steep as 1V:0.5H. The vegetation shields the fabric against damaging UV radiation, and provides visual and riparian habitat benefits. The brushlayers act as horizontal drains that favourably modify the groundwater regime in the vicinity of the slope face, thereby improving stability against mass slope failure	A VMSE structure must be constructed during the dormancy period to insure good vegetative propagation and establishment. Alternatively, the live cuttings may be harvested during dormancy, and placed in temporary cold storage until they are ready for use during an out-of-dormancy period, viz., during the summer months (increases the cost). Materials procurement is more demanding, and installation more complex, because of the blending of two distinct methods, viz., conventional MSE and live brushlayering, into a single approach. Costs will also be more than brushlayering used alone, because of the added expense of the geotextile and the additional labour required to handle and construct the wraps. VMSE streambank structures must be constructed during periods of low water because of the need to excavate and backfill a trench with rock in the streambed to provide a stable foundation.
#45 Vegetated Rip-Rap	When graded or "self-launching" stone are used, riprap is self-adjusting to small amounts of substrate consolidation or movement. The revetment can sustain minor damage and still continue to function adequately without further damage. The rough surface of the riprap dissipates local currents and minimizes wave action more than a smooth revetment (like concrete blocks). Stones are readily available in most locations, and materials are less expensive than many other "hard armouring" techniques. The rock provides a large amount of aquatic habitat it's easily repaired. The fibrous roots of the chosen vegetation prevents washout of fines, stabilizes the native soil, anchors armour stone to the bank, and increases the lift-off resistance. The vegetation also improves drainage of the slope by removing soil moisture for its own use. Vegetated riprap has a more natural appearance, and is therefore more aesthetically pleasing, which is frequently a matter of great importance in high-visibility areas. The vegetation also supplies the river with carbon-based debris, which is integral to many aquatic food webs, and birds that catch fish or aquatic insects will be attracted by the increased perching space next to the stream. The brushlayering methods reach out over the water, and provide shade and organic debris to the aquatic system.	Vegetated riprap may be inappropriate if flow capacity is an issue, as bank vegetation can reduce flow capacity, especially when in full leaf along a narrow channel. In remote areas large rocks may be difficult to obtain and transport, which may greatly increase costs. Riprap may present a barrier to animals trying to access the stream.
#38 Rolls (Coir)	Durable with high tensile strength. Rolls and Mats accumulate sediment while plants grow and roots develop. Biodegradable. Can be combined with brushlayering to provide immediate shoreline or streambank protection.	Coir Rolls are relatively expensive. Technique should be implemented during the dormancy period of the cuttings used for brushlayering and staking.

Table C-5: Procedural BMPs (Planning Strategies) for Erosion and Sediment Control

BMP Objective	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Minimize Exposed Soils	✓	✓	✓	✓	Decrease of disturbed soil area decreases erosion potential and decreases quantity of erosion and sediment control measures required thus decreasing costs	May require topsoiling/seeding completed areas before stripping of new areas
Observe Environmental Timing Restrictions	✓	✓	✓	✓	Minimizes possible negative impacts on fish and wildlife	May affect schedule of adjoining works
Maximize Work During Favourable Weather	✓	✓	✓	✓	Increasing work capacity in favourable conditions minimizes volume of work required in less desirable (wet) conditions, thus decreasing potential for erosion and sediment loss	May require additional resources to increase scale of production/construction
Install BMPs Early	✓	✓	✓	✓	Early installation of erosion and sediment control measures ensures sediment losses are minimized during construction	May cause difficulties with site access or traffic
Avoid Wet Weather Periods	✓	✓	✓	✓	Avoiding construction in wet weather periods minimizes erosion potential	Shutdowns may prolong/delay construction activities
Topsoil and Seed Early	✓	✓	✓		Topsoiling and seeding as early as possible covers exposed soil and reduces erosion potential	
Surface Roughening (Slope Texturing)	✓		✓	✓	Surface roughening reduces erosion: 12% for a dozer ripping on the contour, 52% for track walking up and down the slope, 54% for sheep's foot rolling, and 76% for imprinting	Equipment may need to be retasked at a slight increase in costs
Preserve and Use Existing Drainage Systems	✓	✓	✓	✓	Preserve existing drainage routes and vegetation	May affect scheduling of certain construction activities
Control Construction Traffic				✓	Avoids over-trafficking sensitive areas or areas with increased disturbance	Forcing traffic into localized areas may increase disturbance in high-traffic areas
Signage	✓	✓	✓	✓	Clearly labelling sensitive zones or areas	Increased costs of signs

Table C-5: Procedural BMPs (Planning Strategies) for Erosion and Sediment Control

BMP Objective	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
					not to be disturbed makes workers aware of where work cannot occur	
Scheduling of Work	✓	✓	✓	✓	Placement of topsoil and seeding should be scheduled throughout construction phase. New sections should not be stripped far in advance of construction	May require construction to be completed in one area before starting in another.
Stockpile Control				✓	Stockpiles should be located well away from watercourses and environmentally sensitive areas	May result in longer haul distances.
Direct Surface Water Flow Around Site	✓	✓	✓	✓	Keeps surface water from off-site from increasing erosion	Diversion ditches may require erosion and sediment control measures to be implemented.

Silt Fence Sediment Control	B.M.P. #1

Description and Purpose

- Permeable fabric barriers installed vertically on support posts along contours to collect sediment laden sheet flow runoff
- Causes water to pond allowing sediment to settle out as water filters through fabric
- Entraps and minimizes coarse sediment from sheet flow or overland flow from entering waterbodies
- Perimeter control for sediment transport and deposition

Applications

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

Advantages

- Low permeability silt fences have high filtering capabilities for fine sand to coarse silt
- Filter fence more effective than straw bales at filtering out sediment

Limitations

- Applicable for sheet flow, cannot handle concentrated channel flow volumes
- May fail under high runoff events
- Limit to locations suitable for temporary ponding of sediment laden runoff
- Low permeability silt fences may not be strong enough to support weight of water retained behind it and may require reinforcement (i.e., wire mesh and stronger support)
- Sediment build up needs to be removed on a regular basis
- Damage to fence may occur during sediment removal
- Useable life of approximately one year dependent on regular maintenance

Construction

- Two methods of installation are commonly used
  - Trench method
  - Mechanical (slicing) installation method (e.g. Tommy Silt Fence Machine or equivalent)
- Trench Method
  - Select location of silt fence (usually along contours)
  - Drive support posts a minimum of 0.3 m into ground, spaced a maximum of 2 m apart
  - Excavate trench approximately 0.15 m deep by 0.15 m wide for entire length of fence along upstream side of posts
  - Attach the wire mesh or snow fencing, if used as reinforcement, to upstream side of posts with staples
  - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts
  - Backfill and compact soil in trench, being careful not to damage fence
- Mechanical Installation Method
  - Select location of silt fence (usually along contours)
  - Use mechanical installation machine to embed the fabric a minimum of 0.15 m into the ground. One mechanical installation method is by slicing (with special equipment) the geotextile fabric embeds into the ground without excavation and backfill. There is only minor disturbance of the ground. Tamping of ground is required for compaction.
  - Drive support posts a minimum of 0.3 m into ground, spaced a maximum of 2 m apart
  - Attach the wire mesh or snow fencing, if used as reinforcement to silt fence fabric, to upstream side of posts with staples
  - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts

Construction Considerations

- Site Selection

  - Size of drainage area should be no greater than 0.1 ha per 30 m length of silt fence
  - Maximum flow path length above silt fence should be no greater than 30 m
  - Maximum slope gradient above the silt fence should be no greater than 2H:1V
- Fence should be placed on contour to produce proper ponding
- Fence should be placed far enough away from toe of slope to provide adequate ponding area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of fence should be angled upslope to collect runoff
- Fence should not extend more than 0.6 m above grade
- Posts can be wood or metal material dependent on design and ground conditions
- Posts should be placed on downstream side of fence
- Posts should not be spaced greater than 2 m apart
- Wire mesh or standard snow fencing may be placed between the posts and fabric barrier to provide additional strength and support reinforcement
- Geotextile should be cut from a continuous roll to avoid joints (if joints are necessary, the wrapping of fabric around the fence post and a minimum overlap of 0.2 m with staples should be used to attach the fabric to the post)
- Fence (and wire mesh or snow fence, if used) should be attached to posts with heavy duty staples, tie wires, or hog rings
- Fence (and wire mesh or snow fence, if used) should be dug into a trench at least 0.15 m deep to prevent undercutting of fence by runoff
- Trench backfill should be compacted
- Long runs of silt fence are more prone to failure than short runs
  - Maximum length of each section of silt fence should be 40 m
  - Silt fence should be installed in 'J' hook or 'smile' configuration, with maximum length of 40 m, along contours allowing an escape path for ponded water (minimizes overtopping of silt fence structure)

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Repair undercut fences and repair or replace split, torn, slumping or weathered fabric immediately

Silt Fence Sediment Control	B.M.P. #1

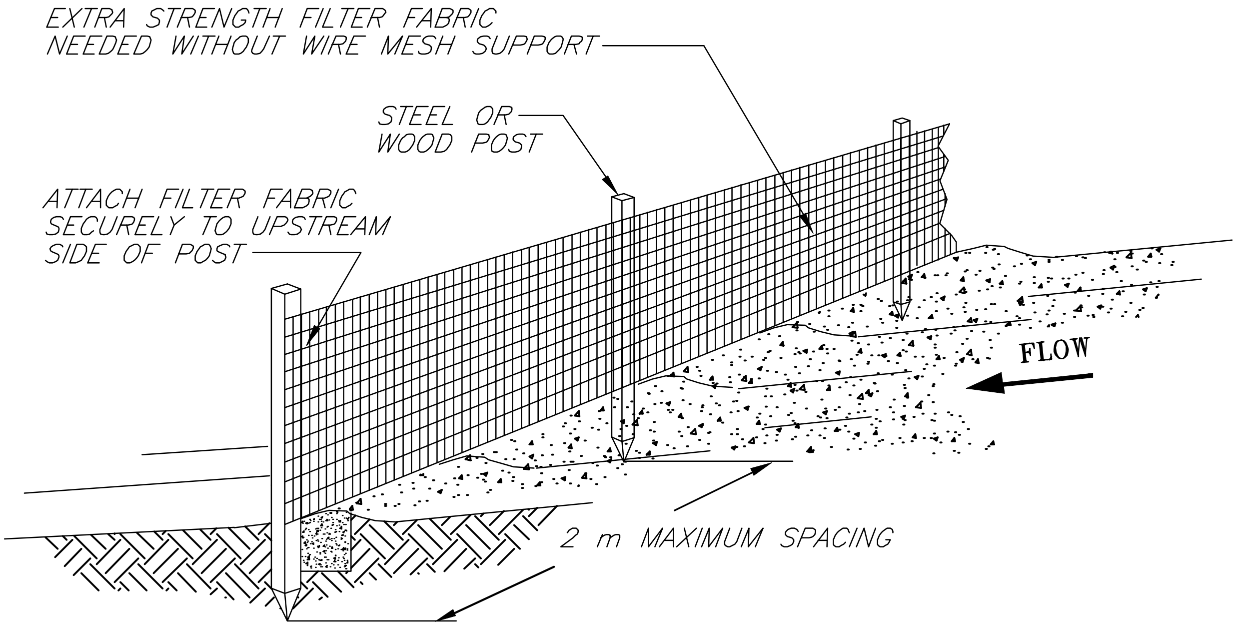
- Sediment build up should be removed once it accumulates to a depth of 0.2 m
- Remove fence after vegetation is established
- Deactivate fabric by cutting-off top portion of fabric above ground; bottom trenched-in portion of fence fabric can be left in-ground thus minimizing ground disturbance

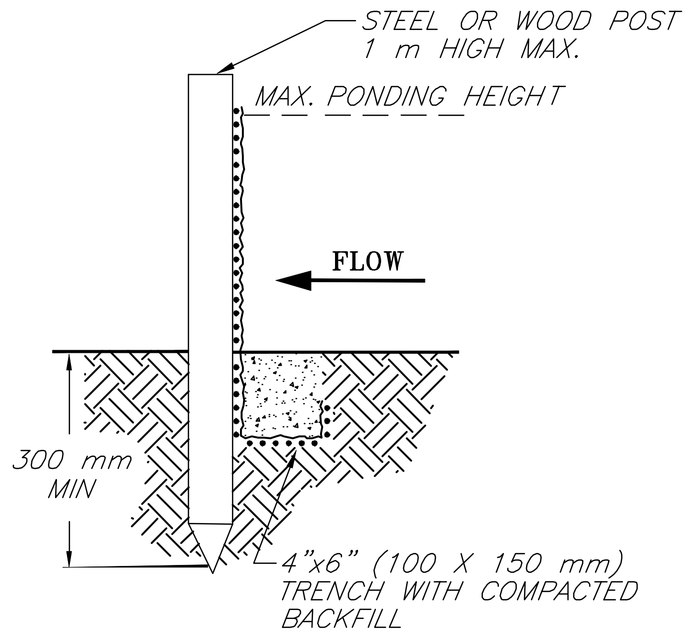
Similar Measures

- Straw Bales
- Rock Barrier
- Permeable/Synthetic Barriers

Design Considerations

- For a silt fence system to work as a system, the following factors should be considered:
  a) quantity – adequate number and frequency of fence for efficient ponding and sedimentation
  b) installation – workmanship
  c) compaction – backfill and trenching of fabric
  d) support – posts adequately embedded, appropriate selection of post material and spacing
  e) attachment – secure fabric to post
- Install silt fences in a 'J' hook or 'smile' configuration





TRENCH METHOD DETAIL

NOTES:

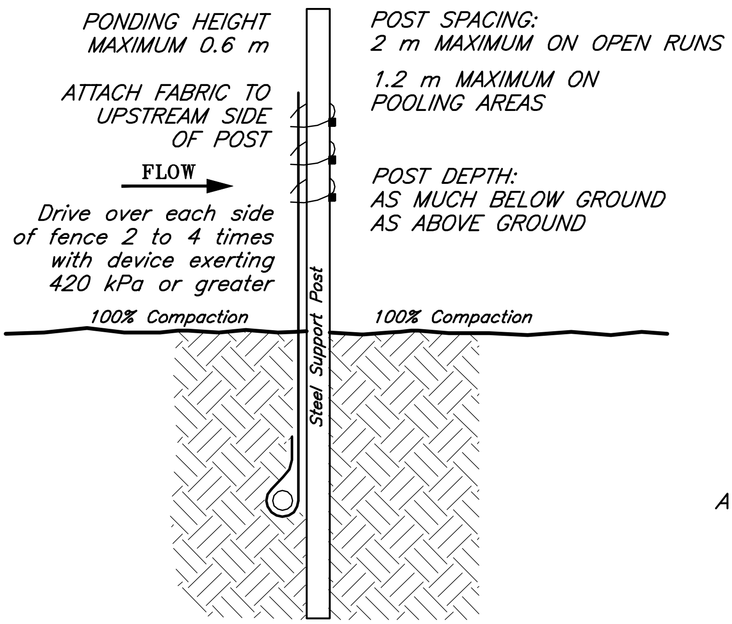
1. SILT FENCE SHALL BE PLACED ON SLOPE CONTOURS TO MAXIMIZE PONDING EFFICIENCY.
2. INSPECT AND REPAIR FENCE DAILY AND AFTER EACH STORM EVENT AND REMOVE SEDIMENT WHEN ACCUMULATED SILT REACHES 200 mm.
3. REMOVED SEDIMENT SHALL BE DEPOSITED TO AN AREA WILL NOT CONTRIBUTE SEDIMENT OFF-SITE.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

SILT FENCE

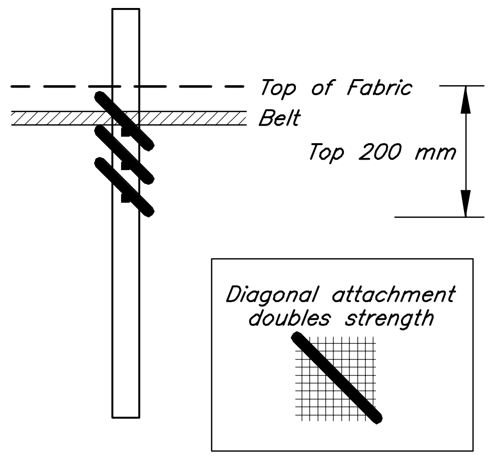
(TRENCH METHOD)

FILE: SILTFENC



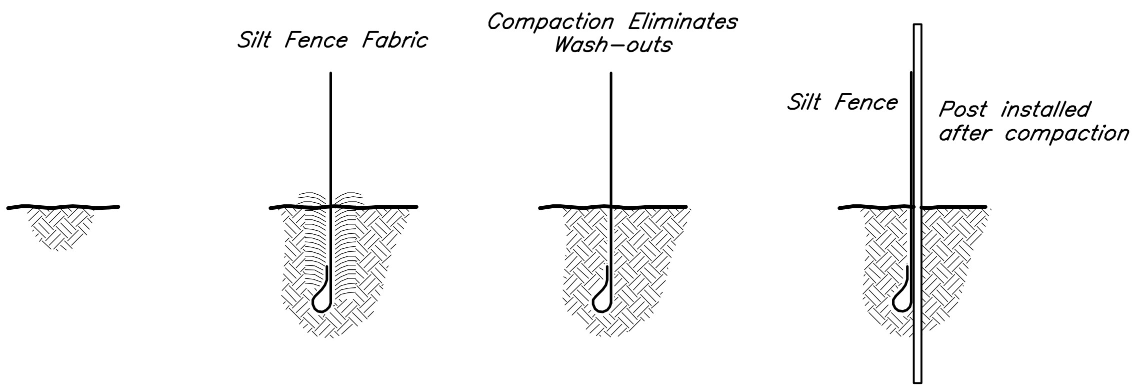
NO MORE THAN 0.6 m OF A 0.9 m FABRIC
IS ALLOWED ABOVE GROUND

MECHANICAL (SLICING) METHOD



ATTACHMENT DETAILS:

- Gather fabric at posts, if needed.
- Utilize three ties per post, all within top 200 mm of fabric.
- Position each tie diagonally, puncturing holes vertically a minimum of 25 mm apart.
- Hang each tie on a post nipple and tighten securely.
- Use cable ties (50 lbs) or soft wire.



a) Before Installation

b) During fabric insertion. Disrupted soil.

c) After Compaction. Greater stability.

d) Completed Installation

MECHANICAL (SLICING) METHOD INSTALLATION SEQUENCE

NOTES:

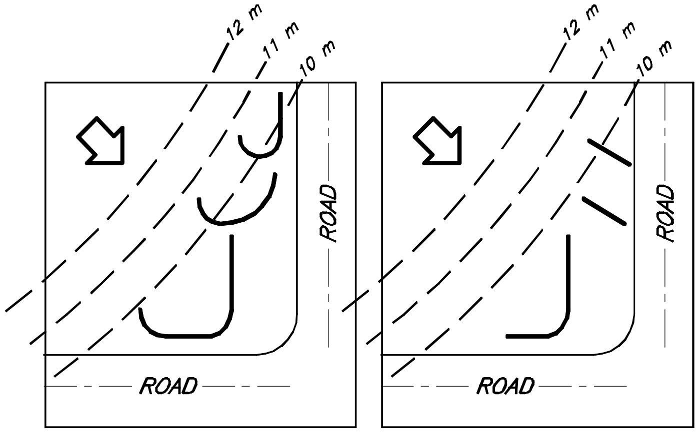
1. INSTALLATION MACHINE MUST ALLOW CONTINUOUS SLICING AND EMBEDMENT OF GEOTEXTILE INTO GROUND WITH MINOR GROUND DISTURBANCE.
2. INSTALLATION MACHINE TYPES WILL VARY WITH MANUFACTURER.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

SILT FENCE

(MECHANICAL METHOD)

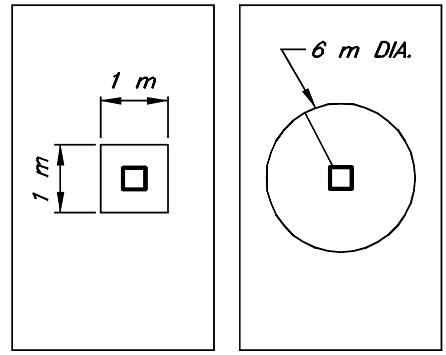
SOURCE: CARPENTER T. 2000



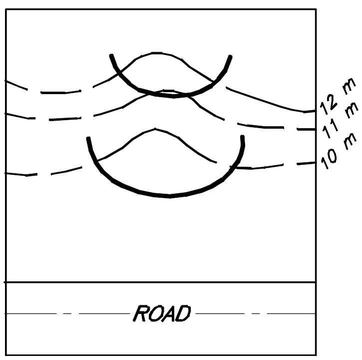
CORRECT

INCORRECT

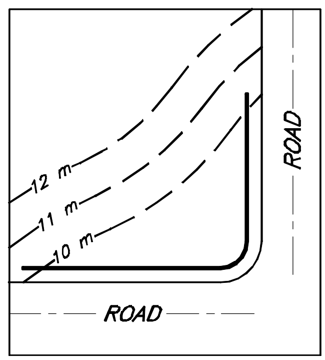
"J" CONFIGURATION



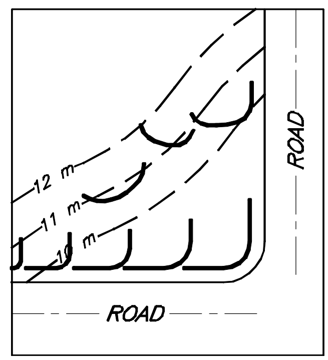
SILT FENCE BARRIER AT STORM INLET



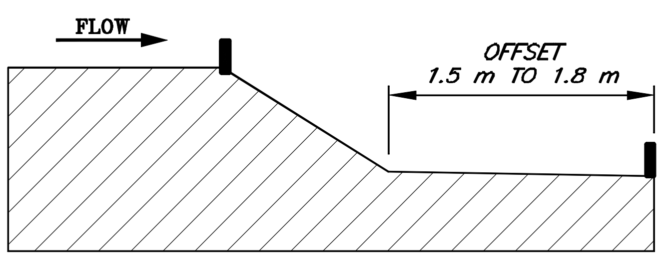
"SMILE" CONFIGURATION



AVOID LONG INSTALLATION



COMBINATION OF "SMILE" AND "J" CONFIGURATIONS



LOCATION AT TOP AND BOTTOM OF SLOPE

NOT TO SCALE

NOTE:

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

SOURCE: CARPENTER T. 2000

SILT FENCE (CONFIGURATION PLAN)

Gabions (a - c) Erosion Control and Sediment Control	B.M.P. #2 (a-c)

Description and Purpose

- Consist of rock placed inside wire baskets to protect steep or erodible slopes from sheet flow erosion
- Protects erodible stream channel banks from potentially high erosive concentrated flow velocities or high tractive forces

a) Slope and Banks

b) Single Gabion Drop Structure for Ditch Channel

c) Double Gabion "Energy Dissipator" Drop Structure for Ditch Channel

Applications

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

Advantages

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

- Trap sediment and support plant growth to effect higher channel resistance to flow; however, cumulative build-up of silt may render gabions less effective with diminished height

Limitations

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

Construction

- Prepare subgrade at designated gabion location on mineral soil
- Excavate trench a minimum of 0.15 m deep to 'key-in' gabion structure
- Construct gabion basket as per manufacturer's recommendations
- Line interior of basket with non-woven geotextile OR a gravely sand filter layer (if required by design) along areas where the basket is in contact with soil
  - Geotextile must be non-woven fabric to act as a separator (filter) between rock-infill and subgrade soils to minimize infiltration of fine grained particles into the gabion structure
- Backfill basket with rock with wire bracing at 1/3 points (or 0.3 m spacings)
- Install gabion basket top
- Backfill trench and compact soil around edges of completed basket

Construction Considerations

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

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans and should be inspected after major storm events, especially where undermining at the toe of the gabion is a concern

- – Repair as necessary; repair may include hand grading and/or infilling undermined area with rocky material

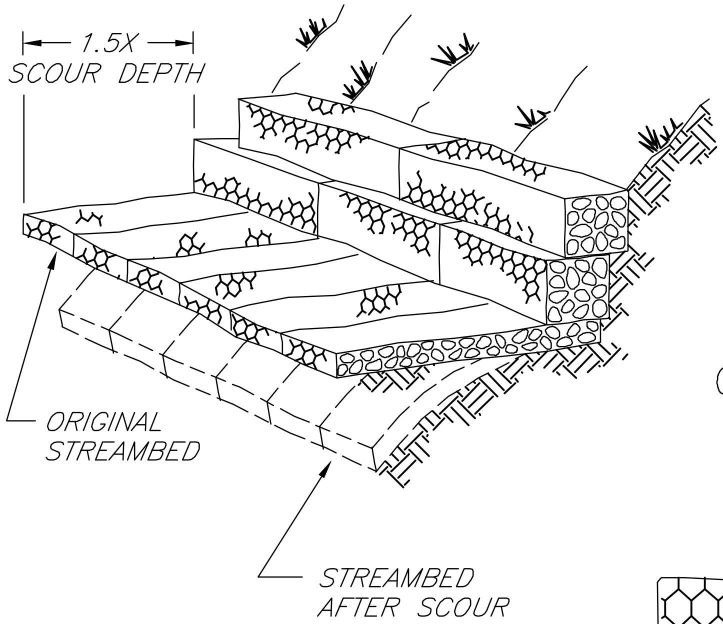
- Removal of silt should be determined based on depth of siltation, channel erosion and establishment of vegetation

Similar Measures

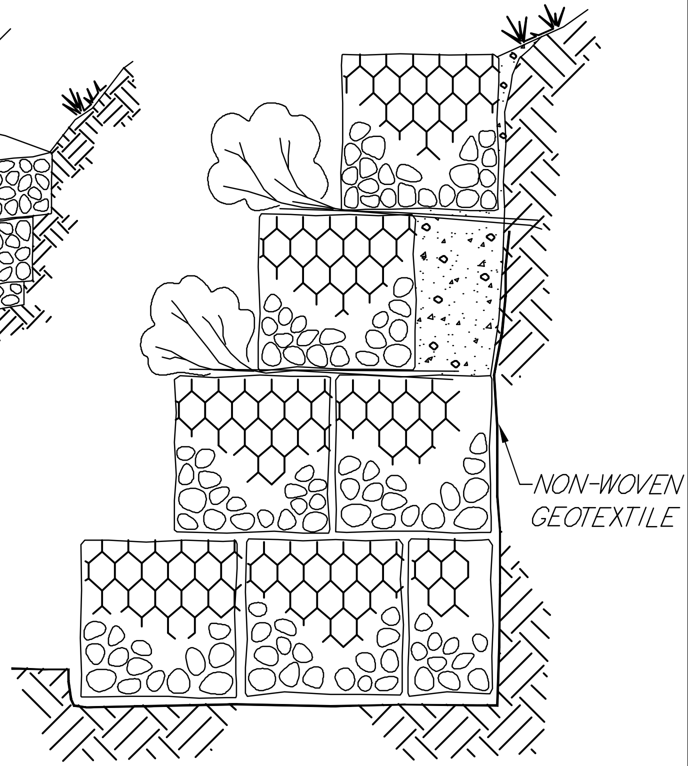
- Berms/Barriers
- Check Dams
- Permeable/Synthetic Barriers
- Rock/Brush barriers
- Sand/Gravel Bag Barriers

Design Considerations

- The design should include an energy dissipator (i.e., a gabion mat as a splash pad) at toe of downstream side of gabion drop structure if overtopping of the gabion is anticipated

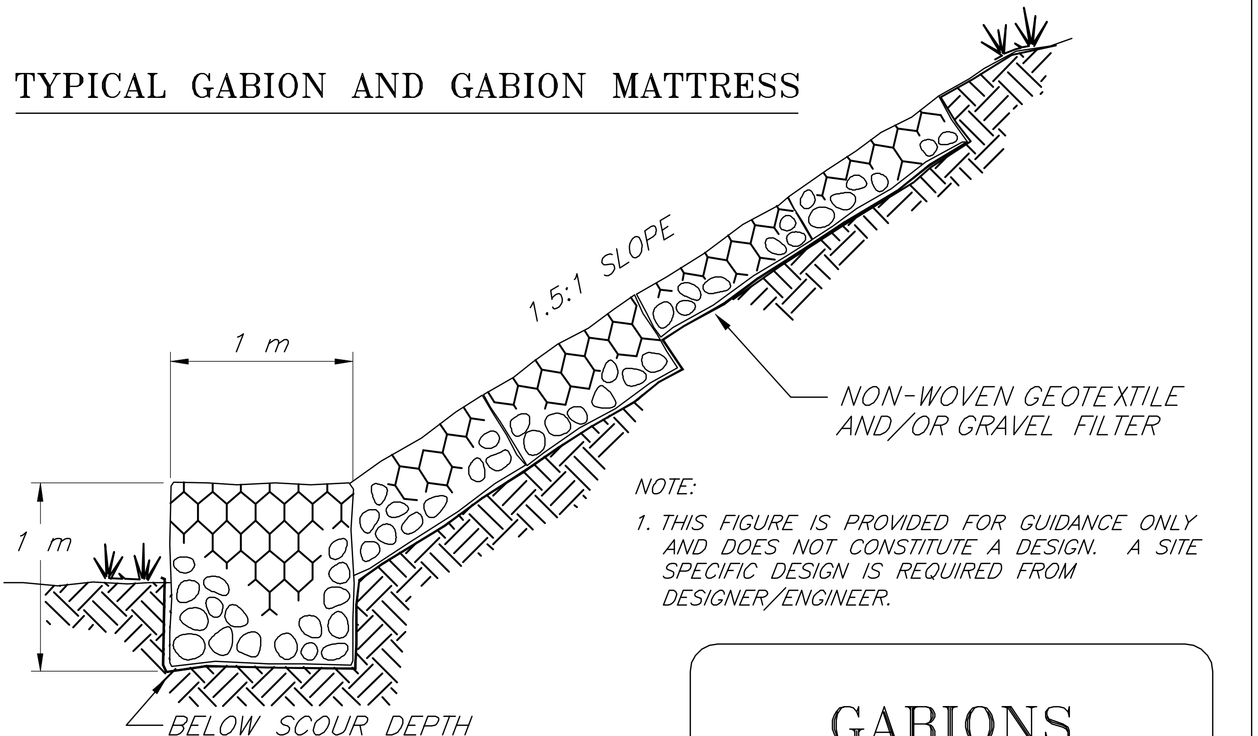


TYPICAL GABION APRON



TYPICAL VEGETATED ROCK GABION

TYPICAL GABION AND GABION MATTRESS

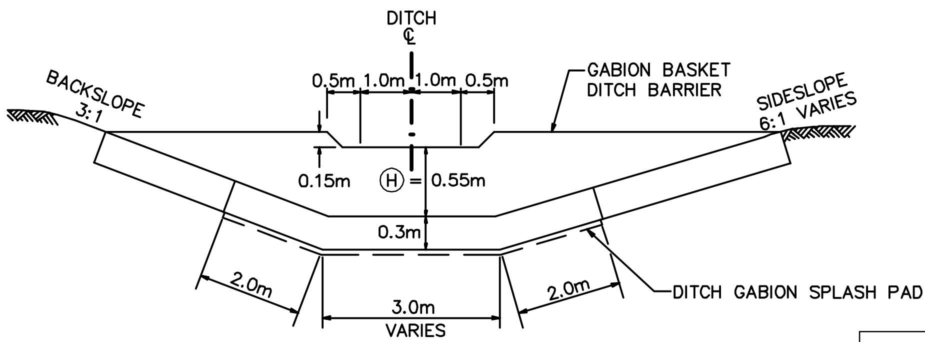


NOTE:

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

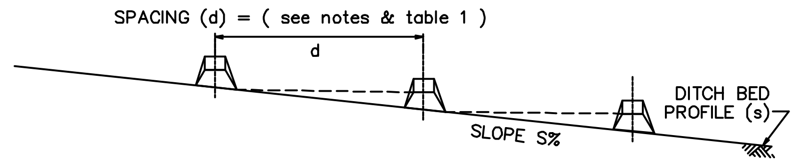
GABIONS
(SLOPE AND BANK)

FILE: GABIONS



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

N.T.S.

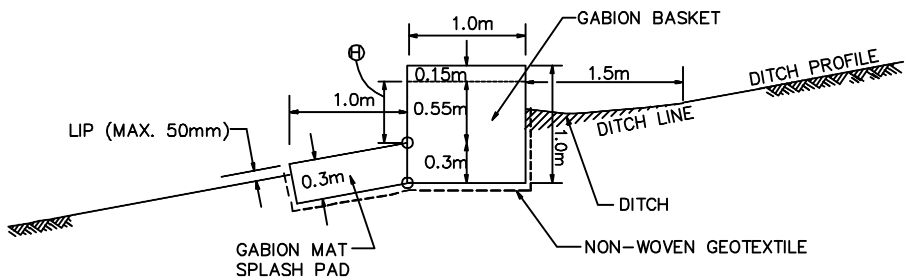


TYPICAL BARRIER SPACING

N.T.S.

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

TABLE 1



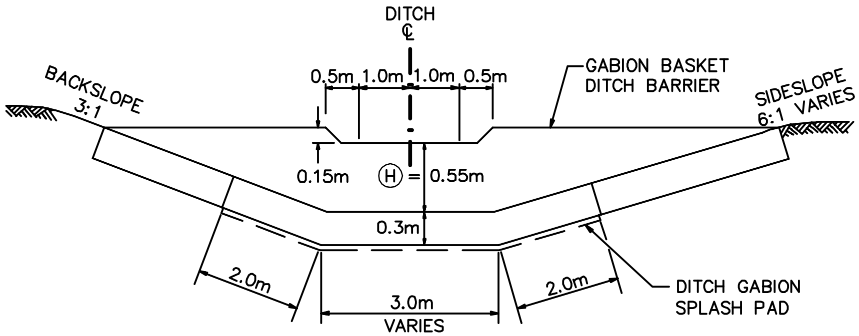
CROSS–SECTION VIEW
"SINGLE GABION" BASKET DITCH BARRIER
& GABION MAT SPLASH PAD

N.T.S.

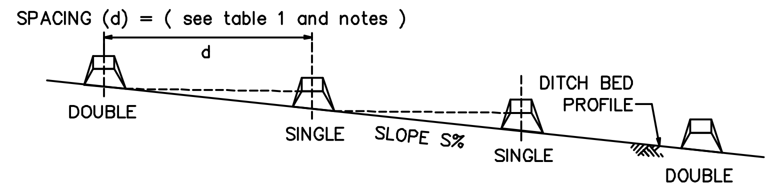
NOTES:

1. SUITABLE FOR MEDIUM TO STEEP GRADES AND CHANNELS LEADING TO WATER COURSE 4% < S < 10%.
2. i) SPACING TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
   ii) USE IN CONJUNCTION WITH DOUBLE GABIONS OR OTHER BARRIER STRUCTURES.
3. SOIL COVERING BETWEEN STRUCTURES SUGGESTED FOR STEEP GRADE SOIL DITCH.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

GABIONS
SINGLE GABION DROP STRUCTURE FOR DITCH CHANNEL



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



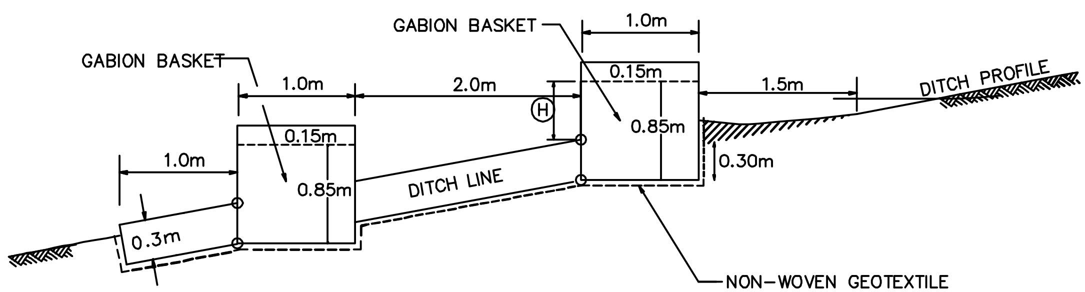
TYPICAL BARRIER SPACING
N.T.S.

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

TABLE 1

NOTES:

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



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

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

Brush or Rock Filter Berm Removed	B.M.P. #3

Continuous Perimeter Control Structures Sediment Control	B.M.P. #4

Description and Purpose

- Constructed of sand or gravel-filled geotextile, or formed structures comprised of compost, shredded wood mulch, and natural fibres
- Used to divert and intercept sheet or overland flow
- May be used to form ponds and allow sediment to settle out
- Compost should possess no objectionable odours or substances toxic to plants
- Compost contains plant nutrients but is typically not characterized as a fertilizer

Applications

- Temporary measure
- May be used in place of silt fences or straw bale barriers to retain sediment on construction sites
- Compost used on AT projects must meet Canadian Council of Ministers of the Environment (CCME) Guidelines for Compost Quality (trace elements, maturity/stability, pathogens), which are adopted by Alberta Transportation and found on AT Products List (www.transportation.alberta.ca).
- May be used in place of silt fences or straw bale barriers to retain sediment on construction sites

Advantages

- Trenching may not be required as weight and flexibility of structure typically allows continuous contact with ground surface

Limitations

- Sand or gravel filled geotextile requires Continuous Structure Machine (CBM) for construction
- Requires specialized blower truck, hose and attachments for berm installation

Construction

- Install structure a minimum of 2 m away from toe of slope to provide adequate ponding area on upstream side of structure
- Follow operating procedures for CBM
- Use of woven geotextile is preferred due to higher tensile strength and small deformation

- If required, PVC drainage pipes (e.g., 50 mm) may be inserted in downstream side of structure, spaced 100 to 150 mm apart, to facilitate drainage
- If required and appropriate, slits may be cut in upstream side of structure to facilitate filtering and drainage

Compost filter berm installation:

- Parallel to the base of the slope, or around the perimeter of affected areas, construct a trapezoidal berm at the following dimensions:

Annual Rainfall/Flow Rate	Total Precipitation	Berm Dimensions (height x width)
Low	25 mm – 635 mm	30 cm x 60 cm – 45 cm x 90 cm
Average	635 mm – 1270 mm	30 cm x 60 cm – 45 cm x 90 cm
High	>1270 mm	45 cm x 90 cm – 60 cm x 120 cm

- Base of berm is twice the height
- Compost shall be uniformly applied using an approved spreader unit - including pneumatic blowers, specialized berm machines, etc
- Seeding the berm may be done in conjunction with pneumatic blowing
- Compost can be blown into a netted sock to be used as a berm

Construction Considerations

- Structure constructed of sand, aggregate, or other pervious soil encased in geotextile fabric
- Maximum structure height is approximately 0.4 m
- Higher permeability fill materials should be used in ‘drainage chambers’ in low areas
- Compost filter berm dimensions and blanket application rates vary with soil characteristics, existing vegetation and climatic conditions
- Use larger berm application rate in high rates of precipitation and rainfall intensity, and snow melt
- Use larger berms in severe grade and long slope lengths
- Berms may be placed at the top and the base of a slope
- A series of berms may be used down a slope (5 to 8 m apart)
- Berms may be used in conjunction with a compost blanket, especially in regions with spring melt, and sites with severe grades and long slopes

- Use smaller berm application rate in lower precipitation rates and rainfall intensity regions
- Use larger berms where they are required to be in place or function for more than one year

Inspection and Maintenance

- Inspection frequency should be in accordance with PESC and TESC Plans.
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-third the structure height
- Inspect for toe undermining, weathered/deteriorated geotextile, and end runs and erosion of the filter and repair immediately
  - Damaged sections may be repaired by restapling or placing another section of continuous structure upstream of the damaged section to provide seal
- If the structure is encased in a geotextile fabric, removal of structure is accomplished by splitting the structure, spilling fill material and removing fabric
- Removal of berm is accomplished by splitting the berm and sock, spilling fill material and removing sock

Similar Measures

- Structures/Barriers
- Sand/Gravel Bag Barriers
- Silt Fence
- Compost Berm

Berm Interceptor Sediment Control	B.M.P. #5

Description and Purpose

- Earth dyke barrier constructed of compacted soil to intercept and divert flow of runoff water away from erodible slopes, sensitive areas or water bodies
- A spillway outlet of erosion-resistant granular material constructed to allow exit of diverted water to less sensitive areas

Applications

- Temporary or permanent measure
- Used instead of, or in conjunction with, diversion ditches
- Perimeter control
- Placed along contours and/or at toe of slope to divert run-off from sensitive areas
- Used to divert water to sediment control structures

Advantages

- Easy to construct
- Can be converted to sedimentation/impoundment pond with the design of a permeable filter berm at the exit spillway area (see BMP #13)

Limitations

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

Construction

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

Berm Interceptor Sediment Control	B.M.P. #5

Construction Considerations

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

Inspection and Maintenance

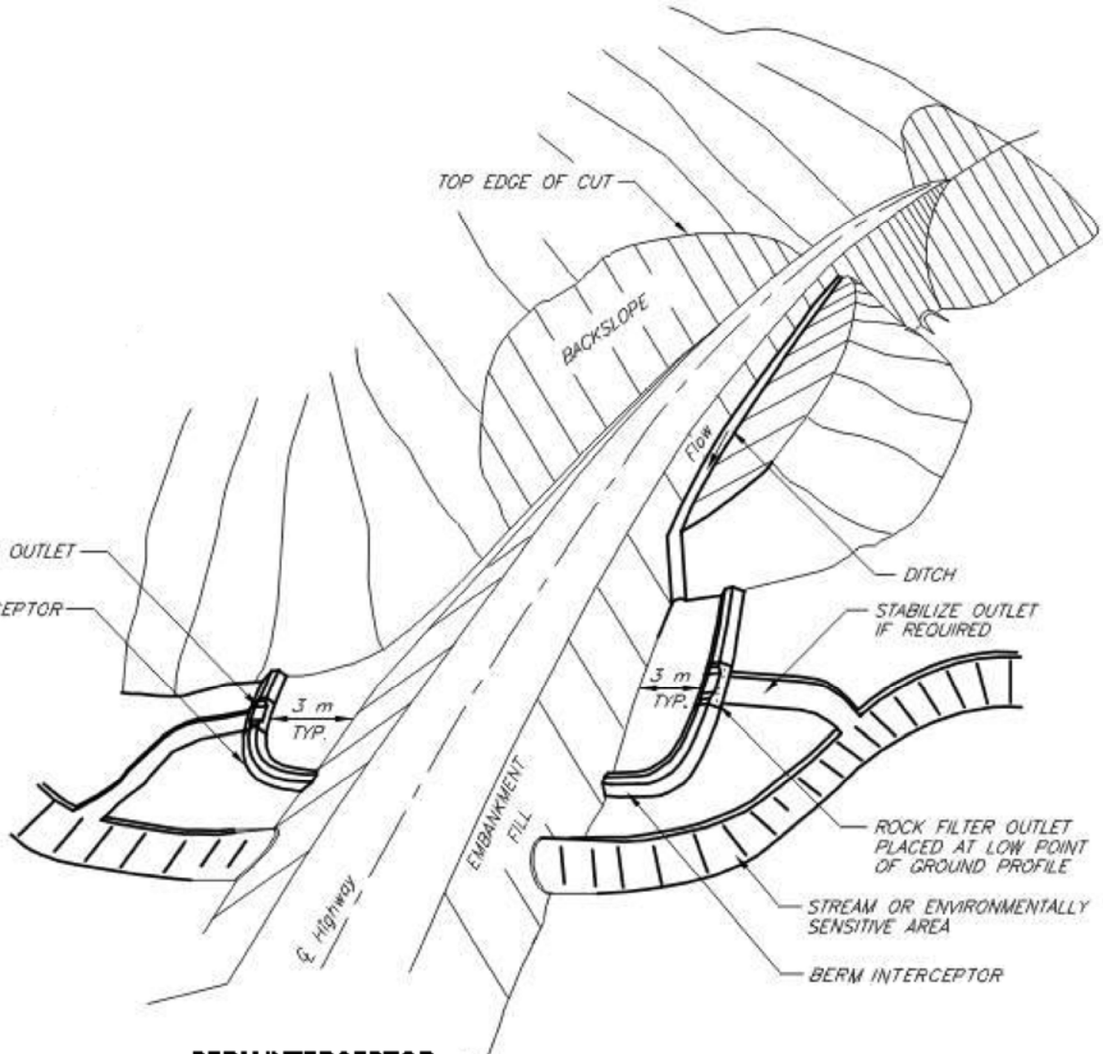
- The degree and extent of inspection and maintenance performed on a earth dyke barrier is directly related to the consequences of failure. An engineer experienced in embankment design and inspection may be required for design, inspection, design of remedial measures, and supervision of their implementation
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Piping failures may be remedied by replacing saturated soils with drier compacted soil and/or by placement of geotextile over the failed area and placing a stabilizing toe berm constructed of granular materials
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-half the barrier height
- Deactivate and remove barrier once slope soils have stabilized and return barrier location to an acceptable condition

Similar Measures

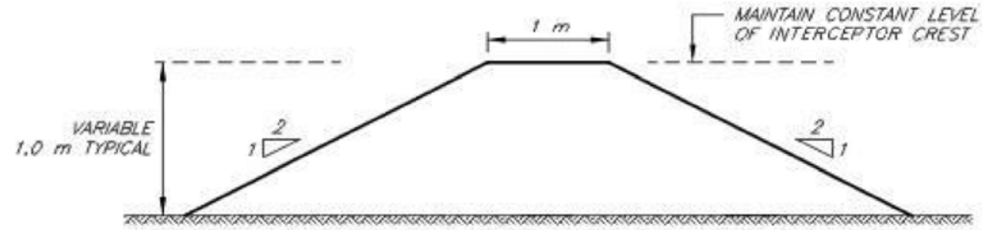
- Berms
- Sand/Gravel Bag Barriers

Design Considerations

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



BERM INTERCEPTOR
TYPICAL LOCATION



TYPICAL SECTION
BERM INTERCEPTOR

NOTES:
1. SILT ACCUMULATION TO BE REMOVED WHEN HALF BERM INTERCEPTOR HEIGHT COVERED.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

BERM
INTERCEPTOR

Storm Drain Inlet Sediment Barrier (a-f) Sediment Control	B.M.P. #6 (a-f)

Description and Purpose

- Temporary devices constructed to minimize the amount of sediment entering a storm drain by ponding sediment laden runoff at the inlet
- Storm Drain Inlet protection can consist of the following measures:

a) Block and Gravel Sediment Barrier – Option 1

b) Block and Gravel Curb Inlet Sediment Barrier – Option 2

c) Sand Bag Curb Inlet Sediment Barrier – Option 1

d) Sand Bag Curb and Gutter Sediment Barrier – Option 2

e) Straw Bale / Gravel Sediment Barrier - Option

f) Silt Fence Sediment Barrier - Option

Applications

- Temporary measure
- Used where storm drains are operational prior to establishing vegetation on disturbed drainage areas
- Can be effective where drainage enters municipal sewers or watercourses
- Used for small, nearly level (less than 5% grade) drainage areas
- Used as curb inlet barriers in gently sloping ditches and gutters
- Used where drainage area is 0.4 ha (1 ac) or less
- Used in open areas subjected to sheet flow and concentrated flows less than 0.014 m^3/s (0.5 cfs)
- Block and gravel bag barriers are applicable when sheet flows or concentrated flows exceed 0.014 m^3/s (0.5 cfs) and is necessary to allow for overtopping to prevent flooding
- Excavated drop inlet sediment traps are appropriate where relatively heavy flows are expected and overflow capacity is required

Advantages

- Easy to install and remove
- Sand bags may be reusable

Limitations

- Ponding around inlet may result in excessive local flooding
- Use only when ponding will not encroach into vehicular traffic, onto erodible surfaces and slopes or beyond the limits of the construction site
- Frequent removal of sediment required for high flow situations

Construction

- Place inlet sediment barrier around entrance to drain/pipe. The option appropriate for use is dependent on site conditions.
- Silt fence barrier can be used for soil surfaces
- Gravel or aggregate filled sand bags should be used for asphalt or concrete surfaces
- Aggregate filled sand bags
  - Place sand bags stacked one or two bags high around inlet
- Gravel barriers
  - Place concrete blocks stacked one or two blocks high, with cavities of blocks aligned with direction of flow, around inlet
  - Wrap 13 mm (1/2 inch) wire mesh around concrete blocks
  - Place 25 mm to 38 mm diameter rock around block and wire mesh assembly ensuring rock extends down from top of blocks to asphalt or concrete surfacing
- Gravel filter curb inlet
  - Place concrete blocks stacked one or two blocks high around inlet, with cavities of blocks aligned with direction of flow, forming a 'U' shape
  - Wrap 13 mm (1/2 inch) diameter wire mesh around concrete blocks
  - Place 25 mm to 38 mm diameter rock around block and wire mesh assembly ensuring rock extends down from top of blocks to asphalt or concrete surfacing

Construction Considerations

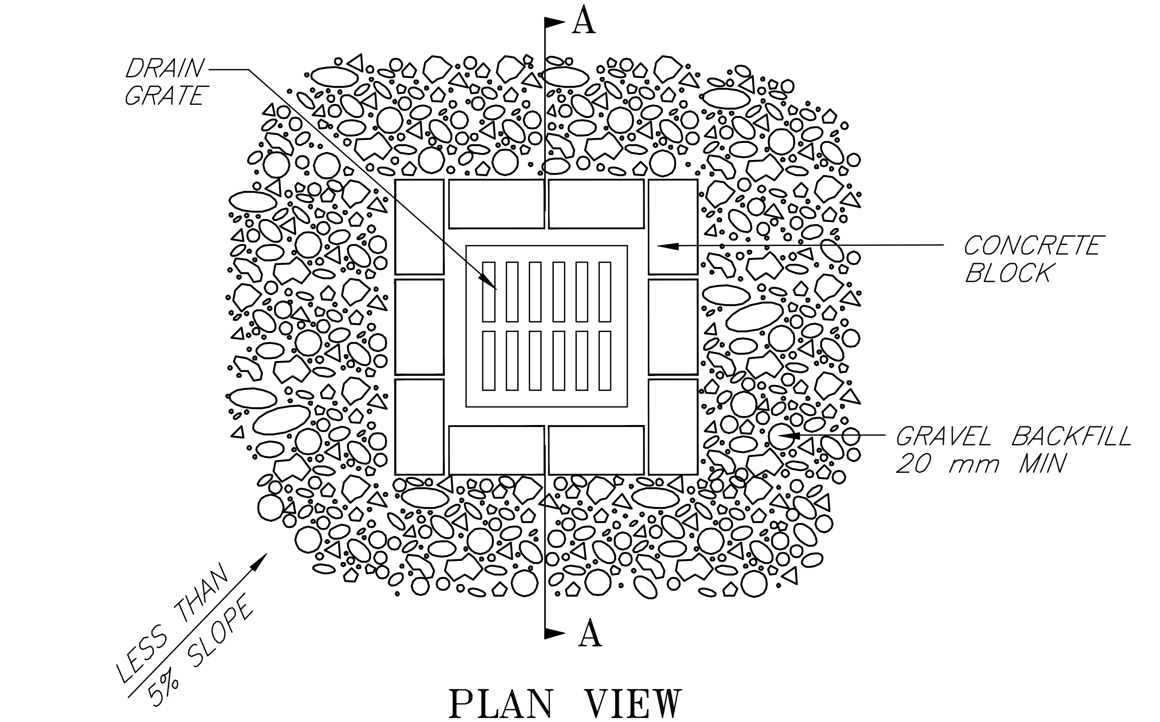
- Gravel or aggregate filled sand bags should be used for asphalt or concrete surfaces
- Aggregate filled sand bags
  - Sand bags should be filled with pea gravel, drain rock, or other free draining material

- – Gravel or aggregate filled sand bags should be filled only ¾ full to allow sand bag to be flexible to mould to contours, maintaining continuous contact with surface
- – Barrier should be placed at least 0.1 m from inlet to be protected
- – Several layers of sand bags should be overlapped and tightly packed against one another
- – A one sand bag wide gap should be left in the lowest point of the upper layer to act as an emergency spillway

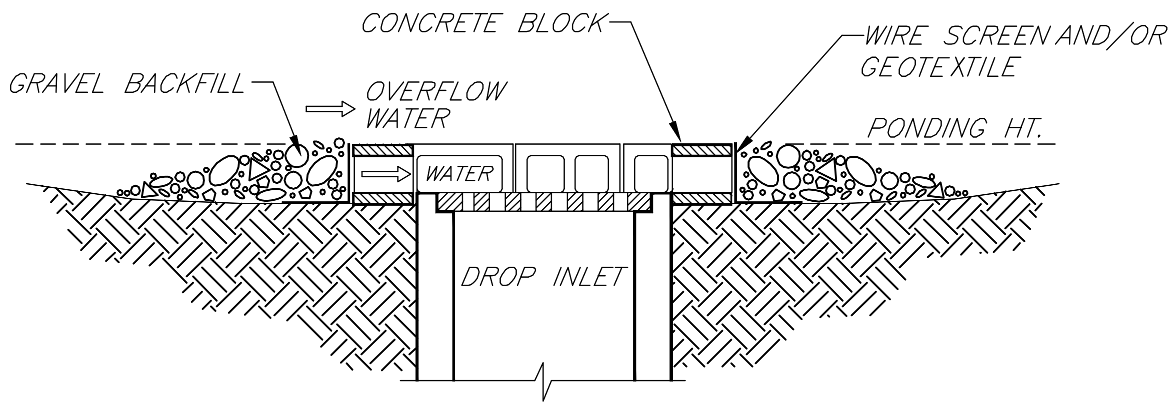
- Gravel filter inlet berm and gravel filter curb inlet
  - – Slope gravel towards inlet at a maximum slope of 2H:1V
  - – Maintain at least 0.3 m spacing between toe of gravel and inlet to minimize gravel entering inlet
  - – 25 mm wire mesh may be placed over inlet to prevent gravel from entering inlet
- For drainage areas larger than 0.4 ha (1 ac) runoff should be directed towards a sediment retention device designed for larger flows before allowing water to reach inlet protection structure
- Use aggregate sand bags filled with 25 mm diameter rock in place of concrete blocks for gravel filter inlet berm or gravel filter curb inlet

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build up after each storm event
  - – Sediment and gravel should not be allowed to accumulate on roads
- Replace gravel if it becomes clogged with sediment
- Remove all inlet protection devices when inlet protection is no longer required



PLAN VIEW



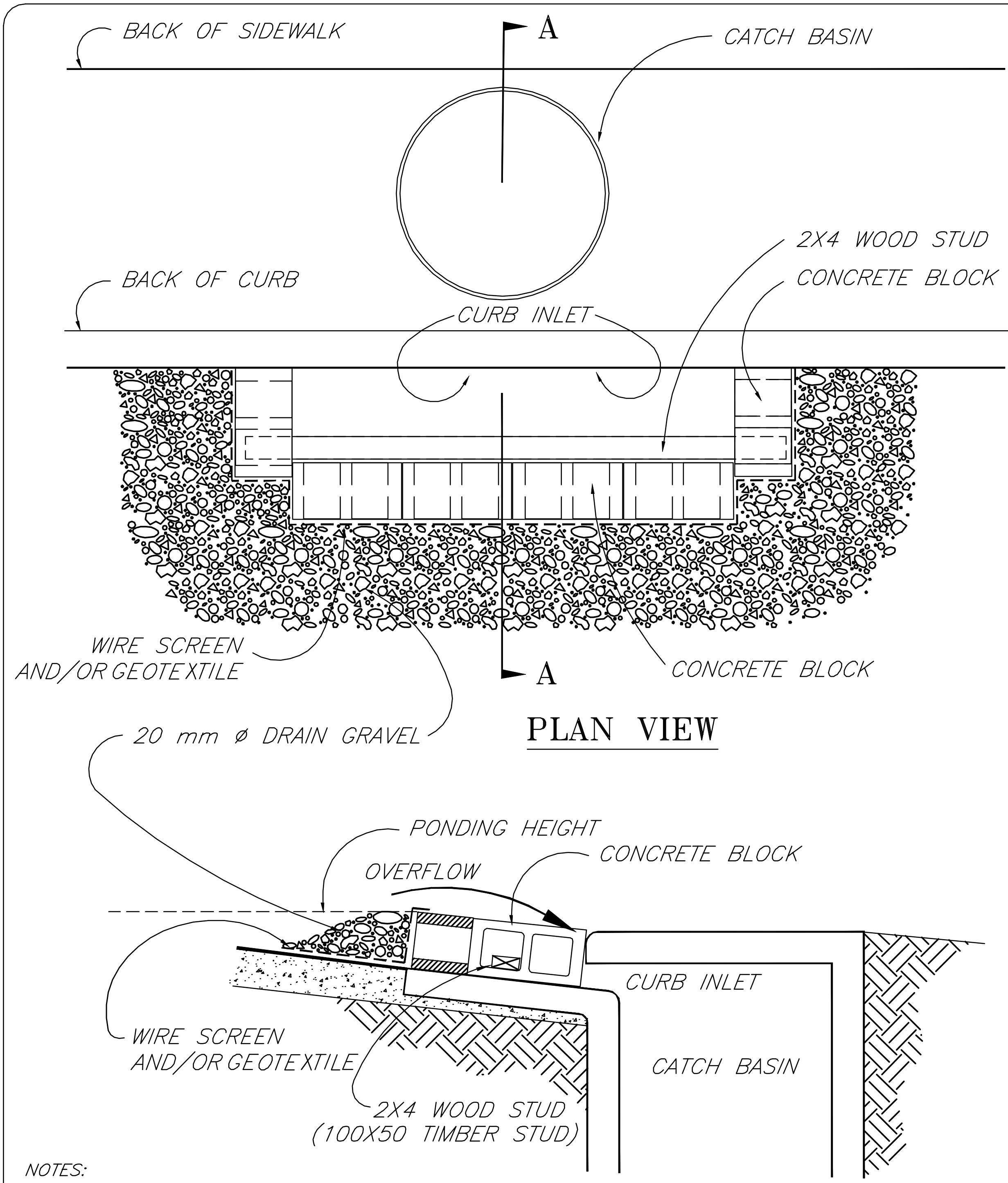
SECTION A – A

NOTES:

1. STORM DRAIN DROP INLET SEDIMENT BARRIERS ARE TO BE USED FOR SMALL, NEARLY LEVEL DRAINAGE AREAS. (LESS THAN 5%).
2. EXCAVATE A BASIN OF SUFFICIENT SIZE ADJACENT TO THE STORM DRAIN DROP INLET.
3. THE TOP OF THE STRUCTURE (PONDING HEIGHT) MUST BE WELL BELOW THE GROUND ELEVATION DOWNSLOPE TO PREVENT RUNOFF FROM BYPASSING THE INLET. A TEMPORARY DYKE MAY BE NECESSARY ON THE DOWNSLOPE SIDE OF THE STRUCTURE.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STORM DRAIN DROP INLET SEDIMENT BARRIER
(BLOCK AND GRAVEL – OPTION 1)

FILE: BGSEDBAR



PLAN VIEW

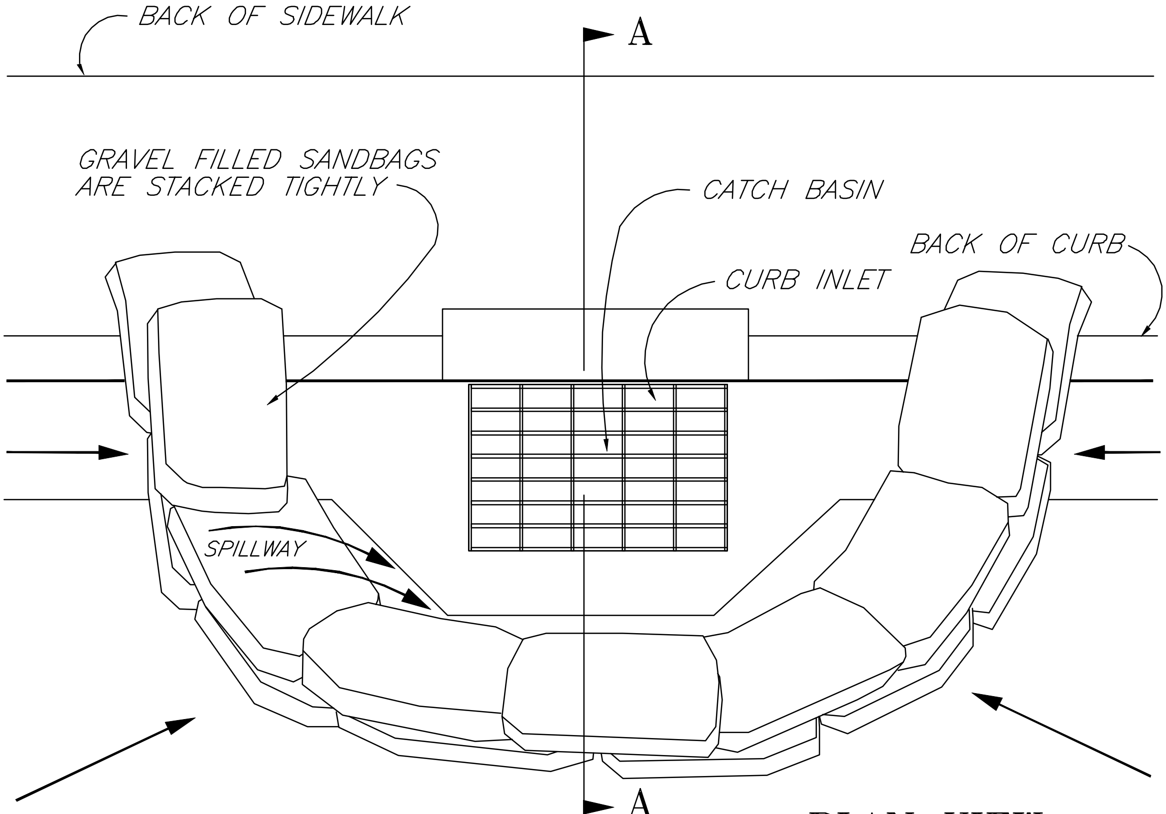
SECTION A – A

NOTES:

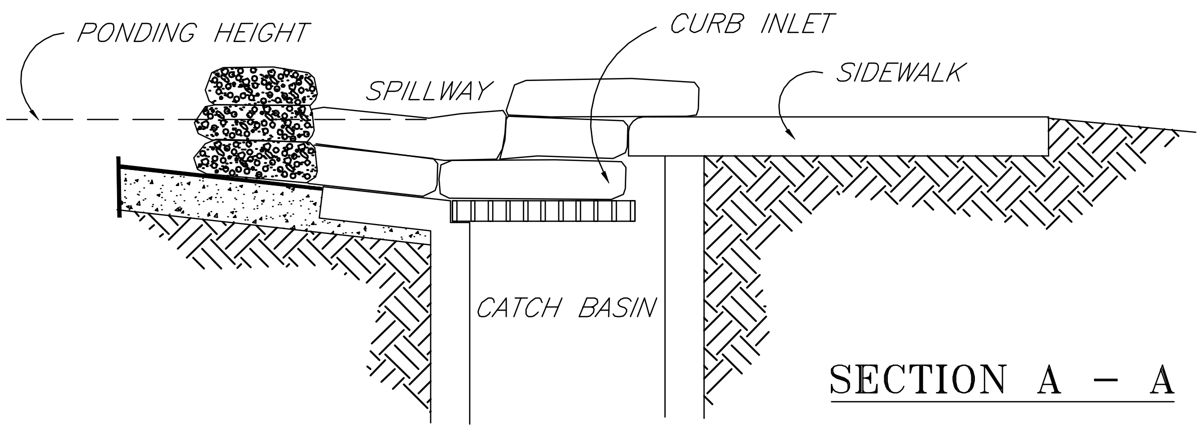
1. USE BLOCK AND GRAVEL TYPE SEDIMENT BARRIER WHEN CURB INLET IS LOCATED IN GENTLY SLOPING STREET SEGMENT, WHERE WATER CAN POND AND ALLOW SEDIMENT TO SEPARATE FROM RUNOFF.
2. BARRIER SHALL ALLOW FOR OVERFLOW FROM SEVERE STORM EVENT.
3. INSPECT BARRIERS AND REMOVE SEDIMENT AFTER EACH STORM EVENT. SEDIMENT AND GRAVEL MUST BE REMOVED FROM THE TRAVELED WAY IMMEDIATELY.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STORM DRAIN CURB INLET SEDIMENT BARRIER
(BLOCK AND GRAVEL – OPTION 2)

FILE: BLCKCURB



PLAN VIEW



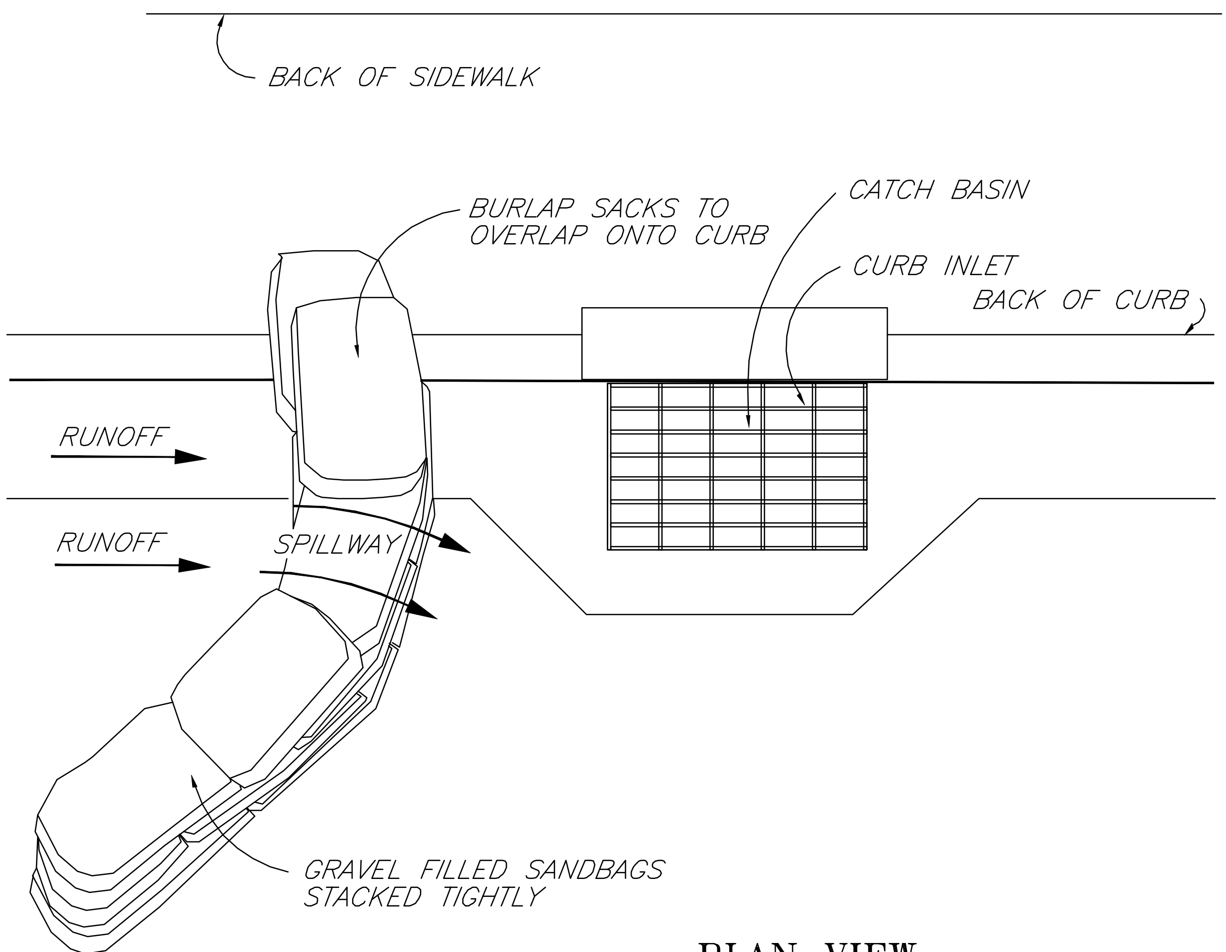
SECTION A – A

NOTES:

1. PLACE CURB TYPE SEDIMENT BARRIERS ON GENTLY SLOPING STREET SEGMENTS WHERE WATER CAN POND AND ALLOW SEDIMENT TO SETTLE OUT.
2. SANDBAGS, OF EITHER BURLAP OR WOVEN GEOTEXTILE FABRIC, ARE FILLED WITH GRAVEL, LAYERED AND PACKED TIGHTLY.
3. LEAVE ONE SANDBAG GAP IN THE TOP ROW TO PROVIDE A SPILLWAY FOR OVERFLOW.
4. INSPECT BARRIERS AND REMOVE SEDIMENT AFTER EACH STORM EVENT. SEDIMENT AND GRAVEL MUST BE REMOVED FROM THE TRAVELED WAY IMMEDIATELY.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STORM DRAIN CURB INLET SEDIMENT BARRIER
(SANDBAGS – OPTION 1)

FILE: SANDCURB



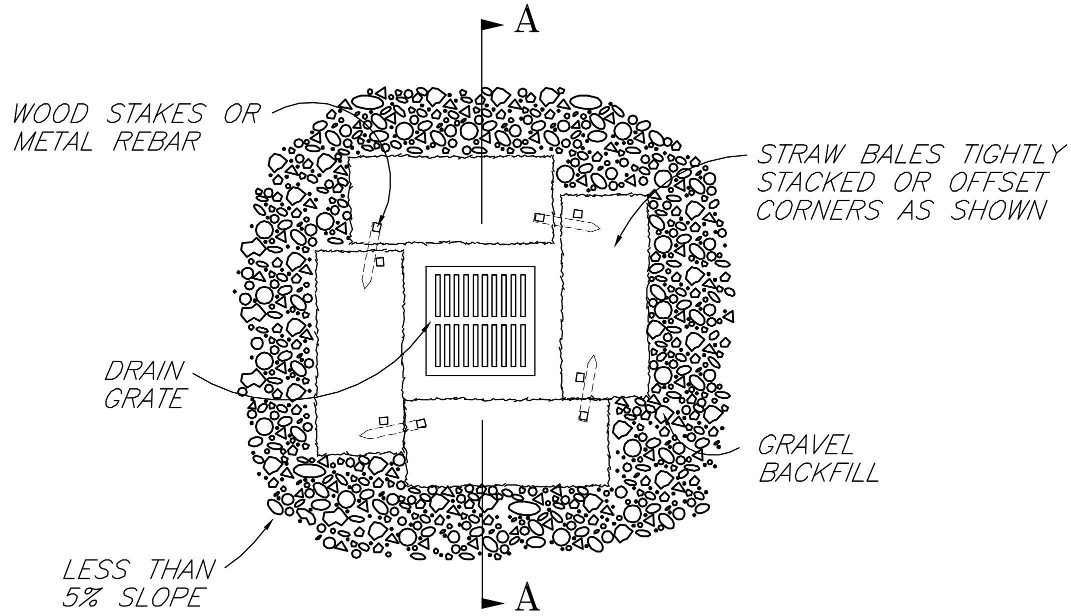
PLAN VIEW

NOTES:

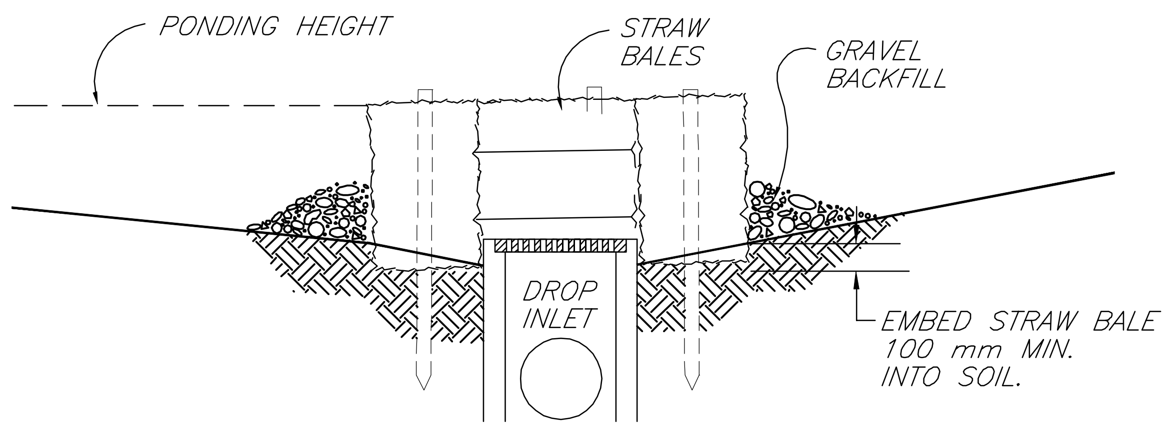
1. PLACE CURB TYPE SEDIMENT BARRIERS ON GENTLY SLOPING STREET SEGMENTS, WHERE WATER CAN POND AND ALLOW SEDIMENT TO SETTLE OUT.
2. SANDBAGS OF EITHER BURLAP OR WOVEN 'GEOTEXTILE' FABRIC, ARE FILLED WITH GRAVEL, LAYERED AND PACKED TIGHTLY.
3. LEAVE A ONE SANDBAG GAP IN THE TOP ROW TO PROVIDE A SPILLWAY FOR OVERFLOW.
4. INSPECT BARRIERS AND REMOVE SEDIMENT AFTER EACH STORM EVENT. SEDIMENT AND GRAVEL MUST BE REMOVED FROM THE TRAVELED WAY IMMEDIATELY.
5. DESIGN CENTRE SPILLWAY LOWER THAN OUTSIDE EDGE TO MINIMIZE FLOW OUTFLANGING.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STORM DRAIN INLET CURB AND GUTTER SEDIMENT BARRIER
(SANDBAGS – OPTION 2)

FILE: CURBGTTR



PLAN VIEW



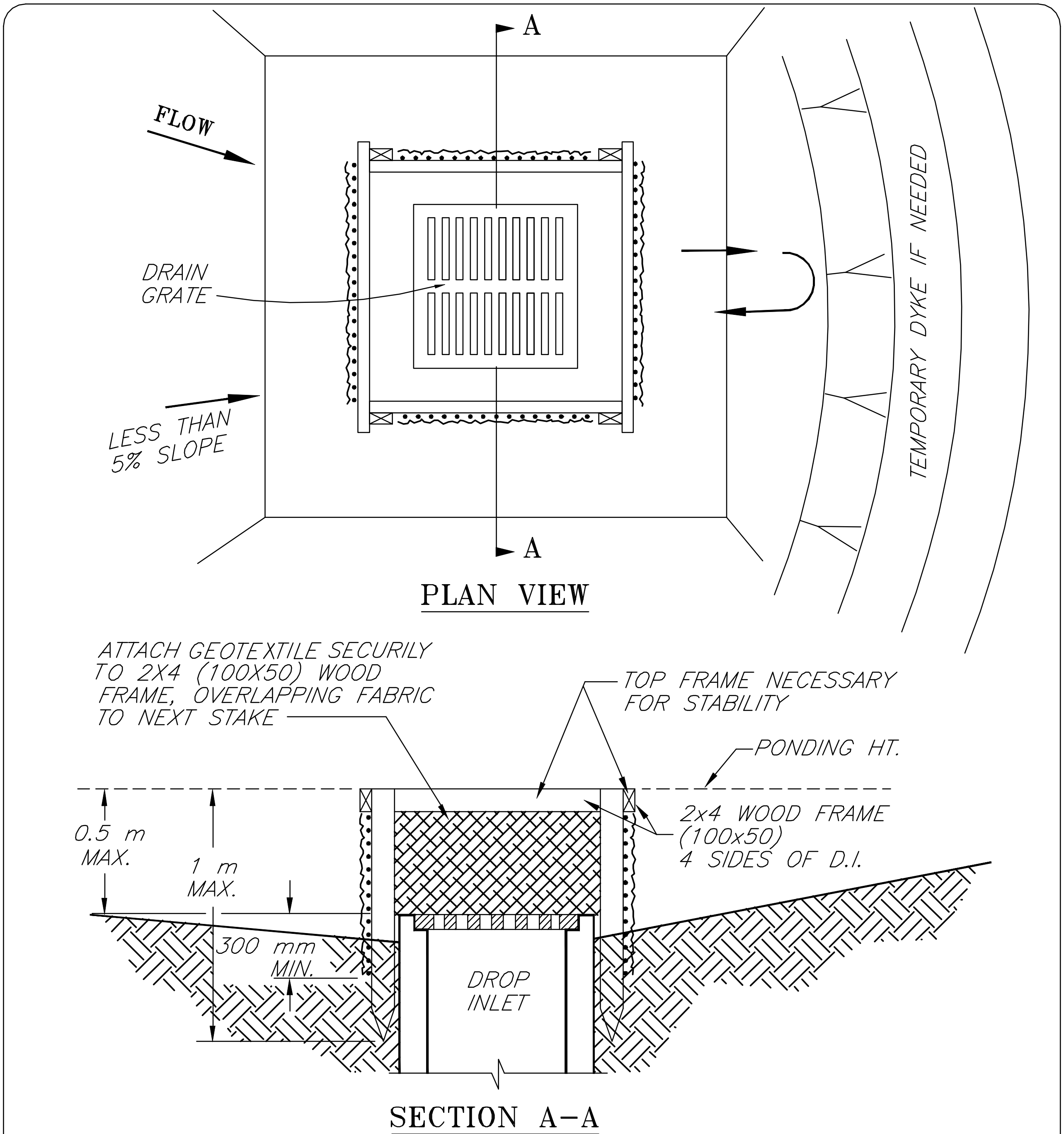
SECTION A–A

NOTES:

1. DROP INLET SEDIMENT BARRIERS ARE TO BE USED FOR SMALL, NEARLY LEVEL DRAINAGE AREAS. (LESS THAN 5%)
2. EMBED THE BALES 100 mm INTO THE SOIL AND OFFSET CORNERS OR PLACE BALES WITH ENDS TIGHTLY ABUTING. GRAVEL BACKFILL WILL PREVENT EROSION OR FLOW AROUND THE BALES.
3. THE TOP OF THE STRUCTURE (PONDING HEIGHT) MUST BE WELL BELOW THE GROUND ELEVATION DOWNSLOPE TO PREVENT RUNOFF FROM BYPASSING THE INLET. EXCAVATION OF A BASIN ADJACENT TO THE DROP INLET OR A TEMPORARY DIKE ON THE DOWNSLOPE OF THE STRUCTURE MAY BE NECESSARY.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STORM DRAIN DROP INLET SEDIMENT BARRIER
(STRAW BALE / GRAVEL – OPTION)

FILE: STRWGRVB



NOTES:

1. DROP INLET SEDIMENT BARRIERS ARE TO BE USED FOR SMALL, NEARLY LEVEL DRAINAGE AREAS. (LESS THAN 5%)
2. USE 2"X4" (100X50mm) WOOD OR EQUIVALENT METAL STAKES, 1 m MINIMUM LENGTH.
3. INSTALL 2"X4" (100X50mm) WOOD TOP FRAME TO INSURE STABILITY.
4. THE TOP OF THE FRAME (PONDING HEIGHT) MUST BE WELL BELOW THE GROUND ELEVATION DOWNSLOPE TO PREVENT RUNOFF FROM BY-PASSING THE INLET. A TEMPORARY DYKE MAY BE NECESSARY ON THE DOWNSLOPE SIDE OF THE STRUCTURE.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

STORM DRAIN DROP INLET SEDIMENT BARRIER
(SILT FENCE – OPTION)

FILE: SILTFDIB

Rock Check Dam Erosion Control and Sediment Control	B.M.P. #7

Description and Purpose

- Small dam constructed of rock placed across steep channel
- Decrease flow velocities to reduce erosion caused by storm runoff
- Sediment laden runoff is detained allowing sediment to settle out

Applications

- Temporary or permanent measure
- Reduces long steep grade to intervals of gentle grades between successive structures
- Reduces flow velocities and kinetic energy to decrease erosion potential caused by runoff
- Sediment laden runoff is retained behind structure allowing sediment to settle out
- May be used in channels that drain 4 ha (10 ac) or less
- May be used in steep channels where storm water runoff velocity is less than 1.5 m/s (5 fps)

Advantages

- Cheaper than using riprap armouring or gabion structures in a ditch
- Easy to construct

Limitations

- Not appropriate for high flow velocity >1.5 m/sec; (use gabion structures for flow velocity >1.5 m/sec)
- Not appropriate for channels draining areas larger than 4 ha (10 ac)
- Not to be placed in grass lined channels unless erosion is anticipated
- Susceptible to failure if water undermines or outflanks structure

Construction

- Excavate a trench key a minimum of 0.15 m in depth at the rock check structure location
- Place non-woven geotextile fabric over footprint area of rock check
- Construct structure by machine or hand
- Structure should extend from one side of the ditch or channel to the other

- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of structures should be less than 0.8 m in height to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 5H:1V (minimum)
- Upstream slope of the check dam should be 4H:1V (minimum)

Construction Considerations

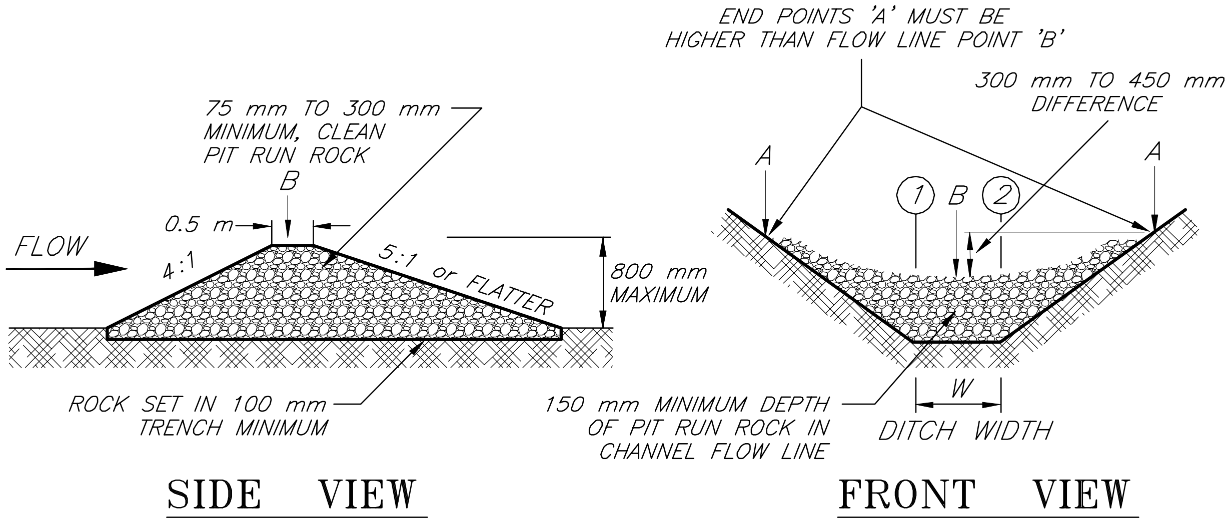
- Should be designed with roadside design clear zone requirements in mind.
- Height and spacing between structures should be designed to reduce steep channel slope to intervals of flatter gradient
- Rock check structures should be constructed of free draining aggregate
- Aggregate used should have a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

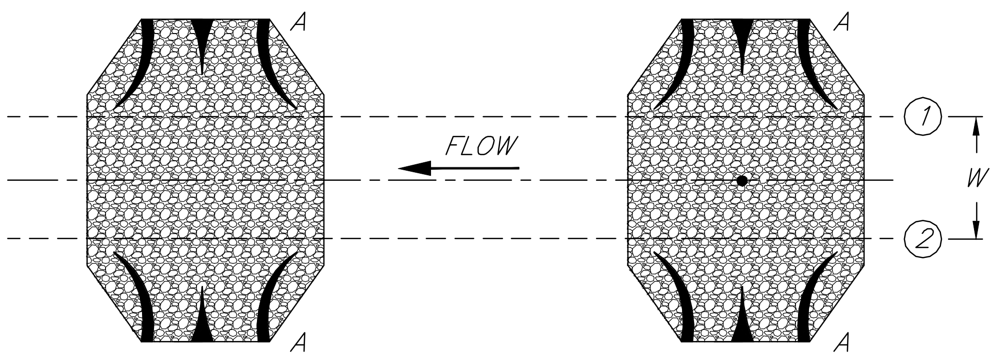
Inspection and Maintenance

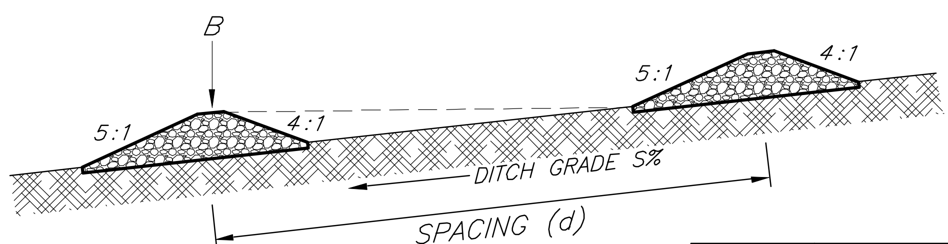
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build up before it reaches one half the check structure height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace dislodged aggregate immediately with heavier aggregate or gabion structures

Similar Measures

- Synthetic Permeable (Ditch) Barriers







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

SUGGESTED ROCK DIAMETER AND OVERFLOW DEPTHS

NOTES:

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

NOT TO SCALE

ROCK CHECK DAM

Aggregate Filled Sand Bag Check Dam Removed	B.M.P. #8

Log Check Dam Removed	B.M.P. #9

Synthetic Permeable Barrier Erosion Control and Sediment Control	B.M.P. #10

Description and Purpose

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

Applications

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

Advantages

- Prefabricated
- Reusable/moveable
- More appropriate for installing at transition areas of changing grades of channels so that hydraulic jumps (or change of flow regime from supercritical to subcritical) may be simulated to dissipate flow energy, thus minimizing erosion potential
- Provide portable drainage control for construction sites, ditches, channels, roads, slopes
- The double panel porous barrier may allow significant energy loss as the flow of water undergoes from supercritical flow to sub-critical flow from the upstream panel

to the downstream panel with a more laminar flow evolving downstream and roughly parallel to the stream bed. Less turbulence and erosion energy may be created when compared with cascading, over-topping and tumbling flow from drop structures (i.e., gabions, check structures, straw bales)

- Barriers constructed of UV resistant material may be left in place for final channel stabilization as UV degradation is low
- Biodegradable synthetic option available
- Observed to enhance aggregation of silt material and to function as a sediment barrier with the formation of an earth block at behind the upstream barrier panel area; the downstream flow exiting at the downstream barrier panel may be of laminar nature and less erosive

Limitations

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

Construction

- Install as per manufacturers recommended installation instructions
- Normally installed in conjunction with erosion control matting in ditches and channels
- Prepare soil surface
- Install basal layer of erosion mat or geotextile fabric; key-in basal mat/fabric at upstream end

- Place and anchor barrier panels with adequate pin anchors to basal soils

Construction Considerations

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

Inspection and Maintenance

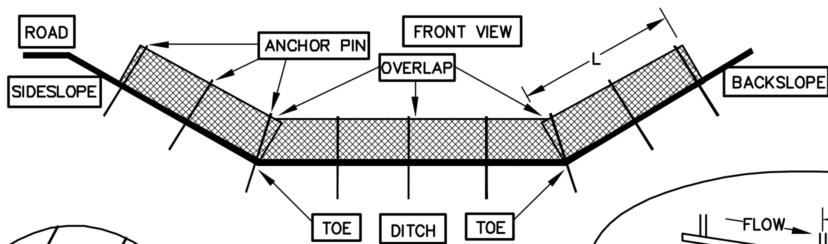
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build-up before it reaches one-half the check structure height
- Do not damage barrier panel during removal of sediment
- Partial or non-removal of sediment build-up will create a non-permeable barrier and low level earth mini-drop structure which will force water flow over-topping the barrier. The option of non-removal of sediments may be open to converting the sediment build-up into a "vegetated earth mini-drop structure" along the ditch with the non-removal of synthetic permeable barrier in-place. This will require topsoil and seeding (or intensive mulch seeding) to promote vegetation growth
- If erosion is noted at the toe or upslope edges of the structure, hand regrading or suitable repairs should be made immediately to prevent failure of the structure
- Remove and deactivate at 1 year after vegetation is established

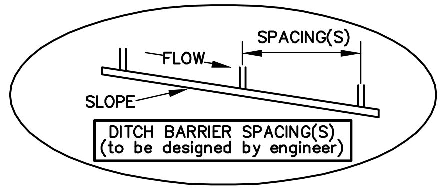
Similar Measures

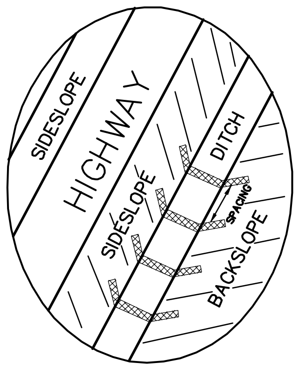
- Silt fences or straw bales partially equivalent in retaining sediment

Design Considerations

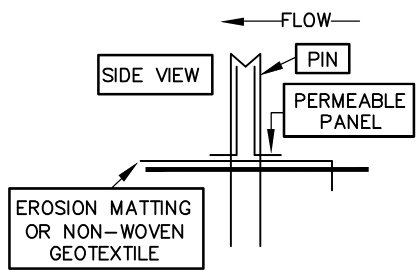
- Install synthetic permeable barrier along ditch interval between permanent drop structures (i.e., gabion); can be economic alternative and supplemental to (i) total hard armouring of complete channel length, or (ii) high frequency of gabion installation required for high flow applications in steep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



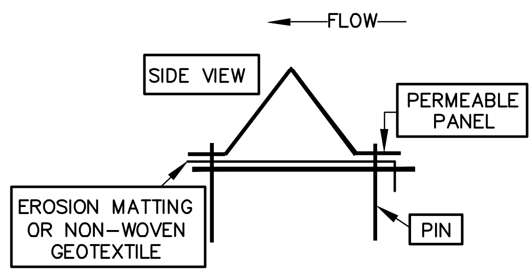




MINIMUM INSTALLATION LENGTH UP SLOPES	
SLOPE	LENGTH: L (m)
2:1	0.55
2.5:1	1.1
3:1	1.1
3.5:1	1.1
4:1	1.1
5:1	1.3
6:1	1.5



1) DOUBLE PANEL



2) TRIANGLE PANEL

SYNTHETIC PERMEABLE DITCH BARRIER

N.T.S.

NOTES:

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

SYNTHETIC PERMEABLE BARRIERS

Straw Bale Check Dam Removed	B.M.P. #11

Straw Bale Barrier Sediment Control	B.M.P. #12

Description and Purpose

- A barrier of strawbale primarily used as a perimeter sediment control measure
- May be used to intercept and detain sediment laden runoff allowing a portion of the sediment load to settle out

Applications

- Temporary measure
- Suitable for flow velocities of 0.3 m/s or less
- Usually placed at 1m to 2 m offsets from toe of disturbed slopes
- Size of drainage area should be no greater than 0.1 ha per 30 m length of straw bale sediment barrier
- Maximum flow path length upstream of barrier should be less than 30 m
- Maximum slope gradient above the barrier should be no greater than 2H:1V
- May be used in conjunction with filter fabric as external wrap to encapsulate the bale

Advantages

- Straw bales are biodegradable
- Only requires one row of straw bales
- Easier to install than other barriers and economical if straw bales are readily available

Limitations

- Not appropriate for flow velocities greater than 0.3 m/s
- Require extensive maintenance following high velocity flows associated with storm events
- Not as robust as some continuous perimeter control structures
- Susceptible to undermining and erosion damage if not properly keyed into substrate soil or if joints are not completely infilled with straw
- Short service life
- Must be installed by hand
- Not to be used on asphalt or concrete covered surfaces

- Availability of appropriate bales may be limited in certain areas of the province
- Maximum straw bale barrier height of one straw bale or 0.5 m maximum height

Construction

- Straw bale barrier should be located a minimum distance 1.8 m away from the toe of the slope to provide adequate ponding and sedimentation area
- Excavate a trench approximately 0.10 m deep with a width of one straw bale at the straw bale barrier location
- Place straw bales in excavated trench along contour, perpendicular to flow direction
  - Ensure twine or wire is not in contact with the soil
  - Ensure straw bale is in continuous contact with base of trench
  - Ends of barrier should be angled upslope to form enclosure to contain runoff
- Infill all joints with loose straw
- Drive two 50 mm by 560 mm section wooden stakes 1.2 m long through each straw bale, ensuring each stake is embedded a minimum of 0.15 m into soil
- Backfill and compact the upstream and downstream edges of the check structure to seat the straw bales into the subgrade

Construction Considerations

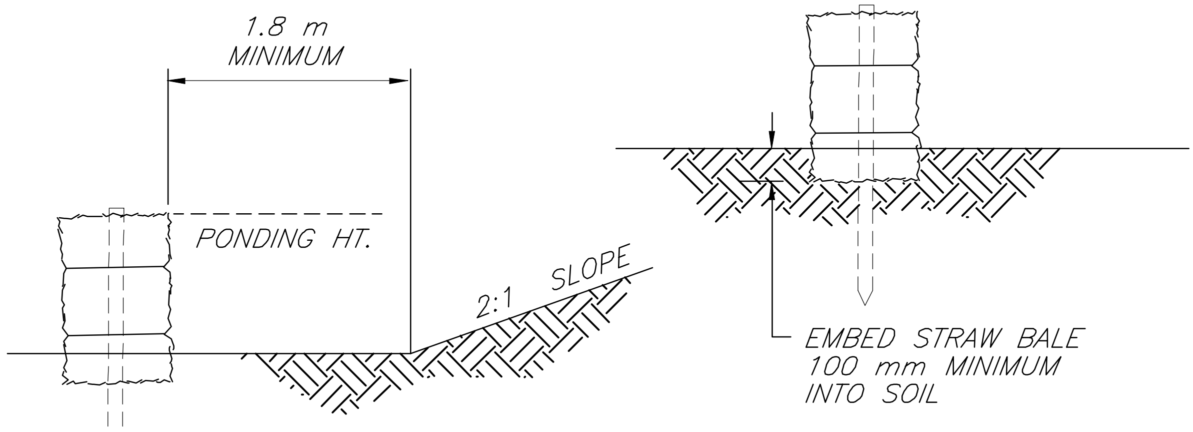
- Maximum lengths of barriers should be 40 m, including ‘J-hook’ or ‘smile’ (similar to silt fence in BMP #1) configuration, to allow escape route for excess runoff
- Barrier should be placed far enough away from toe of slope to provide adequate ponding and sedimentation area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of barriers should be angled upslope (in a ‘J-hook’ or ‘smile’ configuration) to form enclosure to collect runoff
- Straw bales should be:
  - Machine-made
  - Weed free cereal crop straw such as wheat, oats, rye, or barley
  - Tightly compacted and bound with two rows of wire or synthetic string and shall show no signs of weathering
  - No more than one year old

Inspection and Maintenance

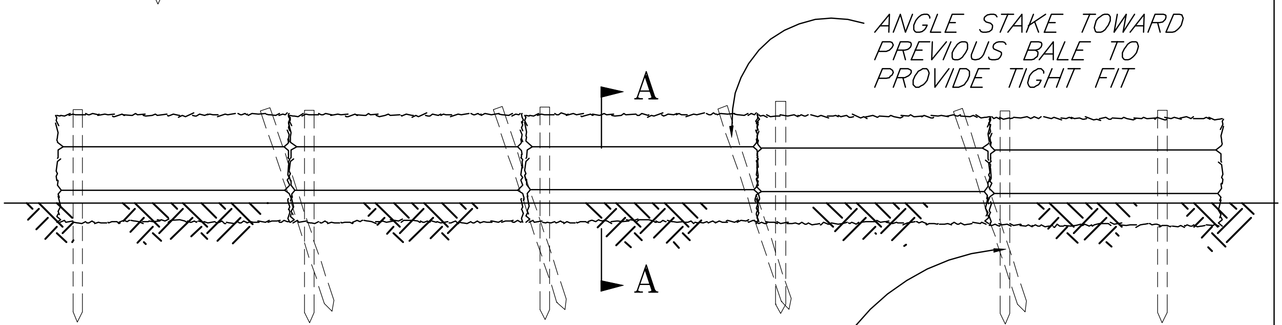
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build up before it reaches one half the check barrier height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace damaged, decayed or dislodged straw bales immediately

Similar Measures

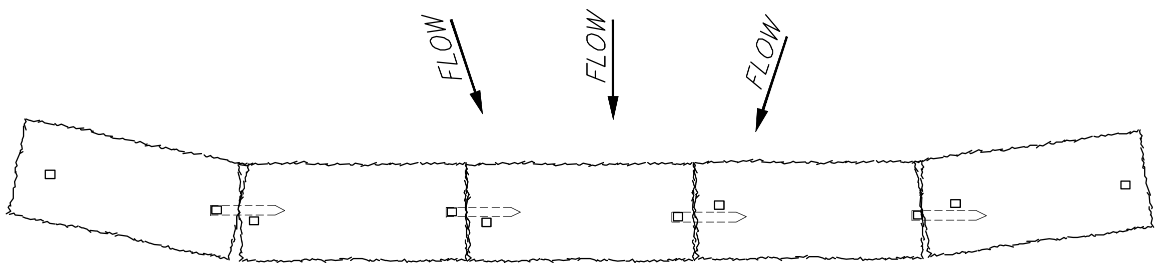
- Silt fences
- Continuous Perimeter Control Structures
- Berm Interceptors



SECTION A – A



SECTION B – B



PLAN

NOTES:

1. THE STRAW BALES SHALL BE PLACED ON SLOPE CONTOUR.
2. BALES TO BE PLACED IN A ROW WITH THE ENDS TIGHTLY ABUTTING.
3. KEY IN BALES TO PREVENT EROSION OR FLOW UNDER BALES.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STRAW BALE BARRIER

FILE: STRWDIKE

Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #13

Description and Purpose

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

Applications

- Temporary or permanent measure
- May be used to protect disturbed, exposed soils for cut or fill slopes at gradients of 2.5H:1V or steeper
- May be used on slopes where erosion potential is high
  - Silts and sands have higher erosion potential than high plastic clays
- May be used on slopes where vegetation is likely to be slow to develop
- May be used to protect disturbed exposed soils in ditches and channels (with high flow velocities) by providing additional tractive resistance cover in conjunction with a successful high density vegetative growth established

Advantages

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

Limitations

- Non-performance of RECP may result from the following:
  - Low density vegetation growth (beneath RECP) due to non-favourable weather and growth conditions (i.e., soil type, moisture, storm events at critical times). It is noted that values of tractive resistance of RECP products for vegetative growth may be generally tested in laboratory after a growth period (e.g., 3 months) under greenhouse growth conditions. The effectiveness of RECP, especially along channels, is very dependent on success of vegetation growth on site. It is important that the designer should assess the effectiveness of RECP in accordance with site, soil, terrain and vegetation growth conditions
  - Hydraulic uplift of RECP and erosion of underlying soils can occur under rapid snow melt conditions when dammed up melt water generates a hydraulic head and high flow velocity generated in constricted snow melt channel. This situation can occur along steep channels interlaced with drop structures and with RECP lining installed in-between the drop structures. Ponding of melt water and non-anchored RECP joint areas allow flow entry beneath the RECP and generate hydraulic heads to uplift the RECP. This can occur along un-anchored edges of RECP at upper edges of ditch when snow melt occurs at tops of ditch and flow beneath the RECP. This is especially critical when underlying soil is easily erodible. (e.g., fine grained non-cohesive silty soils). It is important to trench-in and anchor the edges of the RECP installations and installed anchor pin (staples) at sufficient dense intervals
  - Ice build-up from groundwater seepage source can uplift and dislocate the RECP and causing flow beneath the RECP to erode the substrate soils. Winter ice accumulation may be related to groundwater regime and investigative design on subsurface drainage by a geotechnical engineer is required
- Can be labour intensive to install
- Must be installed on unfrozen ground
- Temporary blankets may require removal before implementation of permanent measures
- Rolled erosion control products (RECP) are not suitable for rocky sites
- Proper surface preparation is required to ensure intimate contact between blanket and soil
- Plastic sheeting can be used at sensitive slopes with precautions:
  - Plastic sheeting RECP product can be easily torn, ripped, non-biodegradable, and should be disposed of in a landfill

- Plastic sheeting product, if used, results in 100% runoff, thus increasing erosion potential in downslope areas receiving the increased flow volumes
- Plastic sheeting should be limited to temporary covering of sensitive soil stockpiles or temporary covering of small critical unstable slope areas

Construction (Slopes)

- RECP should be installed in accordance with manufacturer's directions

The following is a general installation method:

- Prepare surface and place topsoil and seed
- Surface should be smooth and free of large rocks, debris, or other deleterious materials
- Blanket should be anchored at top of slope in a minimum 0.15 m by 0.15 m trench for the entire width of the blanket
- The blanket should be rolled out downslope
  - (1) Where the blanket roll is not long enough to cover the entire length of the slope, a minimum 0.15 m by 0.15 m check slot should be excavated at the location of the lap, and the downslope segment of blanket anchored in the check slot, similar to the method used for the top of the slope, or (2) when blankets must be spliced down the slope, place blanket end over end (shingle style with approximately 0.10 m overlap. Staple through overlapped area at 0.3 m intervals.
  - The upslope portion of blanket should overlap the downslope portion of blanket, shingle style, at least 0.15 m with staple anchors placed a maximum 0.3 m apart
  - Adjacent rolls of blanket should overlap a minimum 0.1 m
  - Anchors should be placed along central portion of blanket spaced at $4/m^2$ minimum (0.5 m spacing) for slopes steeper than 2H:1V and $1/m^2$ (1 m spacing) for slopes flatter than 2H:1V
  - Anchors along splices between adjacent rolls should be placed 0.9 m apart

Construction (Channels)

- **A Blanket should be installed in accordance with manufacturers directions**

The following is a general installation method

  - Prepare surface and place topsoil and seed

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

Construction Considerations

- Slopes should be topsoiled and seeded prior to placing RECP
- Ensure blanket is in intimate contact with the soil by properly grading soil, removing rocks or deleterious materials, prior to placing blanket
- In channels, blankets should extend to above the anticipated flow height, with a minimum 0.5 m of free board
- For turf reinforcement mat (TRM), blanket should be placed immediately after topsoiling
- Blanket should be anchored by using wire staples, metal geotextile stake pins, or triangular wooden stakes
  - All anchors should be a minimum of 0.15 to 0.2 m in length
  - For loose soils, use longer anchors
- Blankets should be placed longitudinal to direction of flow, with fabric not stretched but maintaining contact with underlying soil
- It is essential to understand product specifications and follow manufacturers instructions on installation methods

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

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

- Manufacturer's Certificate on
- Performance specification
  - Permissible Tractive Resistance (include testing methods and vegetative growth conditions)
  - Permissible Flow Velocity (if available)
  - Longevity (for biodegradable or non-biodegradable products)

- Minimum Average Roll Values (MARVs) along with specified testing methods for
  - Physical properties
    - Mass per unit area
    - Thickness
    - Tensile strength
    - UV Resistance
  - Other physical properties (for non-woven below Erosion Mat (if specified)
    - Grab tensile strength
    - Grab elongation
    - Puncture strength
    - Trapezoidal tear
    - UV Resistance

Inspection and Maintenance

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

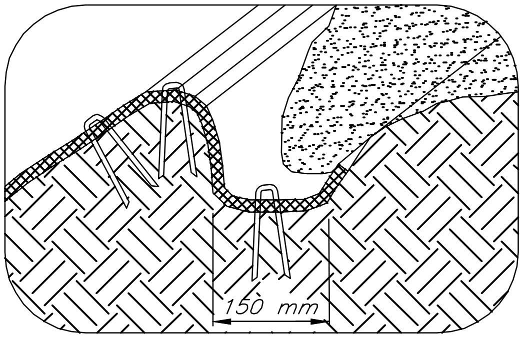
Similar Measures

- Mulching (for slopes only)
- Riprap (primarily in channels)
- Gabion mattresses (primarily in channels)

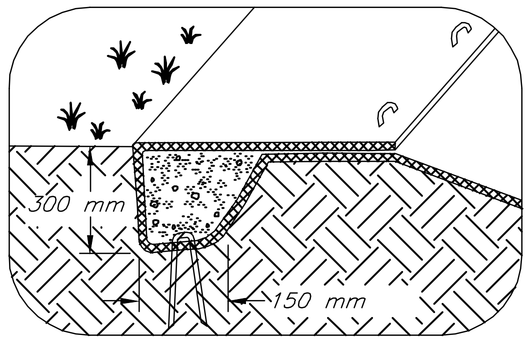
Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #13

Design Considerations

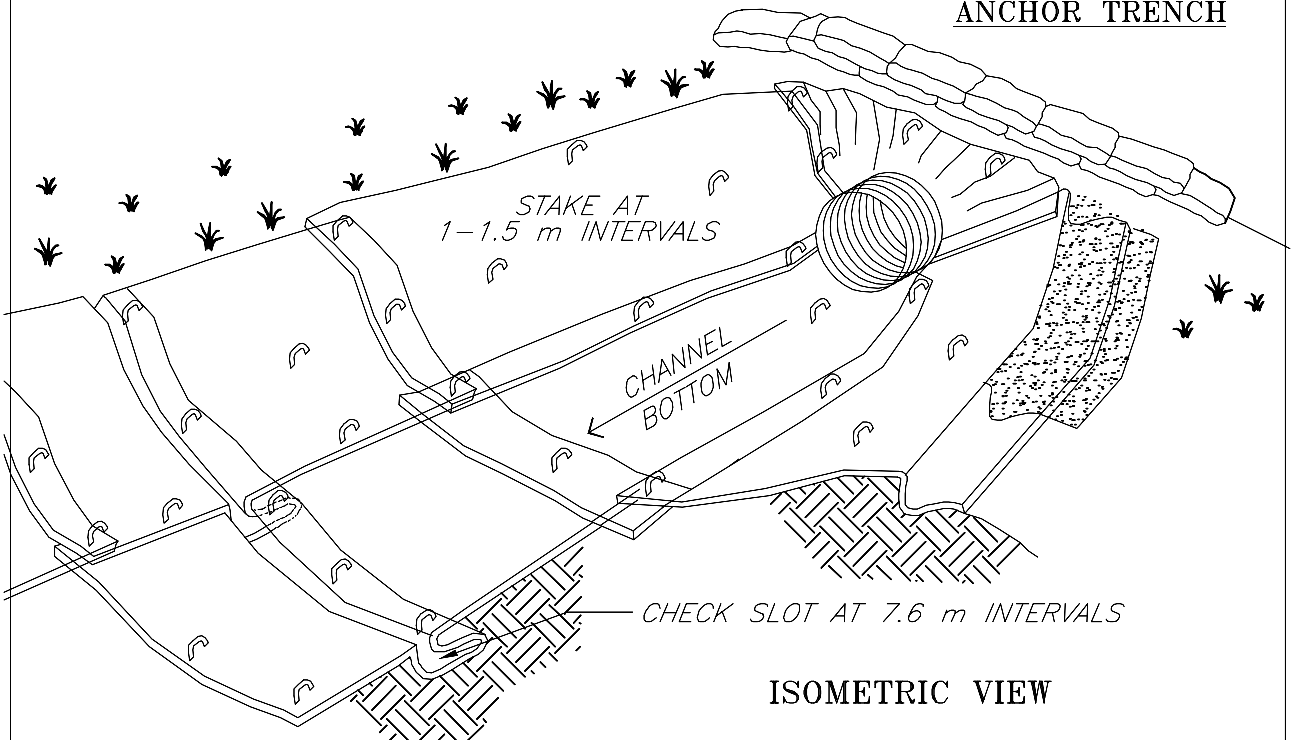
- Assess hydraulic flow conditions and tractive stress on channel
- Assess local soil, weather and growth conditions (favourable/non-favourable) for revegetation (within 3 to 12 months) to allow a determination on use or non-use of RECP as a protective measure. If the revegetation conditions are assessed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



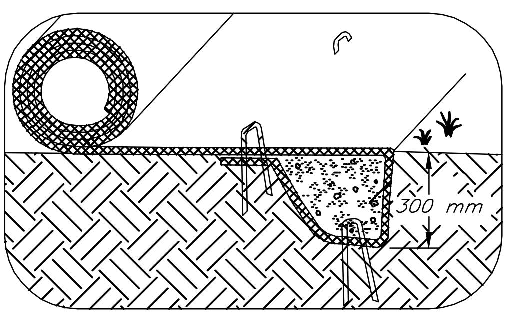
LONGITUDINAL ANCHOR TRENCH



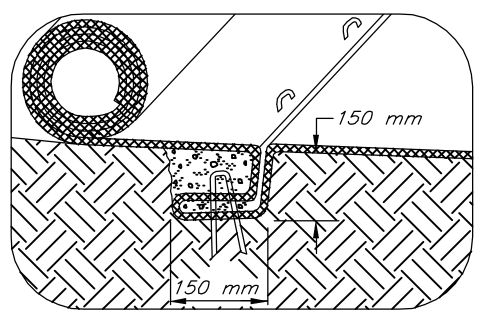
TERMINAL SLOPE AND CHANNEL ANCHOR TRENCH



ISOMETRIC VIEW



INITIAL CHANNEL ANCHOR TRENCH



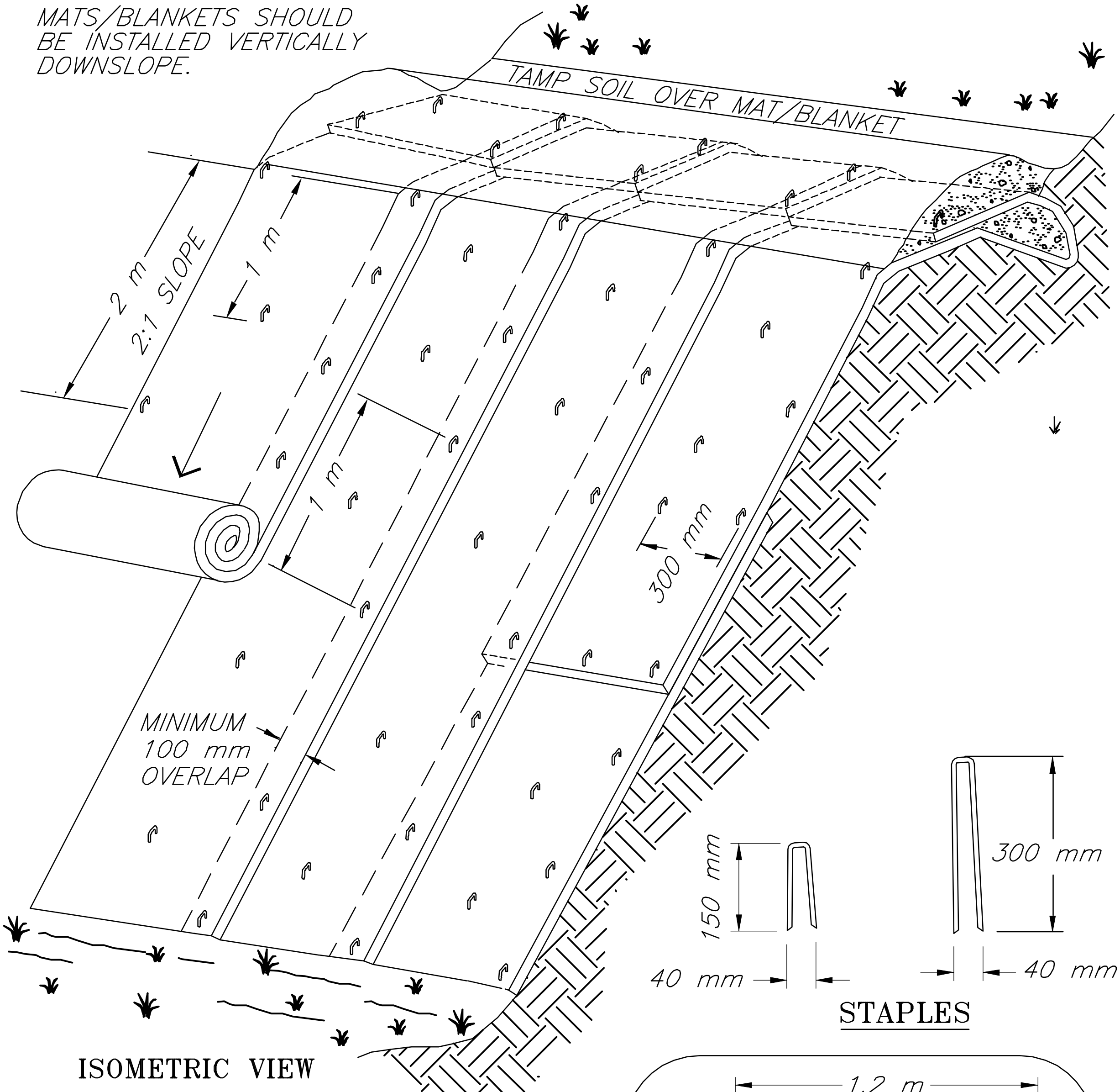
INTERMITTENT CHECK SLOT

NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

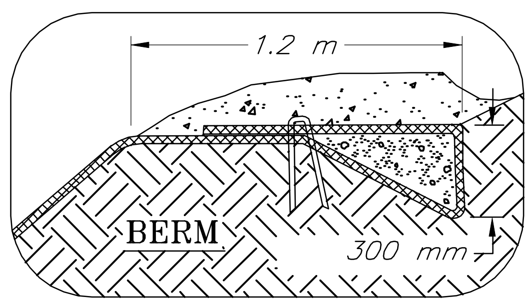
ROLLED EROSION CONTROL PRODUCTS (RECP)

CHANNEL INSTALLATION



ISOMETRIC VIEW

STAPLES



NOT TO SCALE

TYPICAL SLOPE SOIL STABLIZATION

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.
4. CHECK SLOTS, STAKING, STAPLING AND OTHER CONSTRUCTION DETAILS PER MANUFACTURES SPECIFICATIONS.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

ROLLED EROSION CONTROL PRODUCTS (RECP)
SLOPE INSTALLATION

Riprap Armouring a) Slope Protection b) Channel Protection Erosion Control	B.M.P. #14 (a & b)

Description and Purpose

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

Applications

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

Advantages

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

Limitations

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

- Use of gabion is preferred at flow greater than 3 m/s due to larger nominal size of riprap and thickness required for erosion protection during flow velocities of this magnitude
- Can be classified as uniform or graded. Uniform riprap would contain stones which would contain a mixture of stones ranging from small to large. Graded riprap forms a flexible self healing cover

Construction

- Grade the slope or channel to final design grade
- Place filter (underlay) layer on prepared slope
  - Filter layer can consist of non-woven geotextile underlay and/or well graded granular material dependent on hydraulic conditions
- Place riprap layer
- Riprap should consist of a graded mixture of sound, durable stone with at least 50% of the riprap material being larger than 200 mm in diameter
- Riprap should be sized according to the following gradation and mass:

		Riprap Class			
		1M	**1**	**2**	**3**
Nominal Mass **Nominal Diameter**	**kg** **mm**	**7** **175**	**40** **300**	**200** **500**	**700** **800**
None heavier than:	kg or mm	40 300	130 450	700 800	1800 1100
No less than 20% or more than 50% heavier than:	kg or mm	10 200	70 350	300 600	1100 900
No less than 50% or more than 80% heavier than:	kg or mm	7 175	40 300	200 500	700 800
100% heavier than:	kg or mm	3 125	10 200	40 300	200 500

Percentage quoted are by mass.
Sizes quoted are equivalent spherical diameters, and are for guidance only.

Source: AT Bridge Spec. 2010

- Non-woven geotextile fabric underlay below riprap should meet the following specifications and physical properties:

Non-Woven Geotextile Filter Fabric
Specifications and Physical Properties

	Class 1M, 1 and 2	Class 3
Grab Strength	650 N	875 N
Elongation (Failure)	50%	50%
Puncture Strength	275 N	550 N
Burst Strength	2.1 MPa	2.7 MPa
Trapezoidal Tear	250 N	350 N
Minimum Fabric Overlap to be 300 mm		

Source: AT Bridge Spec. 2010

Construction Considerations

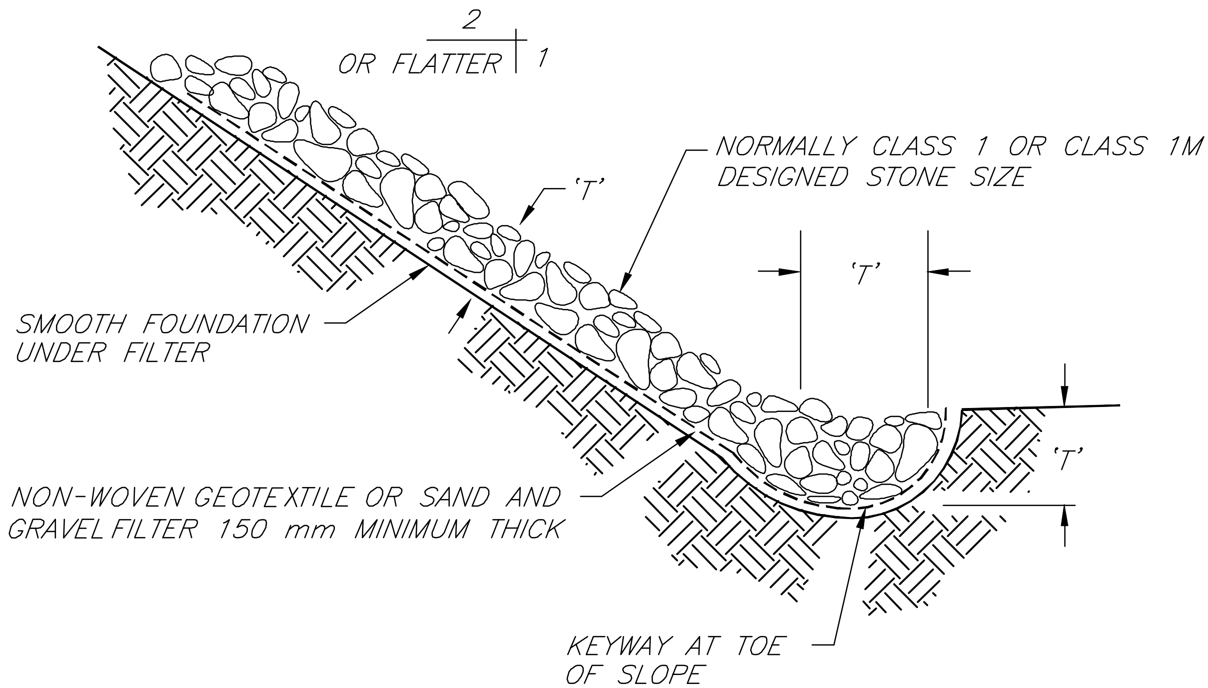
- Riprap should be placed in a uniform thickness across the channel so as not to constrict channel width
- Blasted rock is preferred (if available)
- Riprap layer should be 1.5 to 2 times the thickness of the largest rocks used, 1.5 to 3 times the thickness of the D_{50} material, and not less than 300 mm in thickness

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Periodic inspections to check for erosion of protected material or movement of riprap

Similar Measures

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



TYPICAL SECTION

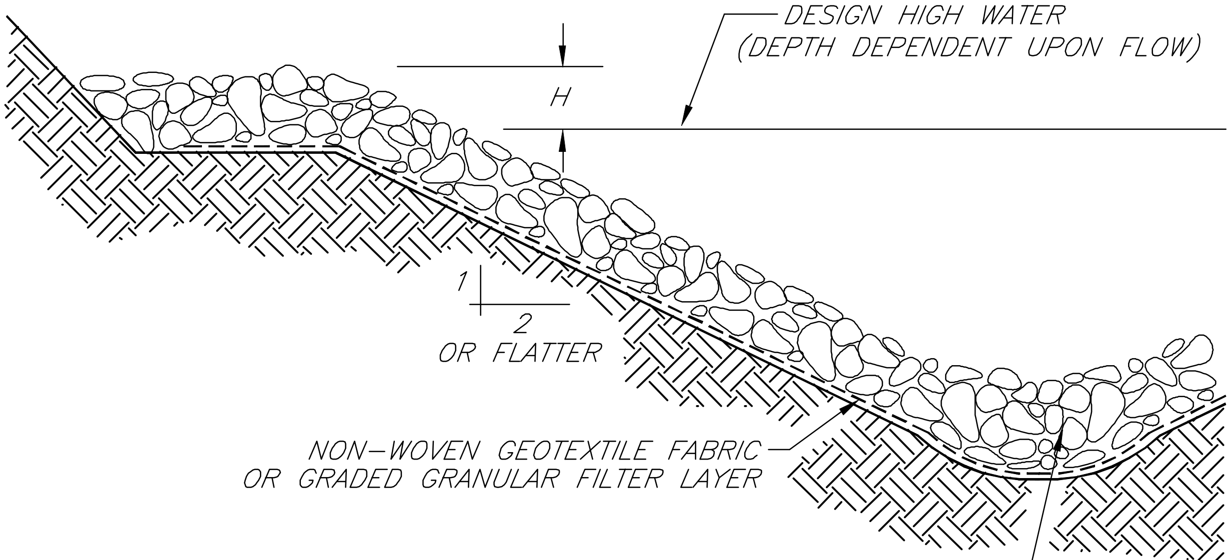
NOTE:

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

RIPRAP ARMOURING FOR SLOPE

FILE: RIPRAP

DESIGN HEIGHT (H), WIDTH AND STONE SIZE SHALL
BE DETERMINED BY THE ENGINEER



TYPICAL SECTION

NOTES:

1. RIPRAP GRADATION AND THICKNESS SHALL BE DETERMINED BY THE ENGINEER IN ACCORDANCE WITH HYDRAULIC CONDITIONS.

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

RIPRAP ARMOURING FOR CHANNEL

FILE: RCKCHNEL

Cellular Confinement System Erosion Control	B.M.P. #15

Description and Purpose

- 3-dimensional, plastic matting with open cells filled with topsoil or aggregate
- 3-dimensional structure stabilizes cut or fill slopes
- Cells confine infilled topsoil or aggregate and protect root zone while permitting surface drainage

Applications

- Permanent measures
- May be used with granular infill on cut or fill slopes up to a slope of 1H:1V
- May be used with granular infill on slopes and in ditches where flow velocities are 3 m/s or less
- May be used as a flexible channel lining
- May be used in temporary low-water stream crossing as granular pad for stream fording
- Matting is light, expandable, and easy to transport and place
- Use of native fill materials reduces costs; local granular fill is preferred

Limitations

- Not widely used in Alberta highway construction
  - Availability can be limited, therefore expensive in some areas
- Installation can be labour intensive
- Not to be used on slopes steeper than 1H:1V
- Slopes of 1H:1V can be hazardous to work on

Construction

- Cellular Confinement System should be installed in accordance with manufacturer's directions
- The following is a general installation method
  - Slope should be graded to design elevations and grades
  - Rocks or other deleterious debris should be removed from matting location

- Matting should be installed in a trench as deep as the matting is thick, extending 0.6 to 1.2 m beyond crest of slope, and matting should be installed so that the top of the matting is flush with surrounding soil
  - Every other cell along crest of slope should be anchored to soil using ‘J’ pins or other suitable sturdy anchoring device
- The matting should be rolled out downslope
- Where the blanket roll is not long enough to cover the entire length of the slope, the downslope section of matting should be butt-jointed to the upslope section and secured using staples, hog rings, or other suitable fasteners
- Adjacent rolls of matting should be butt-jointed and secured using staples, hog rings, or other suitable fasteners
- Anchors are placed at 1 m intervals down the slope
  - Additional anchors may be required to ensure matting is in intimate contact with soil
  - Additional anchors may be required along edges of matting
- Backfilling should start at the crest of the slope and proceed downslope
  - For topsoil, overfill cells approximately 25 to 50 mm and lightly compact so that top of topsoil is flush with matting
  - For granular fill, overfill cells approximately 25 mm and tamp compact so that top of fill is flush with matting
- Seeding should be applied after fill placement

Construction Considerations

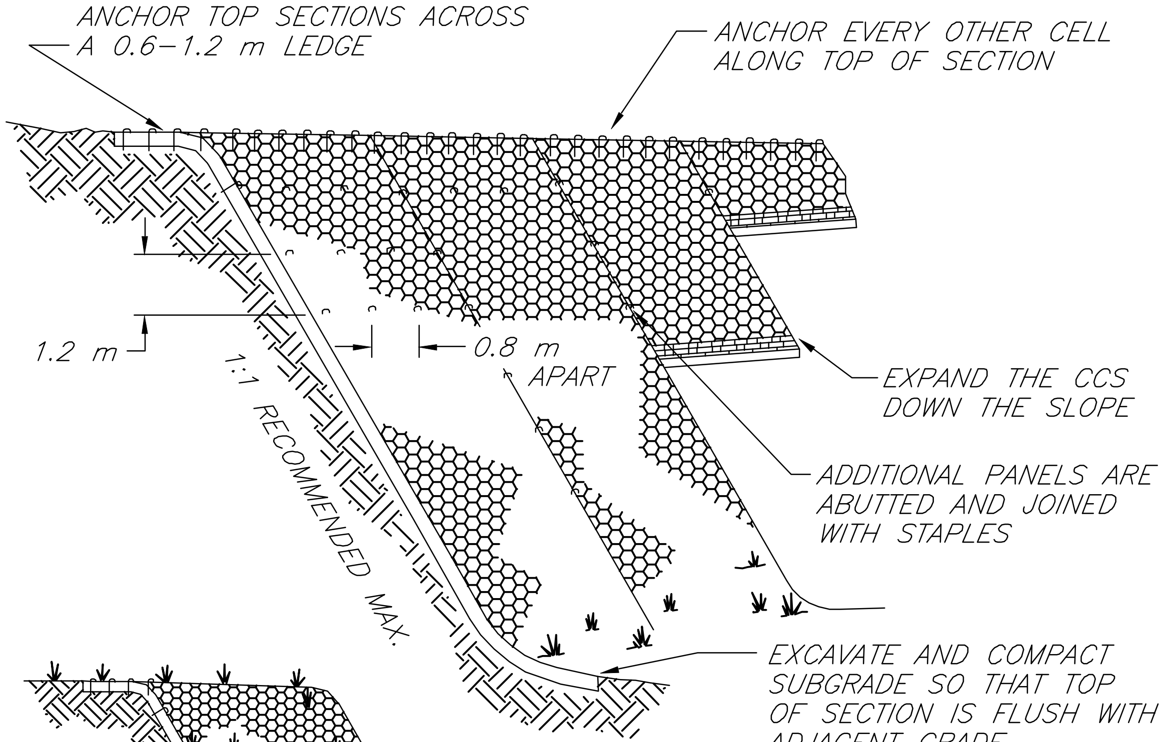
- Properly grading soil surface, removing rocks or deleterious materials, prior to placing matting to ensure matting is in intimate contact with the soil
- Matting should be placed longitudinal to direction of flow or downslope
- Use only a single layer of matting
- Matting elevation should be subexcavated to thickness of matting so that the top of the matting is flush with the adjacent terrain
- Infill from top of slope ensuring placement height of fill into cellular mat is less than 1 m

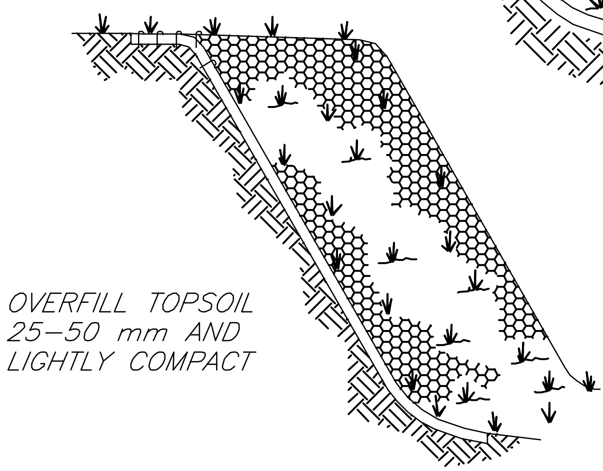
Inspection and Maintenance

- Area covered with matting should be inspected regularly or in accordance with the PESC and TESC Plans, especially after periods of heavy rainfall storms to check for damage or loss of material
  - Any damaged areas should be repaired immediately
- Temporary inspection should continue until vegetation is established
  - Areas where vegetation fails to grow should be reseeded immediately
- If matting is broken or damaged and washout of the underlying soil occurs, the matting should be repaired or replaced after regrading the slope

Similar Measures

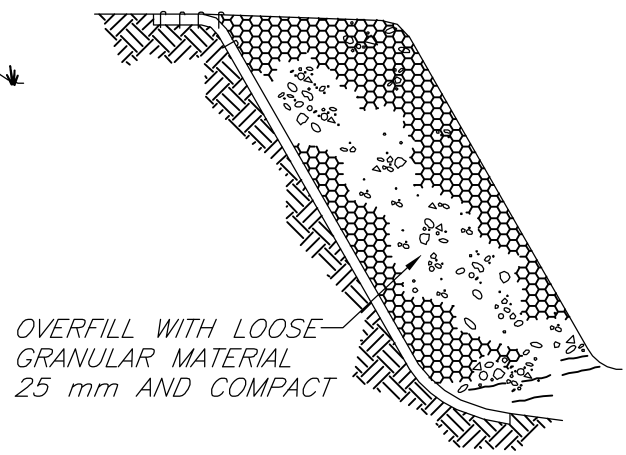
- Rolled erosion control products (RECP)
- Riprap armouring





CCS INFILLED WITH TOPSOIL AND VEGETATED WITH GRASS

CCS INFILLED WITH AGGREGATE



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 DISPLACEMENT AND DEFORMATION OF PANELS WHEN BACKFILLING.
4. INFILL FROM CREST OF THE SLOPE TO TOE TO PREVENT DISPLACEMENT. LIMIT DROP HEIGHT TO 1 m.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

CELLULAR CONFINEMENT SYSTEM FOR SLOPE STABILIZATION

FILE: CELLSYS

Gravel Blankets Removed	B.M.P. #16

Energy Dissipators a) for Culvert Outlet b) for Trough at Bridge Headslope Sediment Control	B.M.P. #17

Description

a) Hard armour (riprap, gravel, concrete) placed at pipe outlets, in channels, and at downstream side of check structures to reduce velocity and dissipate energy of concentrated flows (BMP 17a)

b) Standard Drain Trough Terminal Protection Structure generally used at bridge headslope (BMP 17b)

- Minimizes scour at flow impact location with dissipated flow energy

Applications

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

Advantages

- Reduces flow energy in a relatively small area

Limitations

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

Energy Dissipators a) for Culvert Outlet b) for Trough at Bridge Headslope Sediment Control	B.M.P. #17

Construction

- Grade the area to final design grades and elevations
- Sub-excavate energy dissipator location to thickness of energy dissipator
- Place filtration bedding material on base of excavation
  - Bedding can be comprised of well graded sand and gravel or non-woven geotextile
  - Acts as separating filter between fine grained subgrade and riprap size energy dissipator material
- Place energy dissipator material (riprap, gravel, concrete) over filtration bedding material
  - Top of energy dissipator should be flush with surrounding grade

Construction Considerations

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

Energy Dissipators a) for Culvert Outlet b) for Trough at Bridge Headslope Sediment Control	B.M.P. #17

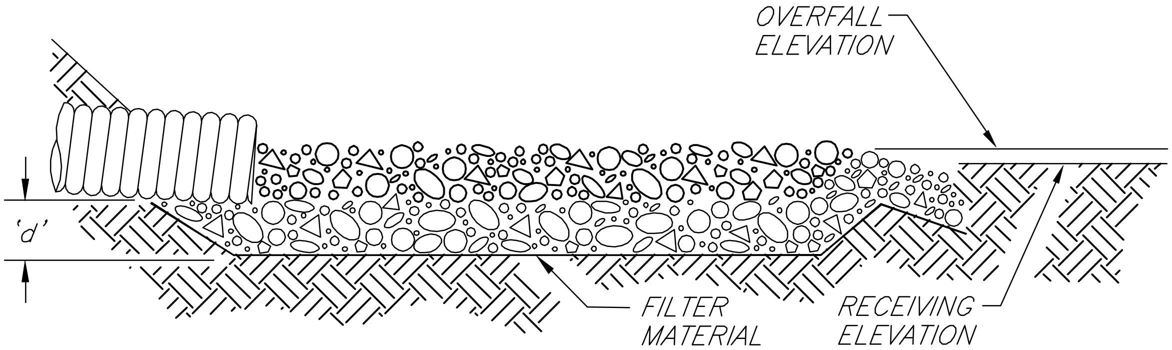
- Energy dissipator shall be designed to accommodate a 10-year peak runoff or the design discharge of the upstream channel, pipe, drain, or culvert, whichever is greater
- The energy dissipator shall be constructed flush with the surrounding grade and shall be directly in line with direction of outlet flow

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Any damage should be repaired immediately

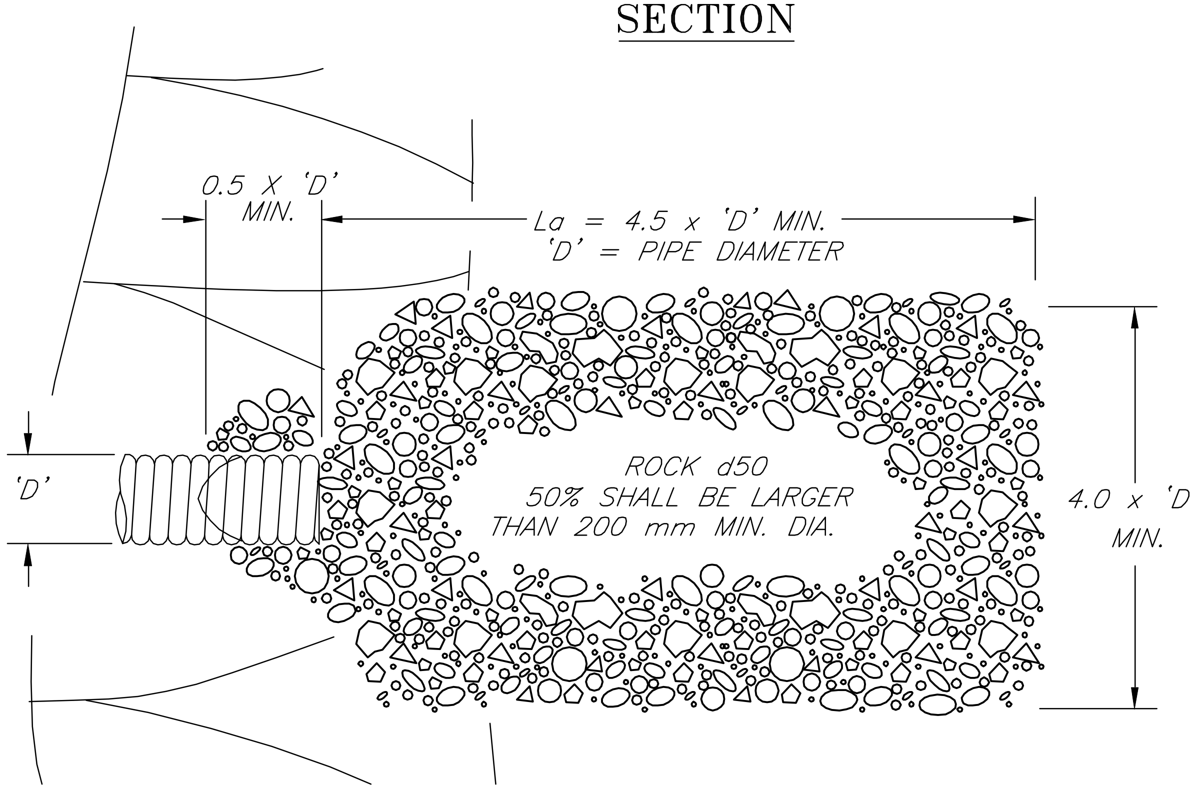
Similar Measures

- Gabion mattresses



B) MINIMUM THICKNESS = 300 mm. (i.e. 1.5x D_{50}) FOR D_{50} = 200 mm.

SECTION



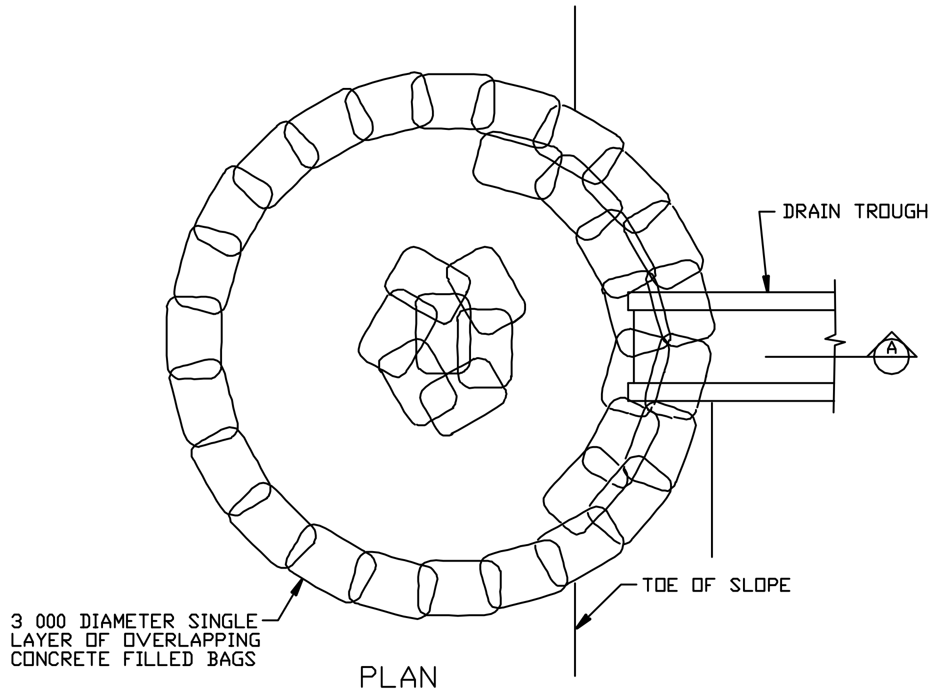
PLAN

NOTES:

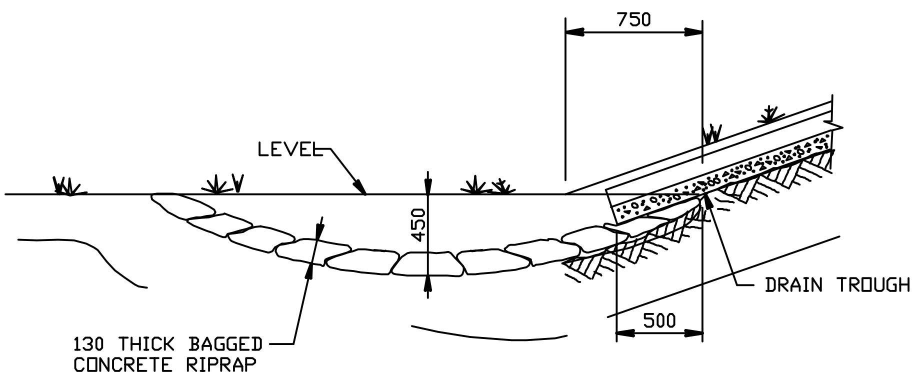
1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 150 mm THICK MINIMUM GRADED GRAVEL LAYER.
4. FOR PIPE DIAMETER > 600 mm, DESIGN BY ENGINEER IS REQUIRED.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

ENERGY DISSIPATOR FOR CULVERT OUTLET

FILE: ENRGYDIS



PLAN



A SECTION

GENERAL NOTES

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

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

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

ENERGY DISSIPATOR

FOR SEMI-CIRCULAR TROUGH DRAIN TERMINAL PROTECTION FOR BRIDGE HEADSLOPE

Sediment Traps and Basins a) Riser Outlet Option b) Permeable Rock Berm Outlet Option Sediment Control	B.M.P. #18

Description and Purpose

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

Applications

- Permanent measure
- Used at terminal or selective intermediate points of concentrated runoff for impoundment of runoff and sedimentation of silt prior to release of treated runoff downstream
- Used as sedimentation control measure at perimeter of construction sites where sediment laden run off may enter watercourses, storm drains, or other sensitive areas
- Used where there is a need to impound a significant amount of sediment from significant areas of land disturbance
- Sediment basins (Type I) used for disturbed drainage areas greater than 2.0 ha
- Sediment traps (Type II) used for disturbed drainage areas of 2.0 ha, or less
- Where practical, contributing drainage areas should be subdivided into smaller areas and multiple sedimentation impoundment installed

Advantages

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

Limitations

- Sediment traps and basins do not remove 100% of the sediment; net efficiency for sedimentation of silt may be around 50% dependent on design
- Anticipated service life of 3 years or longer due to possible clogging of outlets in the long-term
- Sedimentation traps and basins with a riser outlet should have an auxiliary spillway with adequate erosion protection to permit overflow in the event that the riser pipe outlet clogs during a storm event
- For drainage areas greater than 40 ha, multiple basins may be required
- Efficiency on sedimentation is very dependent on surface area; sediment basins require large surface areas to permit settling of sediment
- Fences and signage may be required to reduce danger to the public
- May provide breeding habitat for mosquitoes and other pests
- Sediment traps only remove medium and large diameter silt particles and upstream erosion or sediment control measure is required to reduce the amount of sediment laden to the runoff at downstream sensitive areas
- Periodic removal of sediment build up is required

Construction

- The consequences of failure for any water retaining structure will determine the level of effort in the design and construction phases. The construction guidelines presented herein are minimum requirements. A geotechnical engineer should design water retaining structures if the consequences of failure warrant.
- All footprint area for embankment dyke should be stripped of vegetation, topsoil, and roots to expose mineral subgrade soils
- Embankment fill material should be clean mineral soil with sufficient moisture to allow proper compaction
  - Fill should be placed in lifts not exceeding 150 mm in compacted thickness and should be compacted to a minimum of 95% Standard Proctor maximum dry density (SPD)
- The main outlet structure should be installed at farthest possible point from inlet
  - Outlet should be placed on firm, smooth ground and should be backfilled to 95% SPD
  - Proper inlet and outlet protection should be installed to protect from scour

  - Outlet pipe should consist of corrugated steel pipe to protect (against pinching and blockage)
- The embankment should be topsoiled, seeded or protected with gravel or riprap immediately after construction
- Construct an emergency spillway to accommodate flows not carried by the principle outlet
  - Emergency spillway should consist of an open channel (earth or vegetated) over native undisturbed soil (not fill)
  - If spillway is elevated, it should be constructed of riprap
  - Spillway crest should be depressed at least 0.15 m below embankment

Construction Considerations

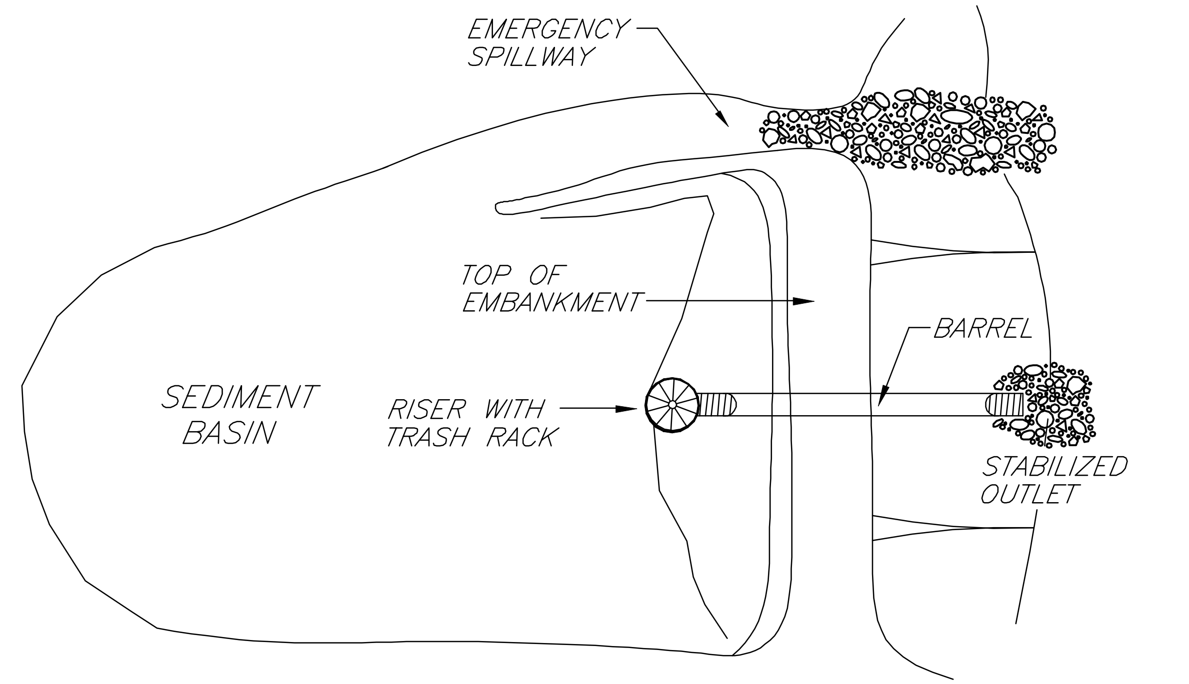
- Preferable to strip to mineral soil only along the footprint area required for dyke construction; can leave pond floor centre area cleared but unstripped
- Can be constructed by excavating, constructing embankments, or a combination of the two methods
- Baffles should be provided to prevent short-circuiting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

Inspection and Maintenance

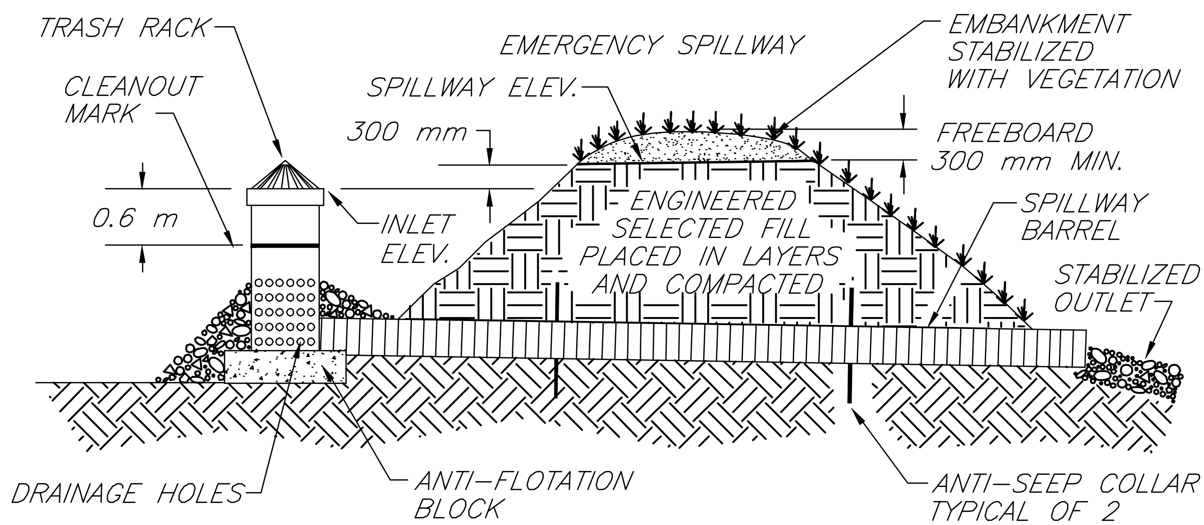
- Regular inspection is required to identify seepage, structural soundness, outlet damage or obstruction and amount of sediment accumulation
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Sediment should be removed upon reaching 1/2 height of the containment berm or within 0.4 m of crest of embankment
- Sediment traps may be deactivated or removed after vegetation of previously disturbed upstream areas has been established

Design Considerations

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



PLAN



SECTION

NOTES:

1. THE TEMPORARY SEDIMENT BASIN, DESIGNED BY A QUALIFIED PROFESSIONAL, IS REQUIRED FOR DISTURBED AREAS GREATER THAN 2.02 HECTARES (5 ACRES) WITH A DRAINAGE AREA LESS THAN 40.4 HECTARES (100 ACRES).

2. THE SEDIMENT BASIN MAY BE REMOVED WITHIN 3 YEARS.

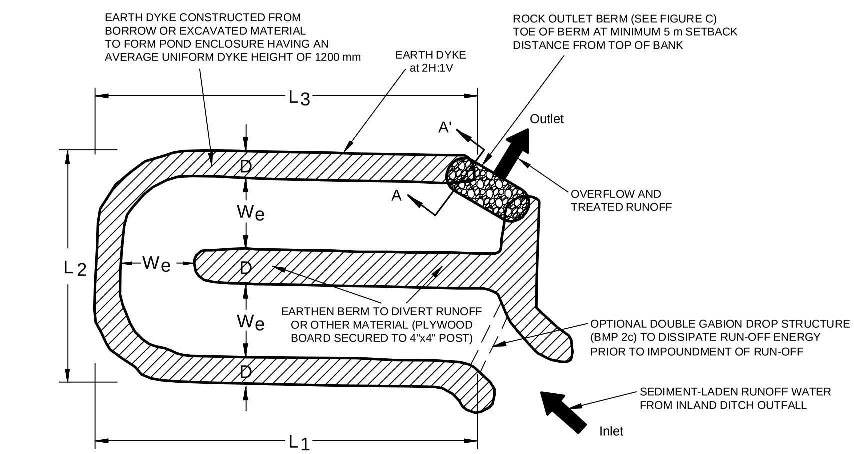
3. HEIGHT OF ENGINEERED SELECTED FILL EQUAL TO 1 m.

4. FOR CONFIGURATION AND FLOW CHAMBER DESIGN (i.e. LENGTH(L) & WIDTH(W_e) OF BASIN), REFER TO BMP 18b.

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

TYPICAL SEDIMENT BASIN (RISER OUTLET OPTION)

FILE: SEDBASIN

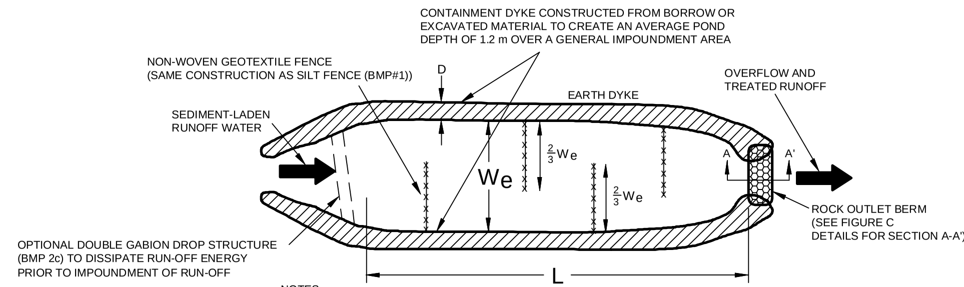


NOTES:

1. CONTRIBUTING RUNOFF AREA CAN BE LARGER THAN 2.0 ha BUT LESS THAN 40.0 ha.
2. EFFECTIVENESS APPROPRIATE FOR REMOVING MEDIUM TO COARSE SILT PARTICLES SUSPENDED IN RUNOFF.
3. FLOW PATH $L = L_1 + L_2 + L_3 \geq$ FLOW WIDTH $W_e \geq$ 6 m MINIMUM
4. PROVIDE 1 TO 2 m (1 TO 2% GRADE) ELEVATION DROP BETWEEN INLET AND OUTLET GRADES.
5. SHAPE OF POND TO CONFORM TO TOPOGRAPHY WITH OUTLET AT MINIMUM 5 m FROM TOP OF BANK.
6. CONSTRUCTION TO ENSURE SWALES AND BAFFLES ARE TO CHANNEL WATER INTO THE PROPOSED SEDIMENTATION PONDS.

Plan View

Figure A Type 1 Sedimentation Pond Containment Structure (Sediment Basin)

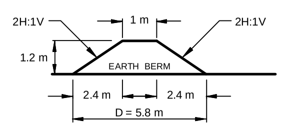


NOTES:

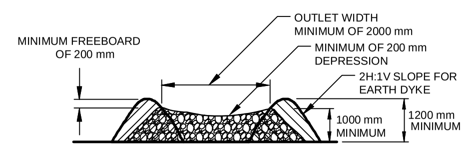
1. CONTRIBUTING RUNOFF AREA SHOULD BE OR SMALLER THAN 2.0 ha.
2. EFFECTIVENESS APPROPRIATE FOR REMOVING MEDIUM TO COARSE SILT PARTICLES SUSPENDED IN RUNOFF.
3. L/W_e RATIO 3:1 CAN BE APPROPRIATE.
4. W_e = 8 m MINIMUM BOTTOM WIDTH.
5. NON-WOVEN GEOTEXTILE FABRIC WITH A0S $\leq$ 0.15mm.

Plan View

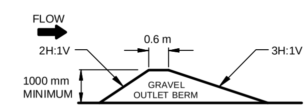
Figure B Type II Containment Structure (Sediment Trap)



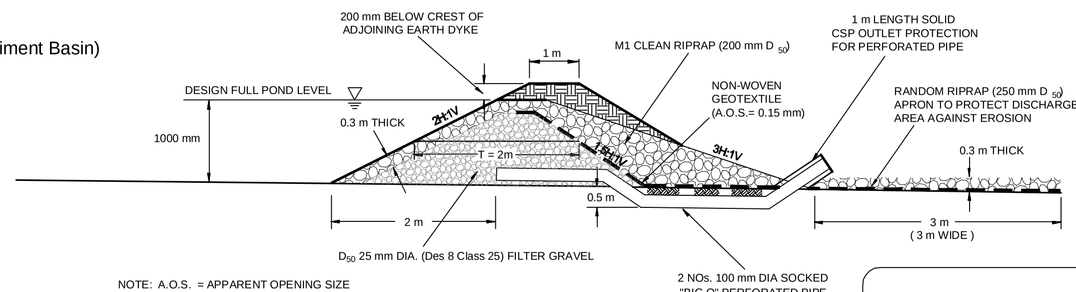
E A R T H D Y K E (D)



O U T L E T F R O N T V I E W



S E C T I O N A - A'
(SIMPLIFIED)



NOTE: A.O.S. = APPARENT OPENING SIZE

Figure C Section A-A' - Details for Sedimentation Pond
(Permeable Structure with Rock Filter Barrier and Perforated Pipe)

NOTES:

1. DEACTIVATED WITHIN 3 YEARS AFTER SATISFACTORY FULL REVEGETATION OF THE DISTURBED AREA OF POTENTIAL EROSION SOURCES UPSTREAM.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: 1) FIFIELD (2001) FOR STRUCTURE PLAN
2) EBA FOR OTHER DESIGN DETAILS

TYPICAL SEDIMENT BASIN (PERMEABLE ROCK BERM OUTLET OPTION)

Government of Alberta
Transportation

B.M.P. #18b
Typical Section

Slope Drains a) Slope Drain b) Overside Drain Sediment Control	B.M.P. #19

Description and Purpose

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

Applications

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

Limitations

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

Construction

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

– Anchor stakes should have a minimum 1 m embankment

Construction Considerations (For guidance only)

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

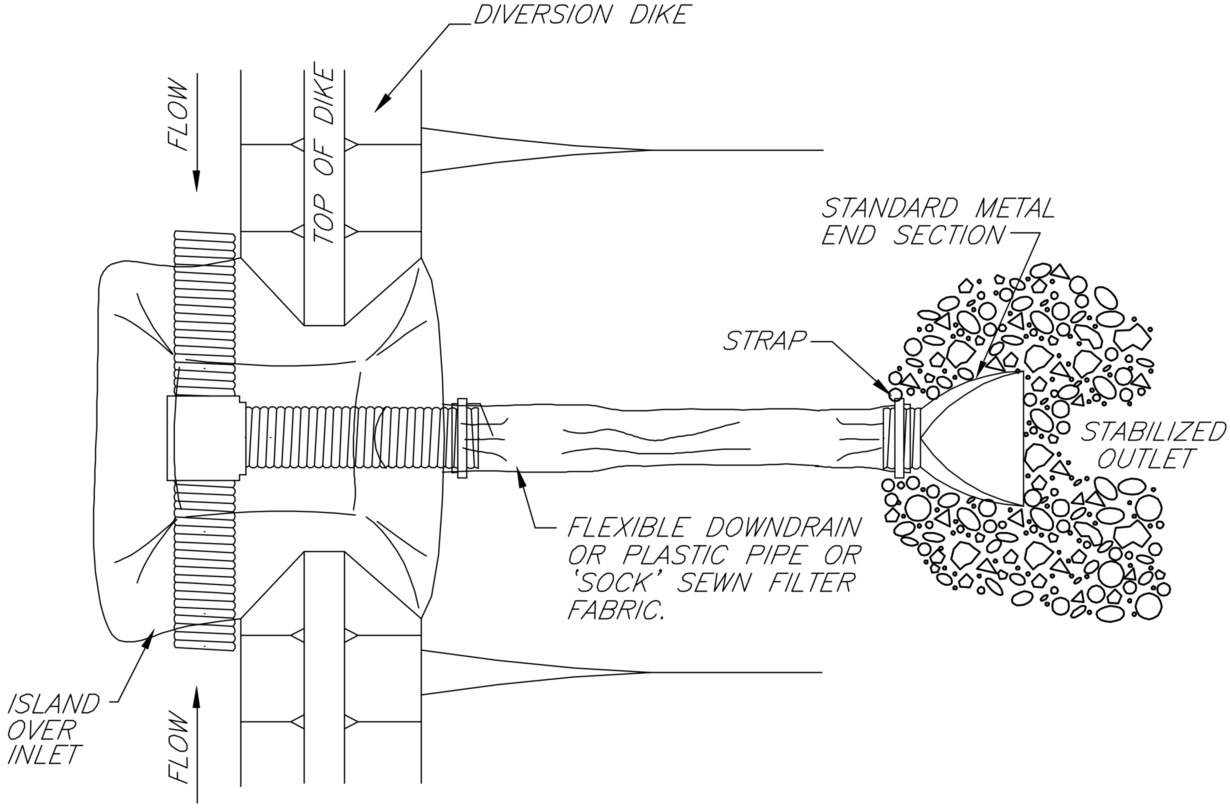
Size of Slope Drain	
Maximum Drainage Area (ha)	**Pipe Diameter (mm)**
0.2	300
0.6	450
1.0	530
1.4	600
2.0	760

Inspection and Maintenance

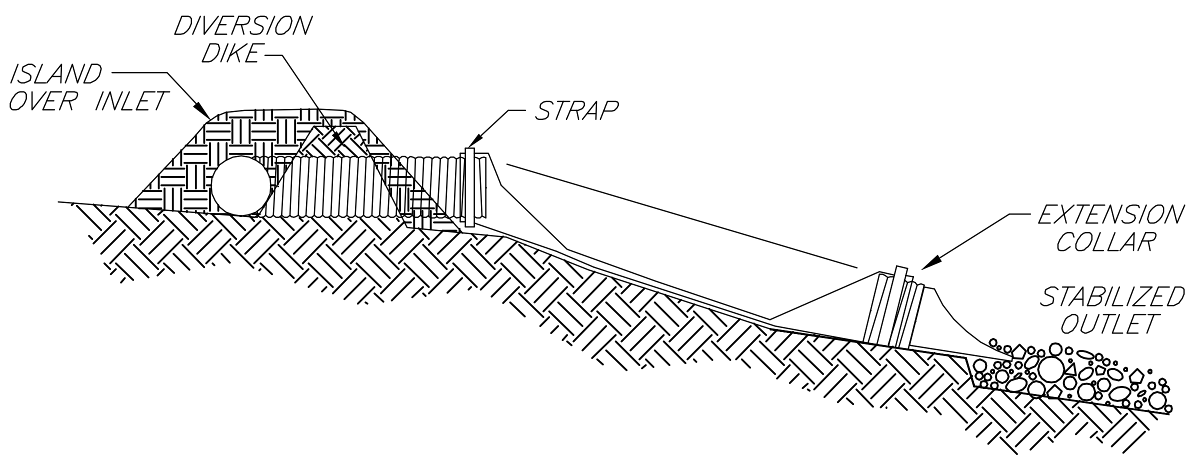
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Repair any damaged section of pipe immediately
- **If evidence exists of pipe movement, install additional anchor stakes to secure and anchor at zones of movement**
- Remove sediment from upslope inflow apron area after each storm event otherwise either downslope sediment transport will occur or cause the drainpipe to be plugged which could result in overtopping of inflow apron structure and sheet flow over slope face

Similar Measures

- Rock lined channel
- Permanent Pipe (slope drains)
  - Corrugated steel pipe (CSP) downdrain (AT Drawing No. CB-6 2.4 M17)
  - Half-round corrugated steel (1/2 CSP) downslope drain (AT Drawing No. CB-6 2.4 M4) for low flow areas such as bridge headslopes



PLAN VIEW



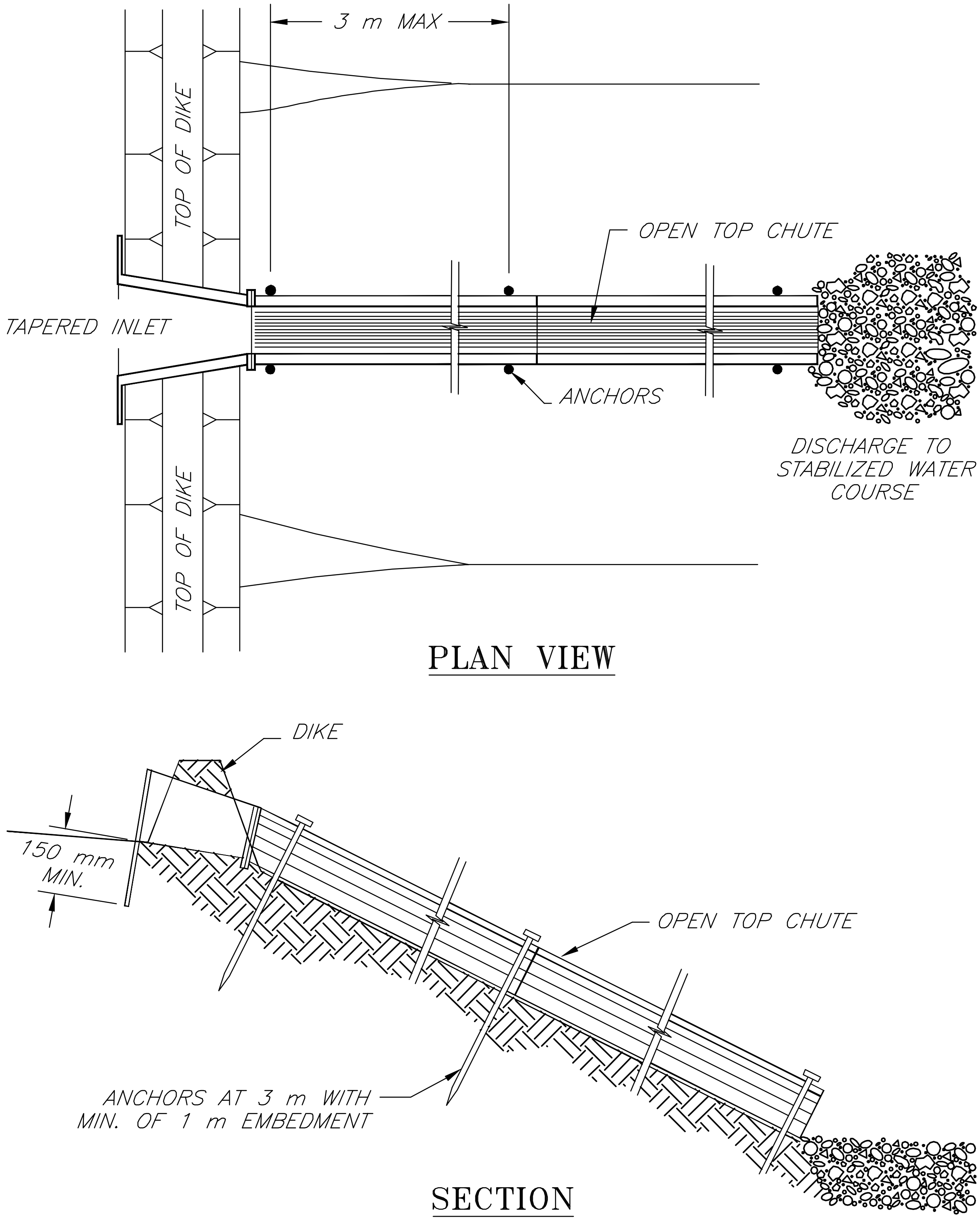
SECTION

NOTE:

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

SLOPE DRAIN

FILE: SLOPEDRN



NOTE:

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

OVERSIDE DRAIN

FILE: OSDRAIN

Groundwater Control (Subsurface Drains or Finger Drains) Sediment Control	B.M.P. #20

Description and Purpose

- Drains that intercept and collect subsurface groundwater and divert it from slope, thus lowering groundwater table to minimize piping erosion reducing seepage flow on slopes and increase slope stability
- Relief drains (perforated finger-drains or French drains) to mitigate high groundwater table to minimize piping erosion

Applications

- Permanent measure
- Used on cutslopes where groundwater seepage exits on slope face

Limitations

- Must be designed by a geotechnical engineer
- Can be expensive to install
- Plugging of drainage outlet can be detrimental to cause build-up of pore pressure; it is mandatory to protect the outlet area to ensure free draining condition

Construction

- Excavate trench at subsurface drain location
- Install drain pipe
- Backfill with clean, coarse drainage gravel and/or non-woven geotextile fabric to provide filtration separation with adjacent soils

Construction Considerations

- When signs of seepage and unstable excavation slope are encountered at excavations, it is advisable to install trench protection measures for safety (i.e., trench box)
- Carry out work as soon as possible to mitigate seepage damage, soil loss and deterioration of unstable slope
- Excavate and install drains to the grade and spacings according to design and recommendations made by the geotechnical engineer
- Protect outlet of drainage with sturdy pipe to ensure free draining condition
- Drains and pipes should be designed with frost penetration and the freezing of pipes in mind

Inspection and Maintenance

- Drains installed below grade will require manhole at frequent intervals (100 m maximum) to facilitate inspection and maintenance
- Flushing and maintenance clean out of drains can be carried out through manhole locations

Offtake Ditch (Intercept Ditch) Erosion Control	B.M.P. #21

Description and Purpose

- Channels or swales commonly located along the crest of cuts slopes to intercept and convey runoff away from flowing down a newly excavated bare soil slope and to minimize erosion of slope from overlanding sheet flow
- Can be tied to outfall to slope drains (or downdrains) which carry water from higher slope elevations to lower elevation of a slope

Applications

- Permanent measure
- Effective method of intercepting runoff to avoid excessive sheet flow over slope and causing erosion, especially on cut slopes in highly erodible soils (sand and silt)
- Can be used in conjunction with slope drains which was installed down a large cut slope
- May be lined with vegetation, rip rap, erosion control blankets, or some other erosion protection measure, but this requirement may be appropriate only at highly sensitive and high risk environmental areas
- Can be used in conjunction with sediment control measures, such as check structures or permeable synthetic barriers as normal channel design, but this requirement may be appropriate only at highly sensitive and high risk environmental areas

Limitations

- Ditch may require lining to minimize soil erosion from concentrated flow
- Ditch may require design by qualified personnel if flow velocities and/or volumes are large
- Channel must be graded to maintain adequate depth, positive drainage to avoid ponding and breaching of channel flow, which may lead to overtopping of the channel to result flow to cause in downslope erosion
- Removal of sediment build up and ditch maintenance may be difficult due to limited access space as offtake ditches are commonly constructed at crest of slopes

Construction

- Use backhoe to form ditch a minimum offset distance of 2 m between crest of highway slope and top of offtake ditch sideslope, thus providing a dyke width of 1 m
  - Place and compact excavated soil to form a dyke between crest of highway slope and offtake ditch channel to provide adequate depth (1 m) of the offtake ditch

- The consequence of failure on this dyke will determine the level of compaction effort required

– Sideslopes of ditch should not be steeper than 2H:1V (depending upon material type)

– Depth of ditch (from base of ditch to top of embankment) should be a minimum of 1 m in depth; width of ditch should be 1 m minimum

– Ditch grade should be graded a minimum of 1% to promote positive drainage and outfall

Construction Considerations

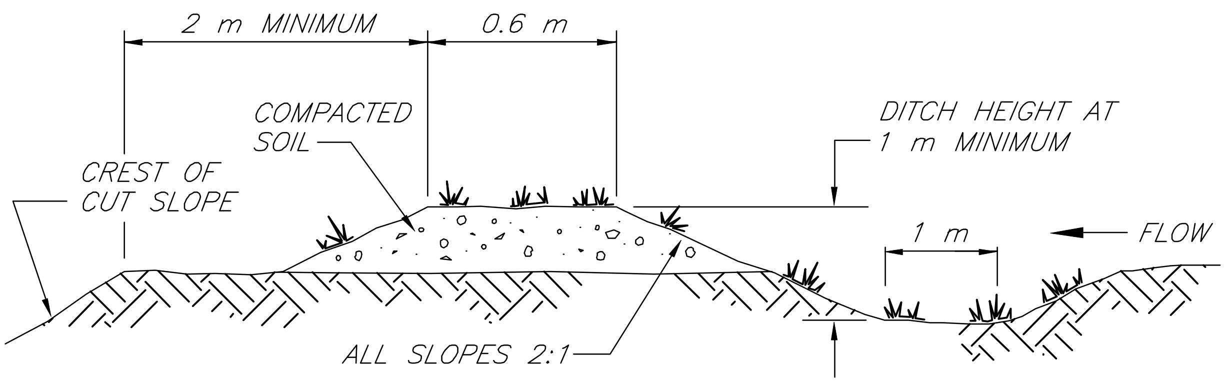
- Channel should be graded towards nearest outfall (draw) or drainage pipe

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Repair any damage to channel immediately

Similar Measures

- Berms
- Barriers



TYPICAL OFFTAKE DITCH

NOTES:

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

OFFTAKE DITCH
(INTERCEPT DITCH)

FILE: TEMPDIKE

Seeding Erosion Control	B.M.P. #22

Description and Purpose

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

Applications

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

Advantages

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

Limitations

- Grasses may require regular maintenance (mowing) along ditches
- Uncut dry grass may present a fire hazard and site distance obstruction adverse to highway safety

- Seeding of steep slopes may be difficult without using measures such as RECP's or hydroseeding-hydromulching methods
- Seasonal windows on planting (early spring or fall) may not coincide favourably with construction schedule
- Areas that have not been covered with seeded topsoil are susceptible to erosion until vegetation is established if RECPs are not used
- Use of topsoil and mulch can reduce rain drop erosion potential during germination and until vegetation is established
- Additional erosion control measures, such as RECPs, may be required for steep slopes and channels
- Reseeding will be required in areas of limited plant growth
- Time to establish root structure may be unacceptable for some high risk areas; shallow sodding should be considered for these areas

Construction

- The site to be seeded should be prepared prior to seeding
- Surface should be graded to design grades and then topsoiled
- Seedbed should be 75 to 150 mm deep, with the top 75 mm consisting of topsoil free of large clods or stones
- Seed should be applied immediately after seedbed preparation using broadcast seed spreaders, cyclone (broadcast) spreaders, or seed drills to ensure uniformity of application
- Seedbed should be harrowed, raked, or chain-dragged to ensure proper seed-soil contact
- Fertilizer should then be applied after seeding

Construction Considerations

- Seeding rate for all mixes should be 25 kg/ha minimum
- Fall rye may be added to each mix to provide early growth and protection from soil erosion.
- Fall rye seeding rate is 5 kg/ha
- Selection of proper vegetation seed mix depends on soil conditions, climate conditions, topography, land use, and site location

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

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Freshly seeded areas should be inspected frequently to ensure growth is progressing
- Additional stormwater control measures should be considered for areas damaged by runoff
- Reseedings may be required within 1 to 5 year intervals after initial seeding
- Small bare spots may need to be reseeded several times at subsequent years after initial application
- Larger areas may need to be completely retreated
- Cutting or mowing grasses will encourage the establishment and spread of the grass

Similar Measures

- Hydraulic seeding and mulching
- Sodding

Design Considerations

- Seed application rate of 25 kg/ha may be used; if fall rye is to be added, it should have an application rate of 5 kg/ha
- When using a seed drill or Brillion seeder, grasses and legumes shall not be planted deeper than 1 cm
- Bacterial inoculants must be used when seeding with legumes
- A specific inoculant shall be used for the legume being seeded in accordance with the supplier's recommendations

- Fertilizer, in lieu of a soil test, shall be as stated in the design, or follow supplier's recommendations
- Fertilizer shall be applied at a rate of 50 to 75 kg of nitrogen/ha, depending upon site conditions
- Fertilizer use shall be carefully controlled as this may increase nutrient loading to receiving streams if runoff is not controlled properly
- Seeding shall occur during periods when germination can be successful and plants have sufficient time to become established before the end of the growing season (approximately May 15 to June 1 and/or August 15 to September 15)
- Seeding should not occur after the 50% frost probability date for the site
- Mulch is required when broadcast seeding or if seeding is carried out after the date specified in which fall seeding should not be carried out
- For specific needs of local growth environment, specific design and advice from local seed supplier or Professional Agrologist may be required

Alberta Transportation has adopted seed mixes (provided below) depending on site location. The various areas of the province used in selecting the seed mix are presented (Alberta Transportation Seed Mixture Zones Map).

Alberta Transportation
Grass Seed Mixtures used on Highway and Bridge Projects

*This Special Provision (*Spc_G039.wpd (2005)*) is to be used in conjunction with AT Standard Specification 2.20 "Seeding" and Design Bulletin No. 25. The Consultant must perform the vegetation assessment and the soil testing for fertilizer (if required) as part of his design work.*

Zone 1 - Peace River District - north and west of High Level:

Seed Mix Zone	**Native Seed Mix - Zone 1**		**% by Dry Weight**
	Common Name	**Latin Name**	
1 Wetland Mixedwood	Slender Wheat Grass	*Agropyron trachycaulum*	40%
	Fringed Brome (1)	*Bromus ciliatus*	15%
	Tufted Hairgrass	*Deschampsia cespitosa*	15%
	Northern Wheat Grass	*Agropyron dasystachyum*	10%
	Rocky Mountain Fescue	*Festuca saximontana*	10%
	Fowl Bluegrass	*Poa palustris*	10%

Note (1): Fringed Brome seed shall be coated.

Agronomic Seed Mix - Zone 1		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	*Agropyron trichophorum*	40%
Dahurian Wildrye	*Elymus dahuricus*	22%
Sheep Fescue	*Festuca ovina*	30%
Perennial Ryegrass	*Lolium perenne*	8%

Zone 2 - Athabasca District (south of Athabasca) and Grande Prairie District

Seed Mix Zone	**Native Seed Mix - Zone 2**		**% by Dry Weight**
	Common Name	**Latin Name**	
2 Dry Mixedwood	Slender Wheat Grass	*Agropyron trachycaulum*	35%
	Fringed Brome (1)	*Bromus ciliatus*	20%
	Tufted Hairgrass	*Deschampsia cespitosa*	10%
	Northern Wheat Grass	*Agropyron dasystachyum*	15%
	Rocky Mountain Fescue	*Festuca saximontana*	10%
	Fowl Bluegrass	*Poa palustris*	10%

Note (1): Fringed Brome seed shall be coated.

Agronomic Seed Mix - Zone 2		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	*Agropyron trichophorum*	40%
Dahurian Wildrye	*Elymus dahuricus*	22%
Sheep Fescue	*Festuca ovina*	30%
Perennial Ryegrass	*Lolium perenne*	8%

Zone 3 - Athabasca District (north of Athabasca) and Hwy. Nos. 88, 750, 986

Seed Mix Zone	Native Seed Mix - Zone 3		% by Dry Weight
	Common Name	**Latin Name**	
3 Central Mixedwood	Slender Wheat Grass	*Agropyron trachycaulum*	35%
	Fringed Brome [1]	*Bromus ciliatus*	10%
	Tufted Hairgrass	*Deschampsia cespitosa*	10%
	Canada Wildrye	*Elymus canadensis*	10%
	Rocky Mountain Fescue	*Festuca saximontana*	20%
	Tickle Grass	*Agrostis scabra*	10%
	Fowl Bluegrass	*Poa palustris*	5%

Note [1]: Fringed Brome seed shall be coated.

Agronomic Seed Mix - Zone 3		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	*Agropyron trichophorum*	40%
Dahurian Wildrye	*Elymus dahuricus*	22%
Sheep Fescue	*Festuca ovina*	30%
Perennial Ryegrass	*Lolium perenne*	8%

Zone 4 - Lethbridge District (east of Hwy 22), Calgary District (east of Hwy 22), and Hanna District

Seed Mix Zone	Native Seed Mix - Zone 4		% by Dry Weight
	Common Name	**Latin Name**	
4 Mixedgrass and Dry Mixedgrass	Slender Wheat Grass	*Agropyron trachycaulum*	30%
	Canada Wildrye	*Elymus canadensis*	15%
	Mountain Brome	*Bromus carinatus*	15%
	Northern Wheat Grass	*Agropyron dasystachyum*	10%
	Western Wheat Grass	*Agropyron smithii*	5%
	Indian Rice Grass	Orzyopsis hymenoides	5%
	Alkali Grass	Puccinellia distans	10%
	Needle and Thread Grass	Stipa comata	10%

Agronomic Seed Mix - Zone 4		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	*Agropyron trichophorum*	32%
Dahurian Wildrye	*Elymus dahuricus*	30%
Sheep Fescue	*Festuca ovina*	30%
Cereal Rye	*Secale cereale*	8%

Zone 5 - Stony Plain, Vermillion, and Red Deer (east of Hwy 22) Districts:

Seed Mix Zone	Native Seed Mix - Zone 5		% by Dry Weight
	Common Name	**Latin Name**	
5 Central Parkland	Slender Wheat Grass	*Agropyron trachycaulum*	25%
	Northern Wheat Grass	*Agropyron dasystachyum*	10%
	Fringed Brome (1)	*Bromus ciliatus*	15%
	Green Needle Grass	*Stipa viridula*	15%
	Canada Wildrye	*Elymus canadensis*	10%
	Indian Rice Grass	*Orzyopsis hymenoides*	10%
	Nuttall's Alkali Grass	*Puccinellia nuttalliana*	10%
	Western Wheat Grass	*Agropyron smithii*	5%

Note (1): Fringed Brome seed shall be coated.

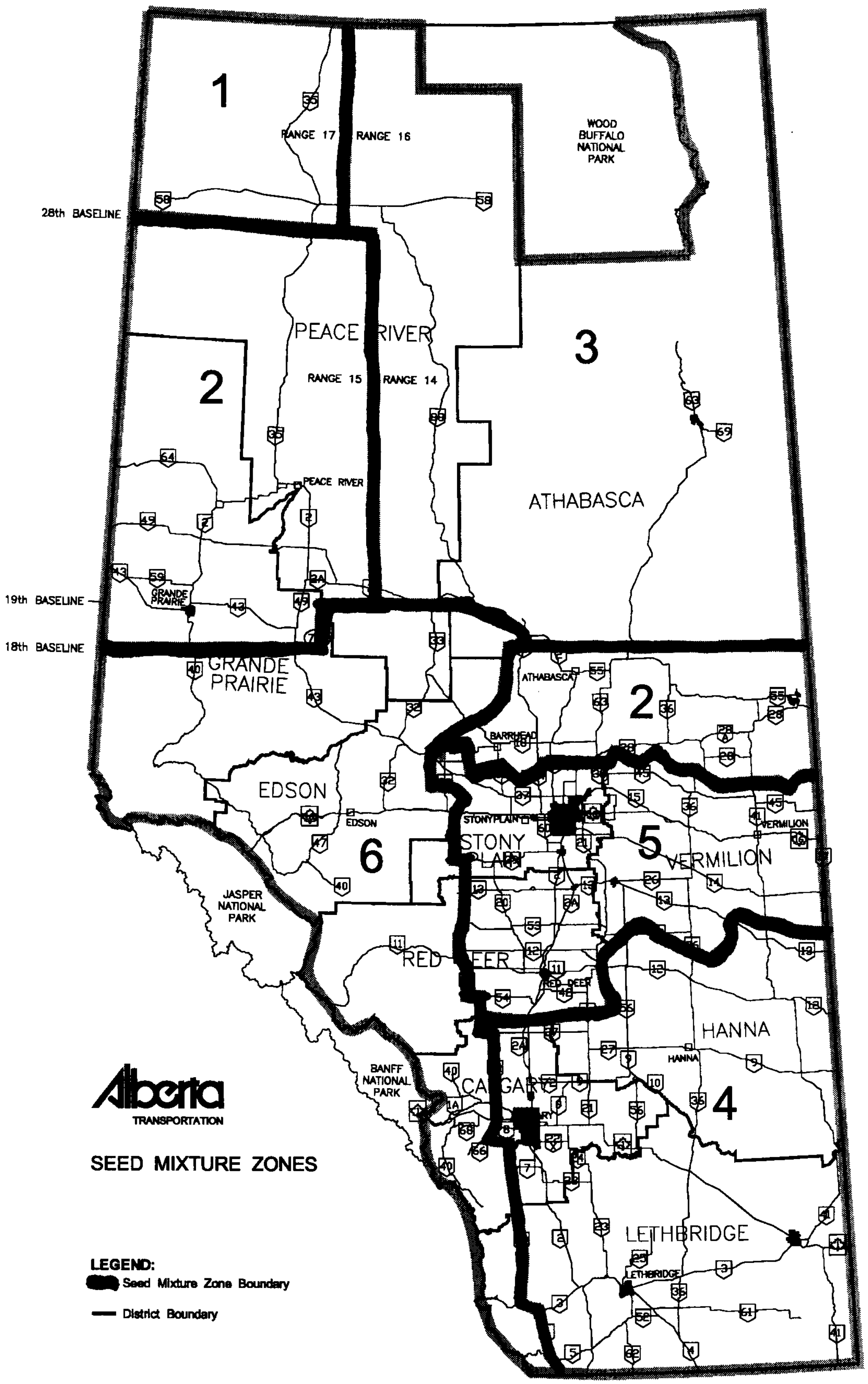
Agronomic Seed Mix - Zone 5		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	Agropyron trichophorum	32%
Dahurian Wildrye	Elymus dahuricus	30%
Sheep Fescue	Festuca ovina	30%
Cereal Rye	Secale cereale	8%

Zone 6 -Lethbridge, Calgary, and Red Deer Districts all located west of Hwy 22):

Seed Mix Zone	Native Seed Mix - Zone 6		% by Dry Weight
	Common Name	**Latin Name**	
6 Lower Foothills	Slender Wheat Grass	Agropyron trachycaulum	30%
	Smooth Wildrye	Elymus glaucus	20%
	Northern Wheat Grass	Agropyron dasystachyum	10%
	Tickle Grass	Agrostis scabra	10%
	Fringed Brome (1)	Bromus ciliatus	10%
	Tufted Hairgrass	Deschampsia cespitosa	10%
	Foothills Rough Fescue	Festuca campestris	10%

Note (1): Fringed Brome seed shall be coated.

Agronomic Seed Mix - Zone 6		
Common Name	**Latin Name**	**% by Dry Weight**
Pubescent Wheat Grass	Agropyron trichophorum	40%
Dahurian Wildrye	Elymus dahuricus	22%
Sheep Fescue	Festuca ovina	30%
Perennial Ryegrass	Lolium perenne	8%



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SEEDMIXZONE.DWG

Mulching Sediment Control and Erosion Control	B.M.P. #23

Description and Purpose

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

Applications

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

Advantages

- Relatively cheap method of promoting plant growth and slope protection

Limitations

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

Installation

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil and seed, if required, and if topsoil is readily available
- Apply mulch as per supplier's recommendations

- Certain mulches may require additional anchoring to minimize loss of mulch due to wind or water erosion

Construction Considerations

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

- Decompose slowly
- Suitable for placing around individual plants (shrubs and trees) and for areas that will not be closely mowed
- Highly resistant to removal by blowing wind and water runoff

– Bark Chips (Shredded Bark)

- By-products of timber processing comprised of small, thin pieces of tree bark
- Suitable for areas that will not be closely mowed
- Have good moisture retention properties and are resistant to removal by blowing wind and water runoff

– Pine Needles

- Comprise needles from coniferous trees (pine, spruce)
- Needles should be air dried and free of coarse material
- Decompose slowly
- Suitable for use with plants that require acidic soils
- Resistant to removal by blowing wind and water runoff

– Compost (Straw Manure)

- Comprised of organic residues and straw that have undergone biological decomposition until stable
- Should be well shredded, free from coarse material, and not wet
- Has good moisture retention properties and is suitable as a soil conditioner promoting plant growth
- Relatively resistant to removal by blowing wind and water runoff if not dried out completely

– Chemical Mulches

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

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by washout or rilling should be regraded if necessary and recovered with mulch immediately
- Additional stormwater control measures should be considered for areas of severe rilling erosion damaged by runoff
- Small bare spots may need to be reseeding and recovered with mulch

Similar Measures

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

Hydroseeding Sediment Control and Erosion Control	B.M.P. #24a

Description and Purpose

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

Applications

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

Limitations

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

Hydroseeding Sediment Control and Erosion Control	B.M.P. #24a

Construction

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

Construction Considerations

- Seed
  - – Seed selection should be made in accordance with Alberta Transportation approved seed mixes
  - – Alberta Transportation has adopted seed mixes used on Alberta Highway and Bridge Projects depending on site location (see BMP #22 Seeding)
  - – The various areas of the province used in selecting the seed mix are presented in the Seed Mix Zones map (see BMP #22 Seeding)
  - – Seed mixes have been developed based on historic performance results throughout Alberta

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion
- Small bare spots may need to be reseeded

Similar Measures

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

Description and Purpose

- The spraying-on of a slurry to a slope or channel surface to provide a layer of growth bedding medium
- The slurry consists of seed, fertilizer, mulch, tackifiers, and water which are mixed together in a tank
- The slurry conserves moisture, reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation or drying of soil

Applications

- Temporary measure
- Can be used in areas where little topsoil is available

Advantages

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

Limitations

- Site must be accessible to hydromulching equipment
  - Usually mounted on trucks
  - Maximum hose range of approximately 150 m

Construction

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

Construction Considerations

- Hydraulic Mulches
  - Cellulose
    - Comprised of recycled paper from newspapers, magazines, or other paper sources
    - Rapid method for applying seed, fertilizer, mulch, and water in almost any disturbed areas
    - Usually installed without tackifier in slurry
    - Short fibre lengths and lack of tackifier limits erosion control effectiveness and does little to moderate moisture content and temperature within the soil
    - Residual inks within the recycled paper may leach into soil, potential problem on environmentally sensitive areas
    - Longevity significantly shorter than for wood fibre mulches or bonded fibre matrices (BFM)
    - Cheaper than wood fibre mulches and bonded fibre matrices (BFM)
  - Wood Fibre
    - Comprised of whole wood chips
    - Industry standard, provides quick and uniform method and medium for re-vegetating large areas quickly and economically
    - Longer fibre lengths than for cellulose mulches
    - Longer lasting and has better wet-dry characteristics than cellulose mulches
    - Provides limited erosion control even when sprayed on with tackifiers
    - Provides limited moderation of soil moisture content and temperature when applied at higher rates
    - Cheaper than BFM, however, less effective than BFM
    - More expensive than cellulose mulches, however, more effective than cellulose mulches

- Bonded Fibre Matrices (BFM)
  - Slurry comprised of either cellulose mulch, wood fibre mulch, or a combination of the two
  - Mulches are bound together using chemical bond, mechanical bond, or a combination of the two
  - All fibres and binding agents are premixed by manufacturer, ensuring uniformity and consistency throughout the application
  - Well suited for sites with existing desirable vegetation and where worker safety and minimal ground disturbance are desired
  - Degree of protection similar to that obtained from rolled erosion control products (RECP)
  - Quicker installation/application than for RECP
  - Chemically bonded BFM may require a 'set-up' or curing/drying period
    - Application must be limited to periods where there is no threat of rain during curing period
    - Mechanically bonded BFM have no curing time and are effective immediately after application
  - Application on dry soils is not recommended
  - More expensive than cellulose and wood fibre mulches
  - More effective than cellulose or wood fibre mulches

- Tackifiers
  - May include vinyl compounds, asphalt, rubber, or other substances mixed with water

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion.

Similar Measures

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

Topsoiling Erosion Control	B.M.P. #25

Description and Purpose

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

Applications

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

Advantages

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

Limitations

- Not appropriate for slopes steeper than 2H:1V
- Placing and grading topsoil can be time consuming and expensive
- Dry topsoil may be removed by blowing wind
- Topsoil may not be readily available in some areas

Construction

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

Topsoiling Erosion Control	B.M.P. #25

Construction Considerations

- Topsoil should be free of weeds which may inhibit re-vegetation of desirable plants (i.e., grass)
- Subgrade should be roughened by track walking up/down the slope prior to topsoiling to promote adhering of topsoil to subgrade (surface roughening of subgrade is especially required if topsoiling is not scheduled immediately after completion of the grade)
- Topsoil should be moistened regularly during periods of hot dry weather to minimize wind erosion
  – Hydroseeding-hydromulching topsoil will minimize wind erosion of topsoil

Design Considerations

- Perform pre and post disturbance survey
- Consider use of a soil mimic in areas with little topsoil or topsoil with poor growth nutrients
- Perform a preconstruction topsoil assessment to determine topsoil thickness hence design thickness

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by washout or rilling should be regraded and re-topsoiled immediately

Similar Measures

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

Sodding Erosion Control	B.M.P. #26

Description and Purpose

- Use of grass sod to cover and stabilize disturbed areas of bare soil
- Rapidly establishes vegetative cover in environmentally sensitive areas where complete cover of the disturbed soil surface is essential and conventional or hydroseeding and mulching may not be effective to erosion protection for high risk areas
- Acts as a vegetative buffer
- 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

- Temporary or permanent measure
- Irrigation (watering) required after placement
- May be used to protect soil surface from water and wind erosion where adequate topsoil and fertilizer can be provided
- Best used for areas that have steep grades or require immediate protection, or at locations where aesthetic appearance is a priority

Advantages

- Immediate protection for sensitive area from water and wind erosion
- Aesthetically pleasing

Limitations

- Expensive
- Labour intensive to install
- Sod may not be readily available in all areas of the province
- 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 can’t be stored on-site for long periods of time

Construction

- Prepare smooth ground surface by removing large rocks or other deleterious materials
- Apply design thickness of topsoil and fertilizer (if required)

- Lay sod strips on prepared surface with long axis perpendicular to direction of slope (or in channels, perpendicular to anticipated direction of flow)
  - Butt-joint ends of adjacent sod strips tightly together
  - Roll or tamp each sod strip to ensure continuous contact between topsoil and underside of sod strip
  - 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 should have staggered joints

Construction Considerations

- Sod must not be placed on frozen ground
- During hot and dry periods, topsoil should be cool and wetted by irrigation prior to placing sod strips
- Freshly installed sod should be irrigated (watered) to moisten the topsoil to minimum depth of 0.1 m
  - Irrigation aids in the development of root matrix within the topsoil
- Successful installation requires the use of freshly cut, healthy sod
  - Storage time of cut sod on-site prior to installation should be kept to as short a time period as possible

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
  - Areas damaged by washout or rilling should be regraded and resodded immediately
- Additional erosion control measures should be considered for rilled or gullied areas
- Small bare spots may need to be resodded
- Sodded areas should be maintained by periodically fertilizing, irrigating (watering), mowing, and weed control, depending on location and maintenance plan
- Sod that is to be mowed periodically as part of its maintenance plan should not be mowed within one month of installation
- Grass clipping from mowing operations should be left on the sod unless they accumulate to a depth greater than 1 cm

Similar Measures

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

Live Staking Streambank Stabilization Technique	B.M.P. #27a

Description and Purpose

- Consists of installing woody plantings (trees and shrubs) to develop a root matrix within the soil, increasing subsurface soil strength and stabilizing slopes with deeper root systems than grasses
- Reduces erosion potential of slopes and channel banks

Applications

- Temporary or permanent measure
- May be used on slopes stable enough to support vegetation; however, there is a low success rate for steep slopes and channel banks with gradients greater than 1H:1V
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as bio-engineering stabilization in cases where there have been historical shallow slope instability, soil movements on eroded slopes and gullies
- May be used along channels to provide higher channel roughness to reduce flow velocity and in sedimentation ponds to provide higher sedimentation duration of runoff impoundment

Advantages

- Promotes development of organic mat
- Dense leaves and large diameter plant stalks increases channel roughness and reduces flow velocities in channel thus decreasing erosion potential
- Traps sediment laden runoff and stabilizes soil
- Aesthetically pleasing once developed
- Grows stronger with time as root structure develops
- Usually has deeper root penetration than grass with greater depth of stabilization
- Manual planting may be attempted on steep slopes that are sensitive to machinery disturbance or represent an area of high erosion potential

Live Staking Streambank Stabilization Technique	B.M.P. #27a

Limitations

- Can be labour intensive to install
- Some level of uncertainty as success of plant growth is dependent on various unknown site parameters (i.e., moisture, soil, terrain, weather, seeding conditions, etc.)
- Re-vegetated areas are susceptible to erosion until vegetation develops; and should be used in conjunction with hydroseeding and/or mulching
- Plants may be damaged by wildlife
- Potential for low success rate
- Few precedents as this measure is generally not used on AT construction projects

Construction

- Used on cut or fill slopes or in ditches/channels
- Comprised of willow or poplar stakes inserted into the ground; other indigenous plants may be acceptable
- Individual dormant willow or poplar stakes should be cut to a minimum length of 0.5 m using pruning shears
  - Cuts should be made at a 45° angle a minimum of 0.05 m (5 cm) below a leaf bud
  - All side shutes should be trimmed to within 0.05 m of the main stem
- Install live stakes in a 1 m by 1 m grid
- Make a pilot hole a minimum of 0.3 m in depth to insert live stake into
  - Use iron bar, broom handle or other tool to make pilot hole
- Insert live stake into pilot hole and lightly tamp soil around live stake
- A minimum of two leaf buds should remain above grade

Construction Considerations

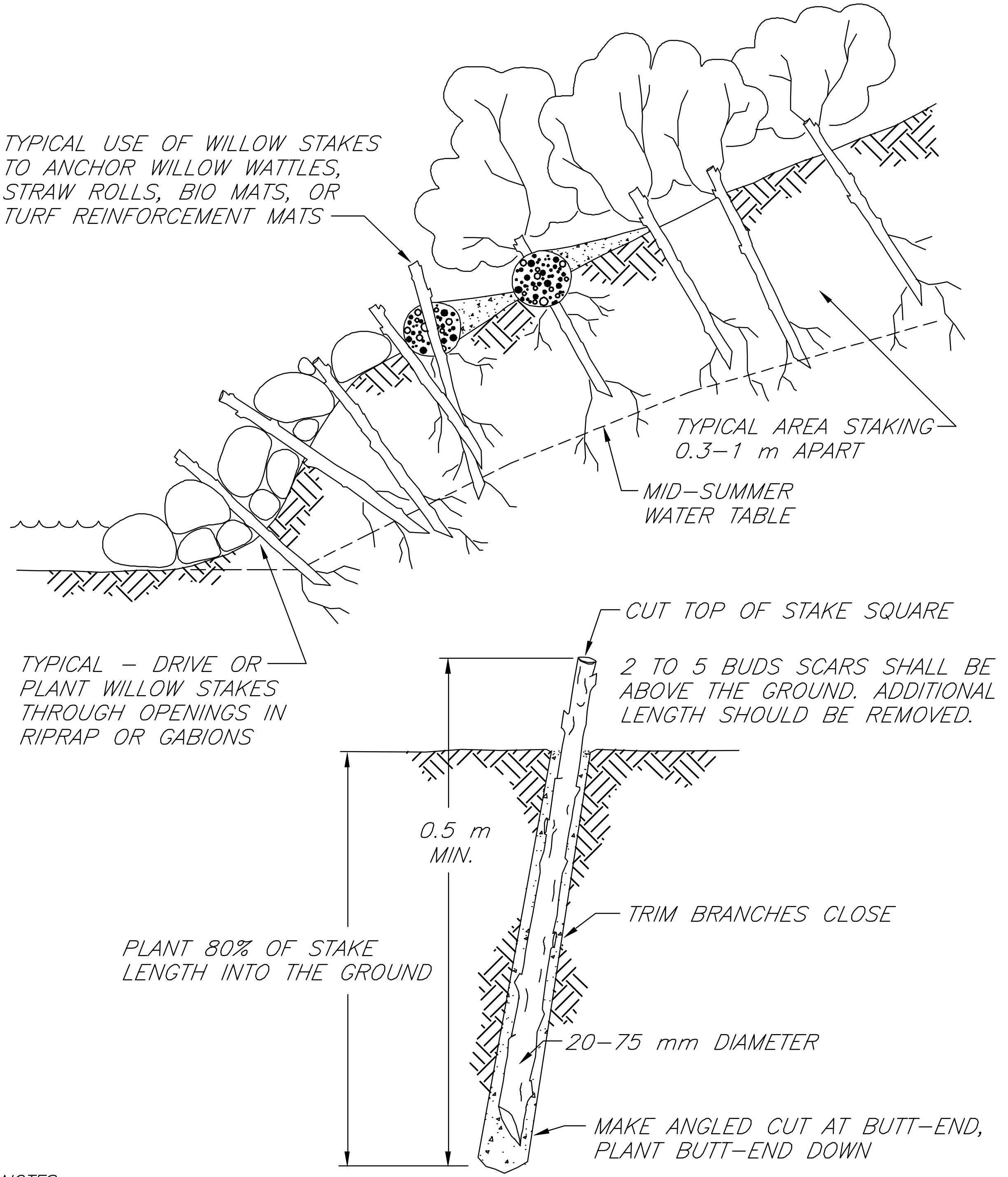
- Successful installation requires the use of freshly cut branches or stakes
  - Storage time of cut branches/stakes on-site prior to installation should be kept to as short a time period as possible
- Successful growth dependant on soil moisture and rainfall conditions
- Consultation with agrologist, greenhouse growers, local expertise can be beneficial in selecting and procuring appropriate species for planting

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
  – Areas damaged by washout or erosion rilling should be replanted immediately
- Additional stormwater control measures should be considered for severe rilling areas damaged by runoff
- Watering plants is required for first one to two months after planting

Similar Measures

- Seeding
- Mulching
- Hydroseeding
- Hydromulching
- Rolled erosion control products (RECP)
- Brush layering



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

NOT TO SCALE

LIVE STAKING

FILE: LIVESTK

Government of Alberta ■
Transportation

B.M.P. #27a
Typical Section

Brushlayering Streambank Stabilization Techniques	B.M.P. #27b

Description and Purpose

- Consists of installing woody plantings (trees and shrubs) to develop a root matrix within the soil, increasing subsurface soil strength and stabilizing slopes with deeper root systems than grasses
- Reduces erosion potential of slopes

Applications

- Temporary or permanent measure
- May be used on slopes stable enough to support vegetation; however, there is a low success rate for steep slopes with gradients greater than 1H:2V
- May be used on slopes with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as bio-engineering stabilization in cases of historical shallow slope instability soil movements on eroded slopes and gullies
- May be used to reduce flow velocity and in sedimentation ponds to provide higher sedimentation duration of runoff impoundment
- Particularly appropriate for highway embankments that encroach upon riparian areas or floodways
- Slopes that need additional geotechnical and erosion reinforcement are good candidates for brushlayering
- Steeper slopes require the use of inert reinforcements such as geotextiles (ECBs, TRMs, coir netting), wire (twisted or welded gabion wire) or geogrids
- If either steady, long term seepage or temporary bank return flows after flood events are a problem, the brushlayers act as a horizontal drainage layer or conduits that relieve internal pore water pressure

Advantages

- Promotes development of organic mat
- Dense leaves and large diameter plant stalks increases channel roughness and reduces flow velocities in channel thus decreasing erosion potential
- Traps sediment laden runoff and stabilizes soil
- Aesthetically pleasing once developed
- Grows stronger with time as root structure develops

- Usually has deeper root penetration than grass with greater depth of stabilization
- Manual planting may be attempted on steep slopes that are sensitive to machinery disturbance or represent an area of high erosion potential
- Of all vegetative biotechnical techniques, brushlayering has the greatest capacity for becoming successfully established, even in severe sites
- The use of synthetic geotextiles or geogrids provides long-term durability and greater security, especially if woody and herbaceous vegetation is established
- Can be used with other toe protection such as, rootwads, coir rolls, and log toes. Combining live brushlayering with rock toes is an effective and relatively low cost technique for re-vegetating and stabilizing streambanks
- Provide immediate soil stability and habitat
- Brushlayers and the pioneer vegetation that develops with them allow the establishment of a stable soil-root complex
- Both living and non-living brushlayers along streambanks enhance fish habitat, while slowing velocities along the bank during flooding flows
- They provide a flexible strengthening system to fill slopes. A bank can sag or distort without pulling apart the brushlayers
- Act as horizontal drains and favourably modify the soil water flow regime

Limitations

- Can be labour intensive to install
- Some level of uncertainty as success of plant growth is dependent on various unknown site parameters (i.e., moisture, soil, terrain, weather, seeding conditions, etc.)
- Plants may be damaged by wildlife
- Potential for low success rate
- Few precedents as this measure is generally not used on AT construction projects
- Brushlayers are vulnerable to failure before rooting occurs, and they are not effective at counteracting failure along very deep-seated failure planes

Construction

- First construct any lower bank or in-stream stabilizing measures such as a rock or log toe structure
- Excavate the first horizontal bench, sloping back into the hillslope at about 10%

- Install any drainage required along the back of each bench
- Place branches that are at least 1.8 m long on the bench
- Branches should crisscross at random with regard to size and age
- Place 20 branches per linear m on the bench, with the butts of the branches along the inside edge of the bench
- 20-45 cm of the growing tip should protrude beyond the face of the slope
- Cover and compact (add water if necessary) the brushlayer with 15 cm lifts of soil to reach the designed vertical spacing, typically 0.5 m to 1.2 m apart
- Slope the top of each fill bench back into the hill
- Construct another brushlayer
- When placed, the protruding tips of the cuttings are above the butts due to the back slope of the bench
- Proceed up the bank as desired
- The erosion and failure potential of the slope (i.e., drainage, soil type, rainfall, and length and steepness of the slope) determine spacing between the brushlayers
- On long slopes, brushlayer spacing should be closer at the bottom and spacing may increase near the top of the slope

Construction Considerations

- Successful installation requires the use of freshly cut branches or stakes
  - Storage time of cut branches/stakes on-site prior to installation should be kept to as short a time period as possible
- Successful growth dependant on soil moisture and rainfall conditions
- Consultation with agrologist, greenhouse growers, local expertise can be beneficial in selecting and procuring appropriate species for planting
- Installed during soil fill operations which result in the branches being inserted deeply into the slopes and thereby increasing the likelihood that the branches will encounter optimum soil and moisture conditions
- Live cuttings are most effective when implemented during the dormancy period of chosen plant species
- Live willow branches (or cuttings of other adventitiously-rooting species) at least 1.8 m long, with a minimum diameter of 20 mm
- Heavy equipment is usually employed for the construction of embankments

- A bucket loader and/or backhoe or excavator can facilitate the work
- Water should be available for achieving optimum soil moisture

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Inspect planted areas at least twice per year or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
  - Areas damaged by washout or erosion rilling should be replanted immediately
- Additional stormwater control measures should be considered for severe rilling areas damaged by runoff
- Watering plants is required for first one to two months after planting
- The live cuttings or branches should establish successfully without irrigation requirements given the proximity to water
- Inspect the cuttings for adequate vegetative establishment (as evidenced by root and shoot production from the imbedded stems) and for signs of localized erosion such as rilling from runoff or sloughing from stream scour
- Brushlayer treated streambanks should also be inspected for localized slope movements or slumps
- These localized slope failures and/or areas of poor vegetative establishment can often be repaired by re-installing the brushlayers in these zones
- The site should be examined for possible signs of flanking erosion, which must be addressed with ancillary protective measures lest the flanking threatens the integrity and effectiveness of the protective brushlayer fill
- As with all resistive streambank structures, flanking is always a potential problem
- If frozen soil is employed in constructing the soil lifts between brushlayers, some settlement may occur when the soil thaws. This settlement may falsely signal a slope failure
- The most likely causes of failure are the following:
  - Inadequate reinforcement from the brushlayer inclusions, i.e., too large a vertical spacing or lift thickness for the given soil and site conditions, slope height, slope angle, and soil shear strength properties
  - Inadequate tensile resistance in the brushlayers as result of too small an average stem diameter and/or too few stems per unit width

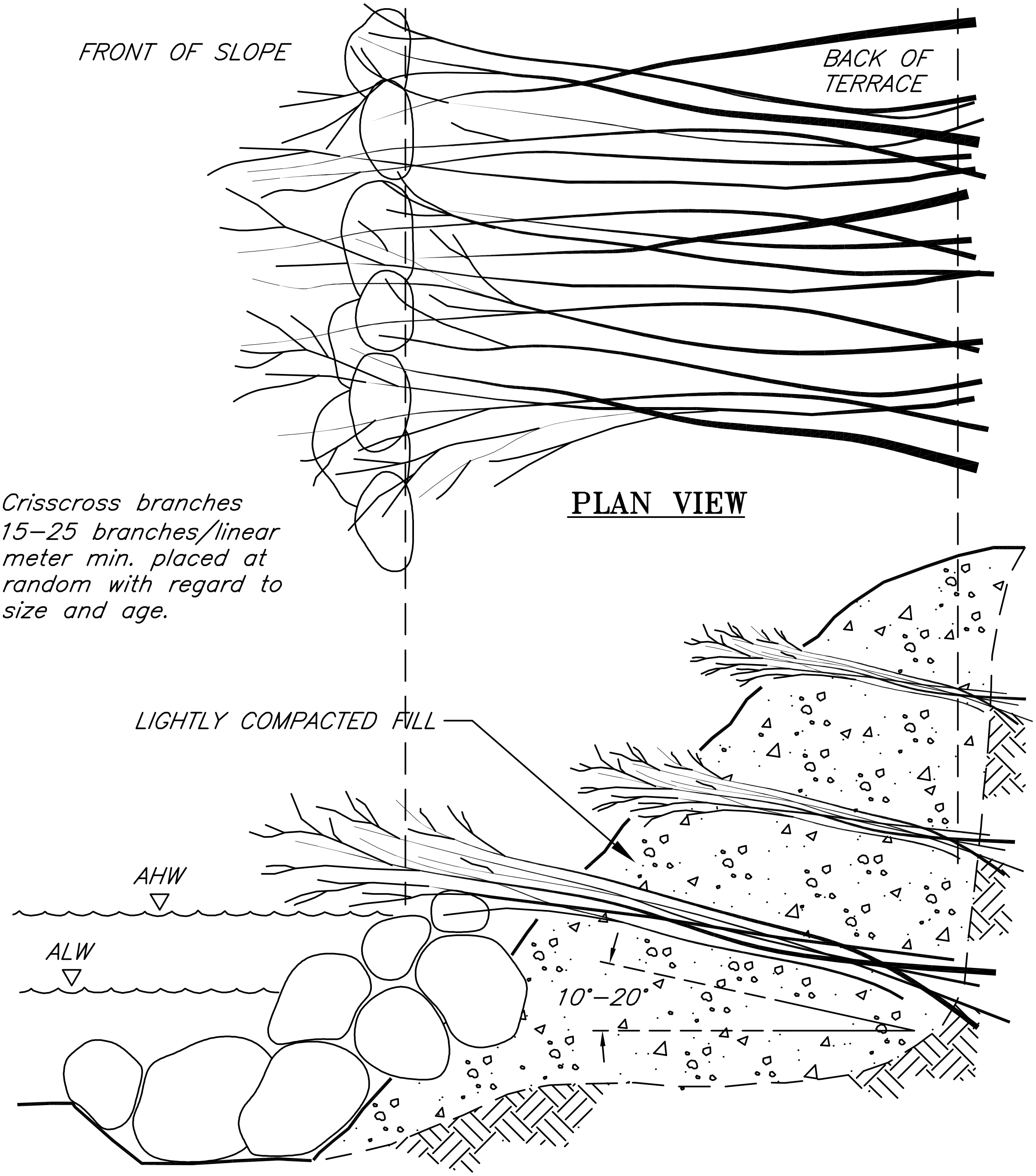
– Failure to properly consider seepage conditions and install adequate drainage measures, e.g., chimney drain, behind brushlayer fill, and conversely inadequate moisture applied during installation, and inadequate attention to construction procedures and details

Design Considerations

- Live branches and brushy cuttings are used to make brushlayers
- Up to 30% of the brush may be non-rooting species that provide immediate strength to the soil mass, but will then rot away
- Plant material harvesting and installation should be performed during its dormant season (late fall to early spring) or in other seasons if soil moisture is available
- The ideal plant materials for brushlayers are those that:
  – root easily
  – are long, straight and flexible
  – are in plentiful supply near the job site
- Willow makes ideal brushlayer material, and some species of *Baccharis*, *Cornus*, and *Populus* also have very good rooting ability
- All cuttings should be soaked for a minimum of 24 hours, whether they are stored or harvested and immediately installed
- Brushlayer reinforced fills must have adequate internal stability
- This means that the tensile inclusions, i.e., the brushlayers, should have a sufficient unit tensile resistance and/or be placed in sufficient numbers to resist breaking in tension
- The inclusions must also be sufficiently long and "frictional" enough to resist failure by pullout
- Allowable velocity for brushlayering is 3.7 m/s and allowable shear stress is 19 to 300 N/m^2 depending on how long the brushlayers have had to establish
- Schiechtl & Stern (1996) suggest an allowable shear stress of 140 N/m^2

Similar Measures

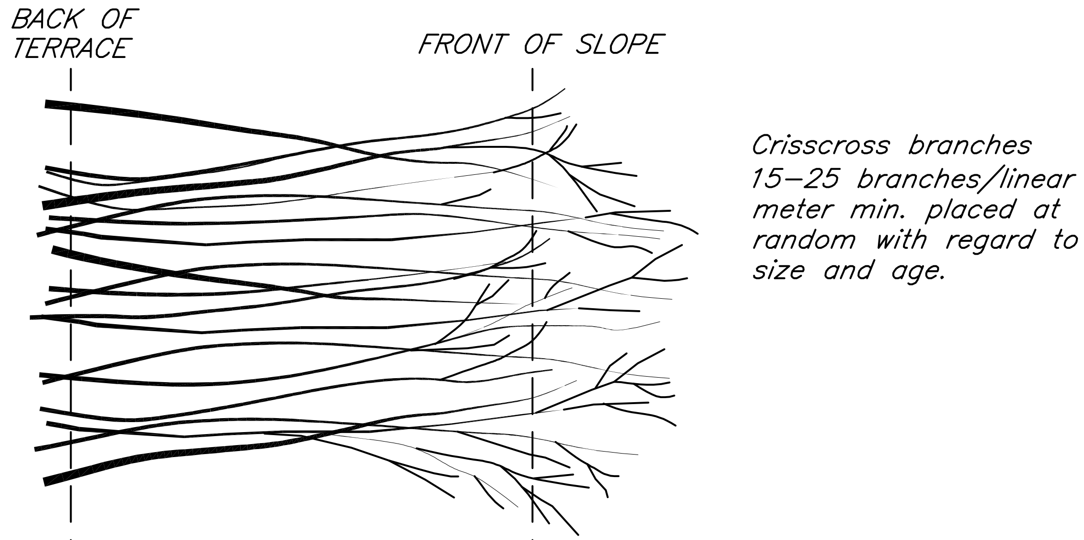
- Seeding
- Mulching
- Hydroseeding
- Hydromulching
- Rolled erosion control products (RECP)
- Live Staking



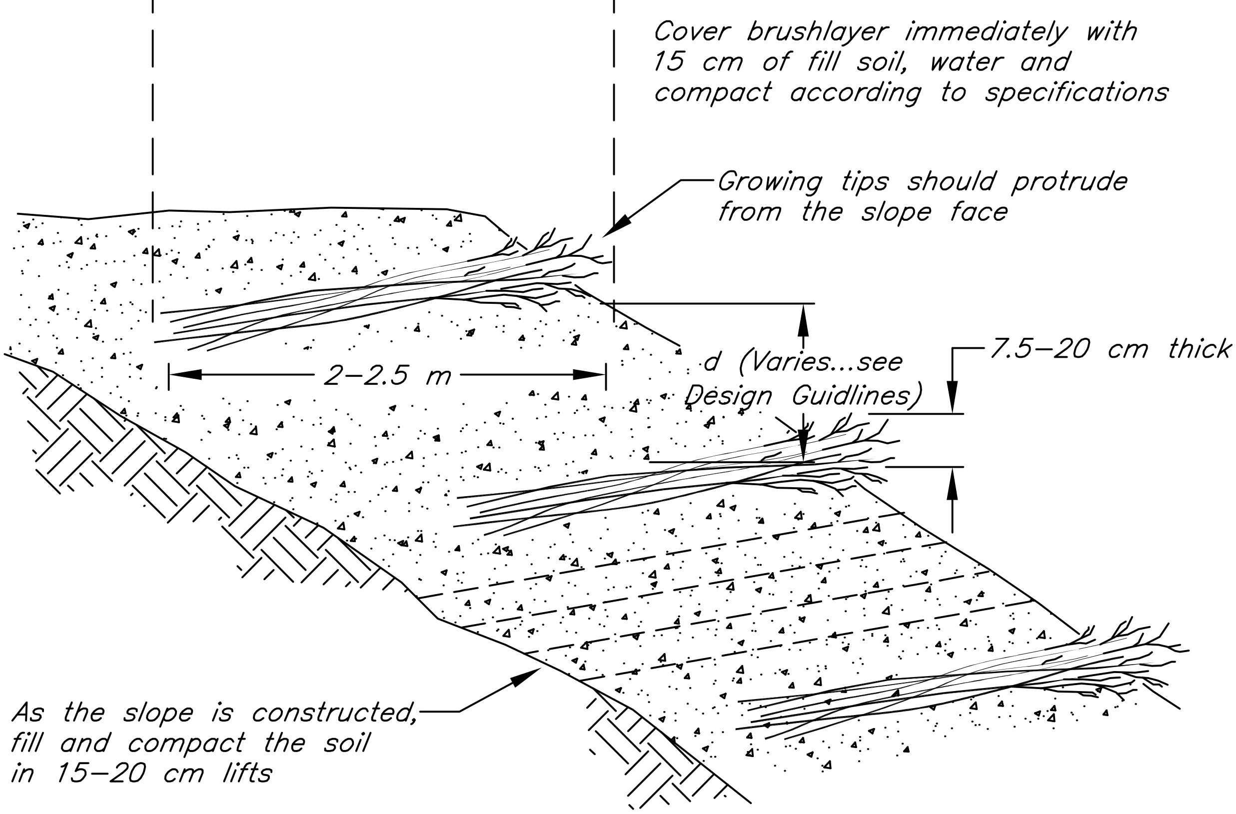
NOTES:
1. Tilt branches down into the slope 10°–20° min.
2. Brushlayering may be constructed with non–compacted or compacted backfill without damage to the brush layer.
3. Branches irrespective of length, should protrude 20–45 cm beyond the face of the slope.

BRUSHLAYERING WITH ROCK TOE PROTECTION

FILE: BRLAY–RT



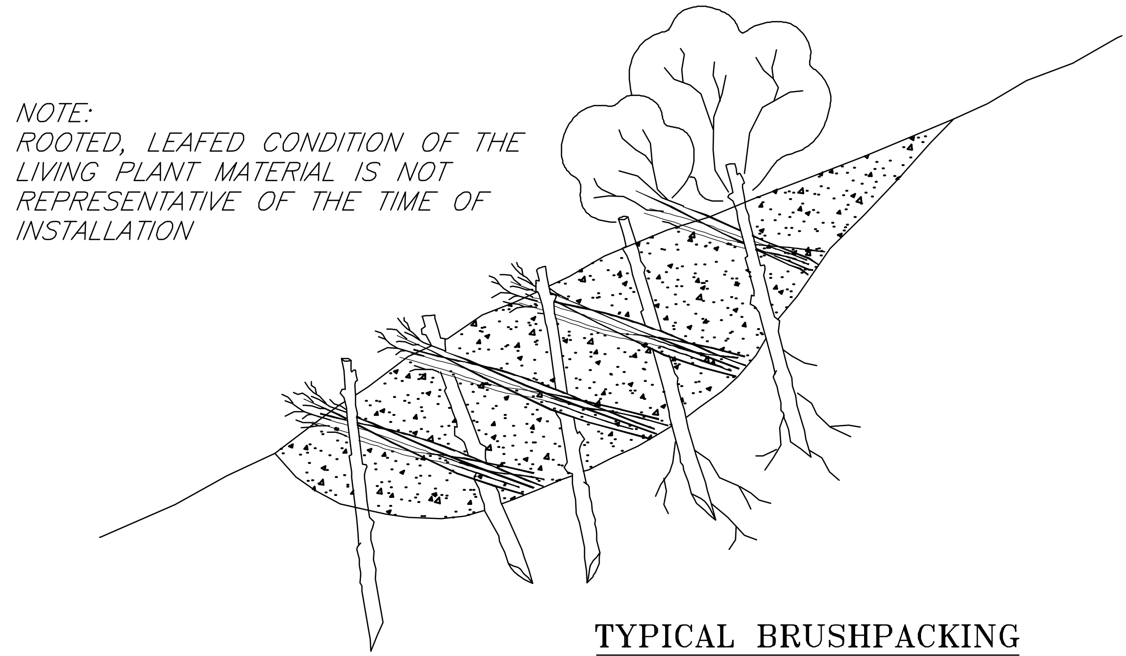
PLAN VIEW



TYPICAL BRUSHLAYERING WITH SLOPE CONSTRUCTION

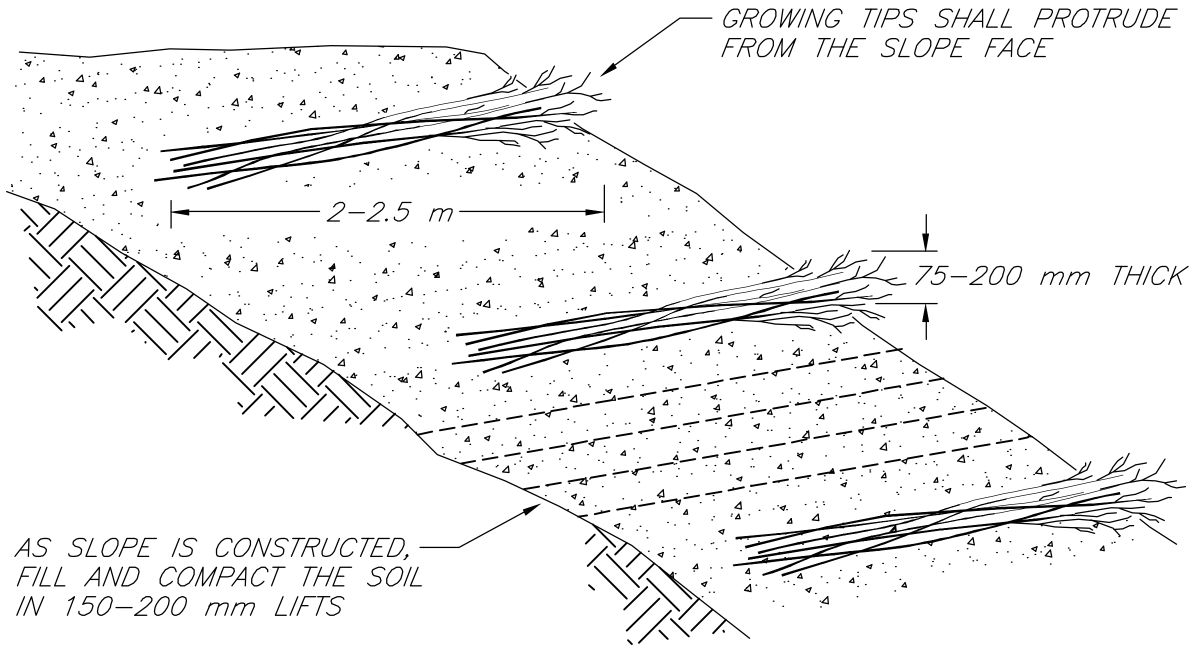
BRUSHLAYERING

FILE: BRSHLAYR



TYPICAL BRUSHPACKING

COVER BRUSHLAYER IMMEDIATELY WITH
150 mm OF FILL SOIL, WATER AND
COMPACT ACCORDING TO SPECIFICATIONS



TYPICAL BRUSHLAYERING
WITH SLOPE CONSTRUCTION

NOTE:

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

BRUSHLAYERING

FILE: BRSHLAYR

Wattles (Live Fascine) Sediment Control	B.M.P. #28

Description and Purpose

- Wattles consist of bundled live fascine to stake into the soil along slope contours
- Normally live staking can be installed to anchor the wattles to provide deep root vegetation with potential favourable moisture retention provided by wattles
- Wattles also capture sediment, organic matter, and seeds carried by runoff

Applications

- Temporary measure
- May be used on slopes stable enough to support vegetation (steep, confined, slopes and channel banks with gradients greater than 1H:1V may have low success potential)
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as grade breaks, where slopes transition from flatter to steep gradients
- May be used on lake shores as wave break to assist in revegetation and stabilization of banks
- Can be used in conjunction with live staking as bioengineering measure

Advantages

- Grade break measure to lower sheet and rill erosion potential
- Can be used on slopes too steep for silt fences or straw bales sediment barriers

Limitations

- Designed for low sheet flow velocities
- Designed for short slopes with a maximum gradient of 1H:1V
- May be labour intensive to install
- Few precedents as this measure is generally not used on AT construction projects
- Susceptible to undermining and failure if not properly keyed into the soil

Construction

- Prepare slope face and remove large rocks or other deleterious materials

- Excavate small trenches a minimum of 0.15 m deep and 0.15 m wide across the width of the slope, perpendicular to slope direction, starting at the toe of the slope and working upwards towards crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place wattles into trench ensuring continuous contact between wattles and soil surface
- Butt-joint adjacent wattle segments tightly against one another
- Use a metal bar to make pilot hole through middle of the wattle a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1 m apart
- Secure wattle to soil using wooden stake or other appropriate anchor; live stake may be used as alternate anchor
- Place soil excavated from trench on upslope side of wattle and compact to minimize undermining of wattle by runoff
- Seed the soil along the upslope and downslope sides of the wattle to promote vegetation growth

Construction Considerations

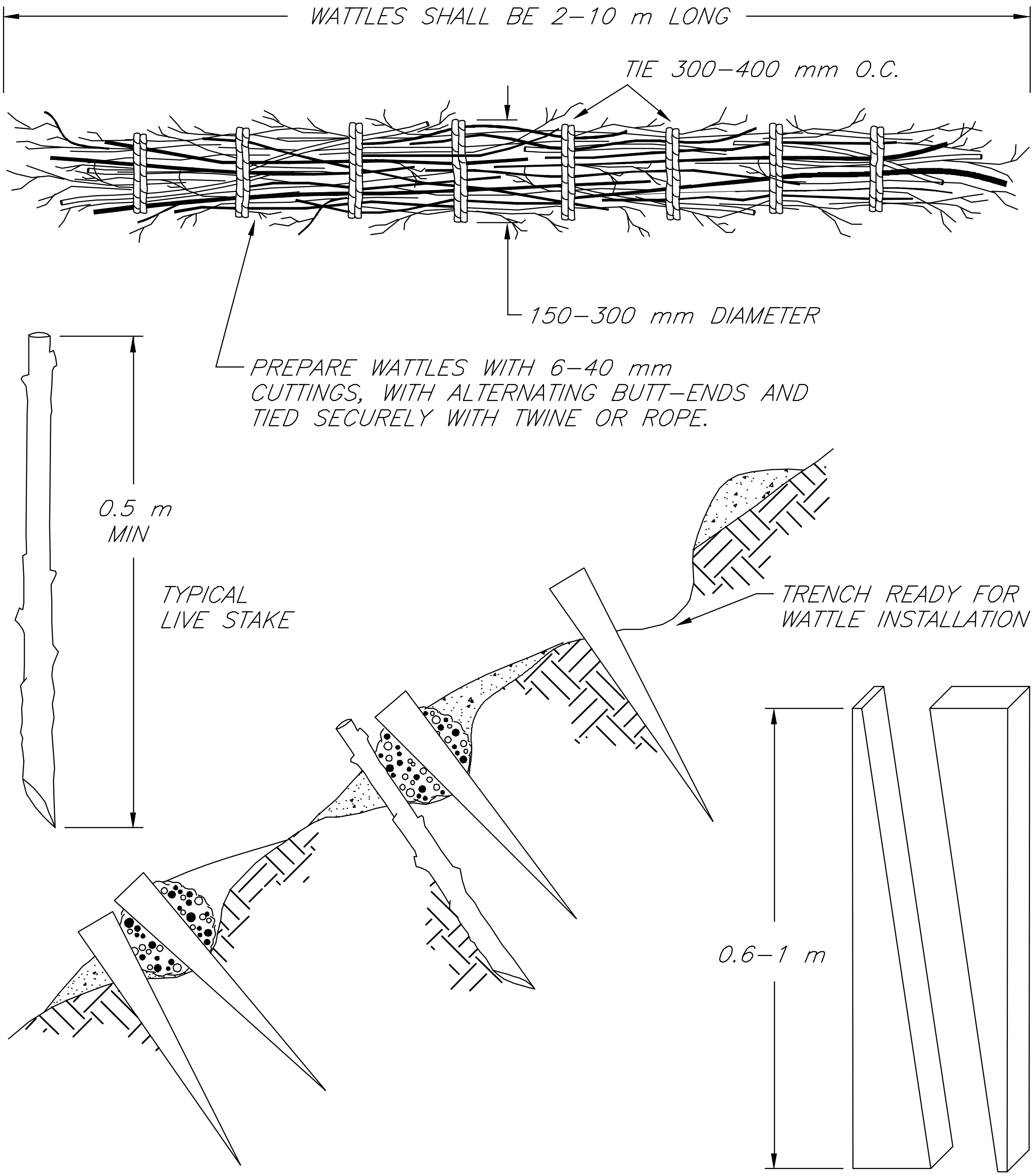
- Use live stakes in place of wooden stakes
- If the slope soil is loose and uncompacted, excavate trench to a minimum depth of 2/3 of the diameter of the wattle
- For steep slopes, additional anchors placed on the downslope side of the wattle may be required

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by washout or rutting should be repaired immediately
- Additional stormwater control measures should be considered for rilling areas damaged by runoff

Similar Measures

- Synthetic permeable barriers



TYPICAL CONSTRUCTION STAKE
SAW 2X4 (100X50 mm) LUMBER
ON DIAGONAL

NOTES:

1. HARVEST AND INSTALL WATTLES DURING DORMANT SEASON.
2. INSTALL WATTLES ON SLOPE CONTOURS.
3. ALL WORK PROCEEDS FROM THE BOTTOM OF THE SLOPE TO THE TOP.
4. FILL OR PARTIALLY COVER WATTLE WITH SOIL FROM SLOPE OR TRENCH ABOVE.
5. COMPACT AND WORK SOIL INTO COMPLETED WATTLES.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

WATTLE (LIVE FASCINE)

FILE: WATTLE

Chemical Stabilization (Tackifiers) Removed	B.M.P. #29

Riparian Zone Preservation Sediment Control and Erosion Control	B.M.P. #30

Description and Purpose

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

Applications

- Permanent measure
- Existing established vegetation acts as an effective sediment control and erosion control buffer strip barrier to slow down flows and allow sedimentation filtration to occur
- May be used along property boundaries to minimize sediment transport off construction site despite non-presence of watercourse adjacent

Advantages

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

Limitations

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

Construction

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

- Define and delineate riparian zones to be preserved in Environmental Construction Operations Plan (ECO Plan) prior to commencement of construction
- Clearly mark riparian zones to be preserved in the field (with construction fencing, survey flagging, or other highly visible measure) so all personnel involved with construction operations can identify areas to be preserved

Construction Considerations

- Riparian zones must be fenced off immediately to minimize trespassing and to ensure effectiveness of riparian zone is maintained
- Do not allow equipment to enter areas not necessary to construction
- Based on site-specific situations established buffer zones of adequate width

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Maintain fences protecting riparian zones from trespassing

Pumped Silt Control Systems (Filter Fabric Bags) Sediment Control and Erosion Control	B.M.P. #31

Description and Purpose

- The extraction of sediment is effected by pumping sediment laden runoff into a bag manufactured with a permeable geotextile. Water will filter through the filter bag with the sediment being retained within the filter bag

Applications

- Temporary measure
- Can be used in high risk areas to supplement performance of containment pond systems
  - An example area would be where containment pond space is limited on construction site and appropriate sized containment pond cannot be constructed adjacent to high risk areas
- Useful for additional extraction of sediment dewatering sumps, sediment ponds, or other retention facilities with accumulations of sediment laden runoff

Advantages

- Filter bag is lightweight and portable
- Simple cleanup and disposal
- Sediment is captured within filter bag for removal from site

Limitations

- May be expensive
  - Extra costs associated with cost of filter bags and costs of pumping out retention facilities
- Power supply for pumps may be required
- Useful for only short periods of time and small volumes of water
- Can only retain particle sizes larger than the Apparent Opening Size (AOS) of the filter fabric bag
- Refer to manufacturers' product performance information
- Generally for available non-woven filtration geotextile, AOS values of 0.15 mm range or lower can be realistically manufactured. Potentially, only particle size larger than the design AOS value can be removed from the bag types. It is important to require manufacturer to provide performance specification and physical properties of the bags. The designer and supplier of the filter bag should choose

the fabric and AOS based on the anticipated gradation of the sediments to ensure the sediments are retained in the bag.

- Few precedents as this measure is generally not used on AT construction projects, however, it can be resorted as emergency measure for highly sensitive sites

Implementation

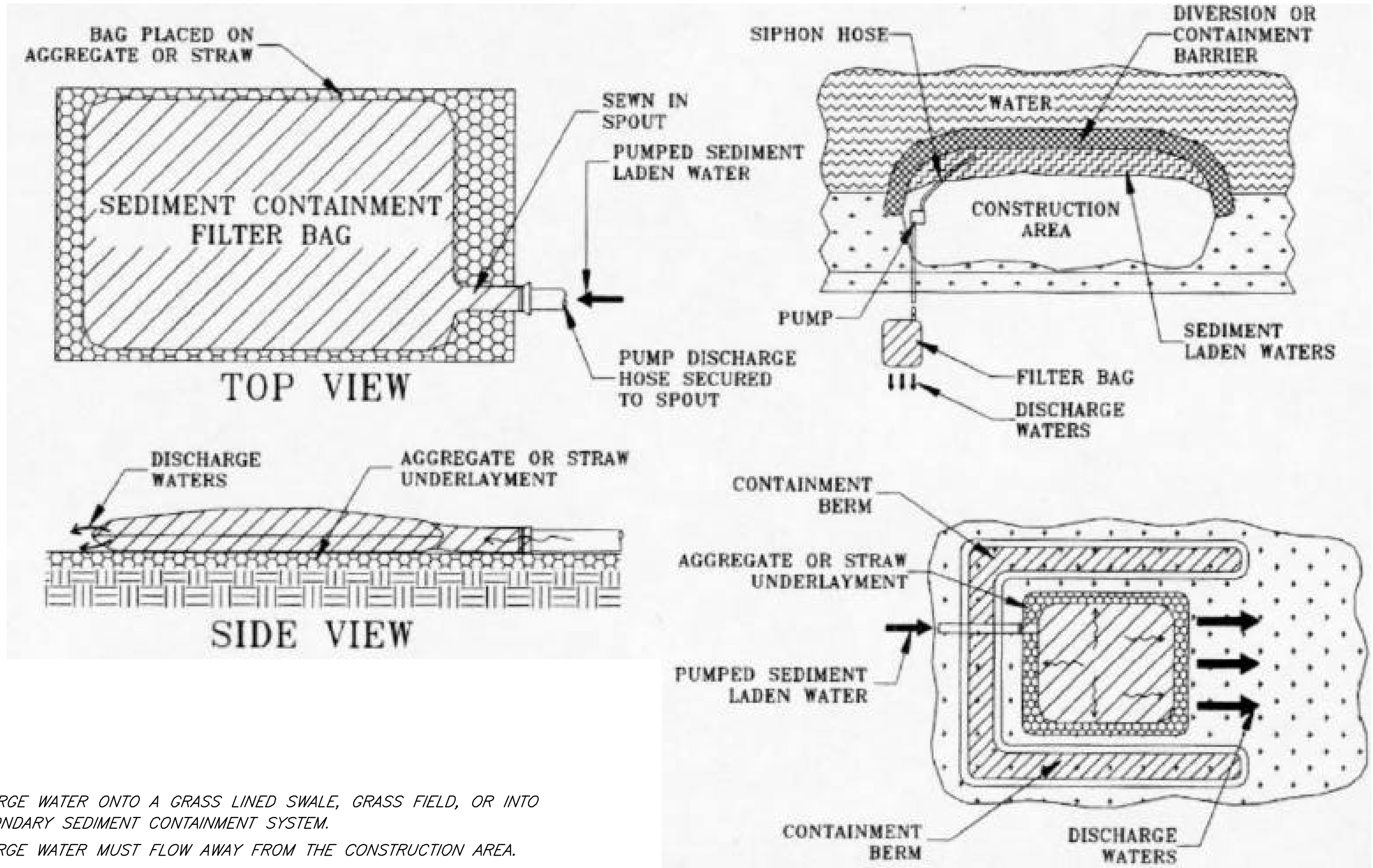
- Place filter bag on free-draining base (such as gravel pad or straw pile) on a slight slope, with opening to silt bag facing upslope
- Attach hose to opening of filter bag
  – Ensure tight seal to prevent discharge of sediment laden runoff outside of bag
- Attach hose to pump and insert extraction hose into retention facility to be dewatered
- Turn on pump and remove sediment laden water until filter bag is full of sediment
- Disengage pump once filter bag is full, tightly close opening to filter bag to prevent spilling of sediment and remove bag
- Repeat process (using new filter bags) until retention facility is dewatered to acceptable levels

Implementation Considerations

- Full filter bags can be removed from site or buried in designated locations on-site
- Care should be taken to ensure filter bag is not overfilled, which may cause filter bag to tear, spilling sediment
- Care should be taken when transporting full filter bags to ensure filter bag is not torn

Inspection and Maintenance

- Inspect all hoses and connections before and during pumping operations to minimize leaks



NOTES:

1. DISCHARGE WATER ONTO A GRASS LINED SWALE, GRASS FIELD, OR INTO A SECONDARY SEDIMENT CONTAINMENT SYSTEM.
2. DISCHARGE WATER MUST FLOW AWAY FROM THE CONSTRUCTION AREA.
3. SEDIMENT CAPTURED BY THE FILTER BAG MUST BE REMOVED AND STABILIZED.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: FIFIELD 2001

PUMPED SILT CONTROL SYSTEM

Scheduling Sediment Control and Erosion Control	B.M.P. #32

Description and Purpose

- Scheduling the sequence and timing arrangement of construction activities (1) to efficiently maximize the amount of erosion protection installed (such as topsoiling and seeding) as soon as a portion of grade construction is completed, and (2) to limit the portion of land disturbance (construction) compatible with the efficient rate of construction of erosion control measures achievable
- Incorporating erosion and sedimentation control concerns during the scheduling phase will minimize the amount and duration of bare soil exposure to erosion elements and ensure erosion and sedimentation control measures are implemented at an appropriate time
- Scheduling may be designed during planning stages by the contractor and altered during construction to suit actual conditions encountered

Applications

- Temporary measure

Advantages

- Ensures erosion and sedimentation control issues are identified during the planning stage by the Contractor
- May be used to minimize bare soil exposure and erosion hazard with careful planning and utilization of equipment in construction projects

Limitations

- May be more costly as erosion control measures (such as topsoiling and seeding) have to be implemented immediately after completion of each phase or a short section of construction

Implementation

- Incorporate a schedule with erosion protection perspective to form part of the overall construction plan
- Determine sequencing and timetable for the start and end of each item, such as clearing, grubbing, stripping, etc.
- Incorporate installation of appropriate erosion and/or sediment control measures in construction schedule
- Allow sufficient time before rainfall begins to install erosion and/or sediment control measures

- Whenever possible, schedule work to minimize extent of site disturbance at any one time
- Incorporate staged topsoiling and revegetation of graded slopes as work progresses
  – Don’t leave all topsoiling and revegetation until the very end of the project

Inspection and Maintenance

- Routinely verify that construction activities and the installation of erosion and sediment control measures is progressing in accordance with schedule
  – If progress deviates from schedule, take corrective action
- When changes to the project schedule are unavoidable, alter the schedule as soon as practicable to maintain control of erosion

Stabilized Worksite Entrances Sediment Control and Erosion Control	B.M.P. #33

Description and Purpose

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

Applications

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

Advantages

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

Limitations

- Sediment control measures should be installed to collect sediment laden runoff from gravel pad
- Installation of gravel pads may be limited by space constraints

Implementation

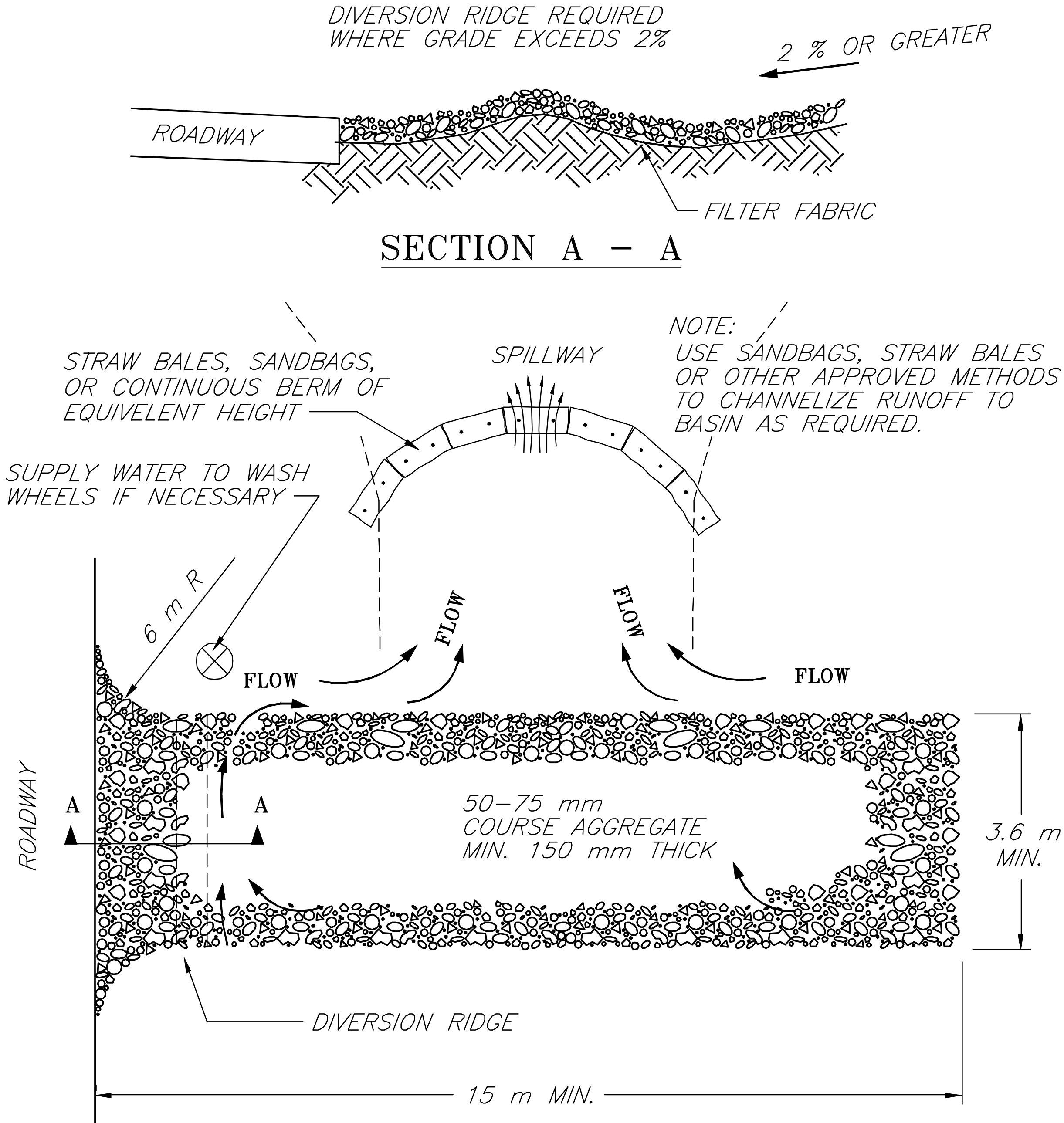
- Install gravel pad at planned entrances to worksite
  - Gravel pad (minimum of 15 m in length) should be of sufficient length to accommodate longest anticipated vehicle entering or exiting the site
  - Width of pad should be sufficient to accommodate the widest anticipated vehicle entering or exiting the site (minimum of 3.6 m in width)
  - Thickness of gravel pad should be a minimum of 0.30 m thick (0.3 m thickness is preferred for highway projects) and should comprise 50 to 150 mm diameter coarse aggregate placed on top of woven geotextile filter fabric
- Install temporary sediment control measures (such as straw bale barriers or silt fences) to collect washed off sediment from gravel pad

Construction Considerations

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

Inspection and Maintenance

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



PLAN

NOTES:

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

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT

FILE: ENTRANCE

Slope Texturing (a-c) Sediment Control	B.M.P. #34 (a - c)

Description and Purpose

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

a) Surfacing Roughening

b) Grooved or Serrated Slope

c) Benched Slope

Applications

- Temporary measure
- May be used to roughen the exposed soils on the slope surface in the direction of water flow to minimize erosion and to entrap some sediments
- May be used on fresh cut or fill slopes (8 m length or longer; practical travel reach of a dozer) with gradients of generally 3H:1V or steeper (2H:1V as general steepness limit) constructed in cohesive soils
- May be used on slope subgrade that will not be immediately topsoiled, vegetated or otherwise stabilized
- May be applied to topsoiled slope to provide track serration to further reduce erosion potential
- May be used in graded areas with smooth and hard surfaces
- As part of slope design, benching may be used to effect a reduction of erosion hazard where a long slope length needs to be shortened into smaller sectional lengths with mid-benches; normally a 3 m wide bench can be appropriate
  - – Benching is usually a permanent slope design feature and should only be designed by a qualified geotechnical engineer
  - – Benching of a long slope section to divide into short sections can reduce erosion hazard in the range of 30 to 50% (e.g., sediment yield for 15 m high 3H:1V slope with mid-bench)

Slope Texturing (a-c) Erosion Control	B.M.P. #34 (a - c)

Advantages

- Reduces erosion potential of a slope
- Texturing will create protrusions to increase surface roughness to reduce overland flow velocities and erosion energy
- Texturing will create minor spaces to entrap a portion of the coarse sediment and reduces amount of sediment transported downslope
- Texturing of slopes will benefit development of vegetation
- Texturing of slopes aids in performance of mulches and hydroseeding
- Texturing with track-walking up/downstream may effect a 50% reduction of sediment yield compared with untracked slope

Limitations

- Surface roughening and tracking may increase grading costs
- Surface roughening and tracking may cause sloughing in certain soil types (i.e., sandy silt) and seepage areas; geotechnical advice is recommended
- Texturing provides limited sediment and erosion control and should be used as a temporary measure prior to topsoiling
  – Should be used in conjunction with other erosion and sediment control measures (i.e., offtake ditches) to limit the sheet flow downslope

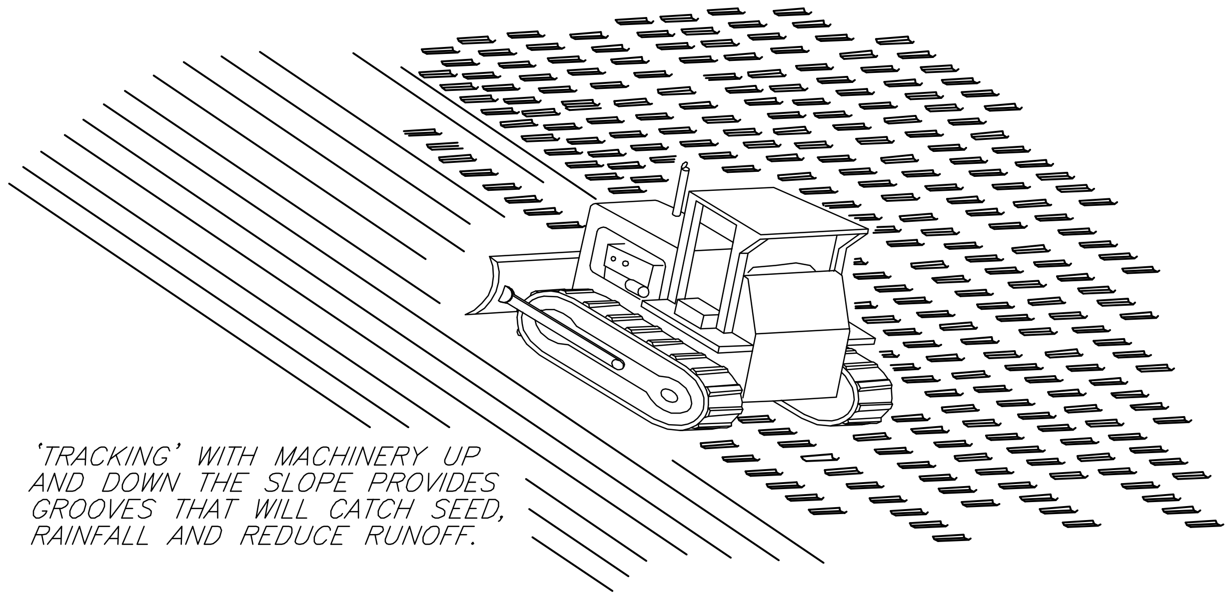
Construction

- Surface Roughening
  – Leave soil in rough grade condition, do not smooth grade soil
  – Large lumps of soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Surface Tracking
  – Using tracked construction equipment to move up and down the slope, leaving depressions perpendicular to the slope direction; limit passes to prevent overcompaction of the surface
  – Depressions in the soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Grooving
  – Excavating shallow furrows across the width of the slope, perpendicular to the direction of the slope

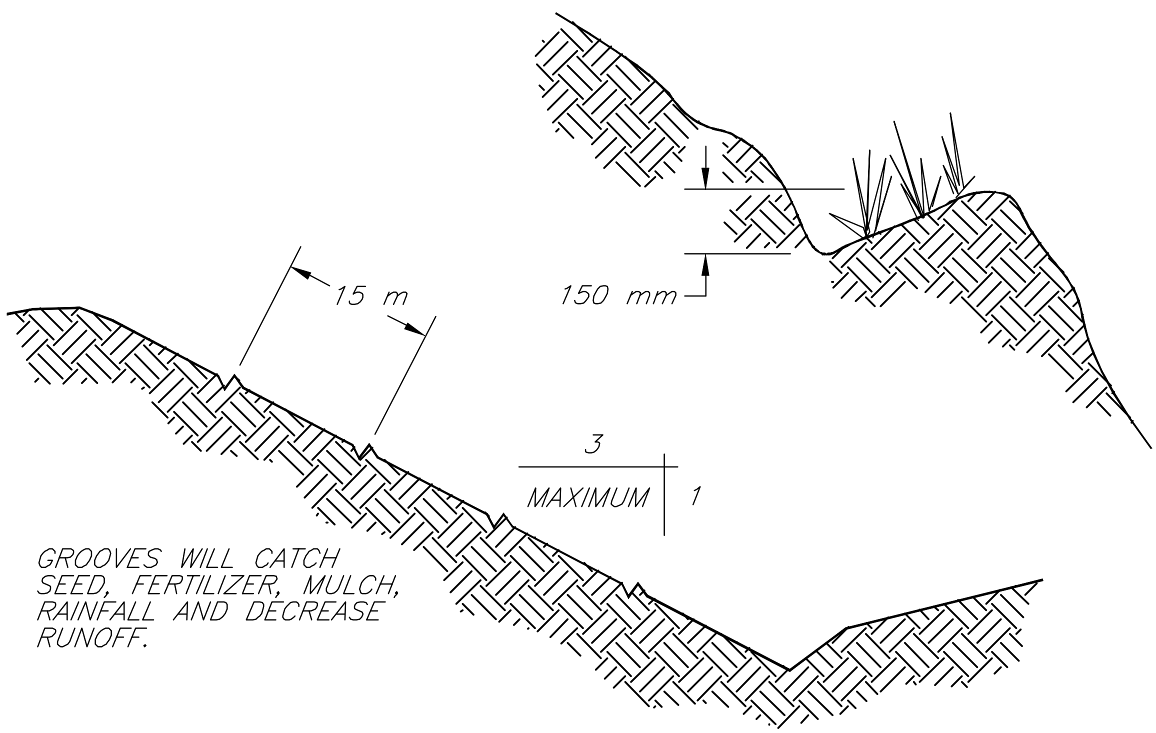
  - If used, contour grooves should be approximately 0.1 to 0.2 m in depth
- Grooves can be made by using equipment or hand
- Benching
  - Construction of narrow, flatter sections of soil on the slope, perpendicular to the direction of the slope
  - Benches should be designed by qualified geotechnical engineer

Construction Considerations

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



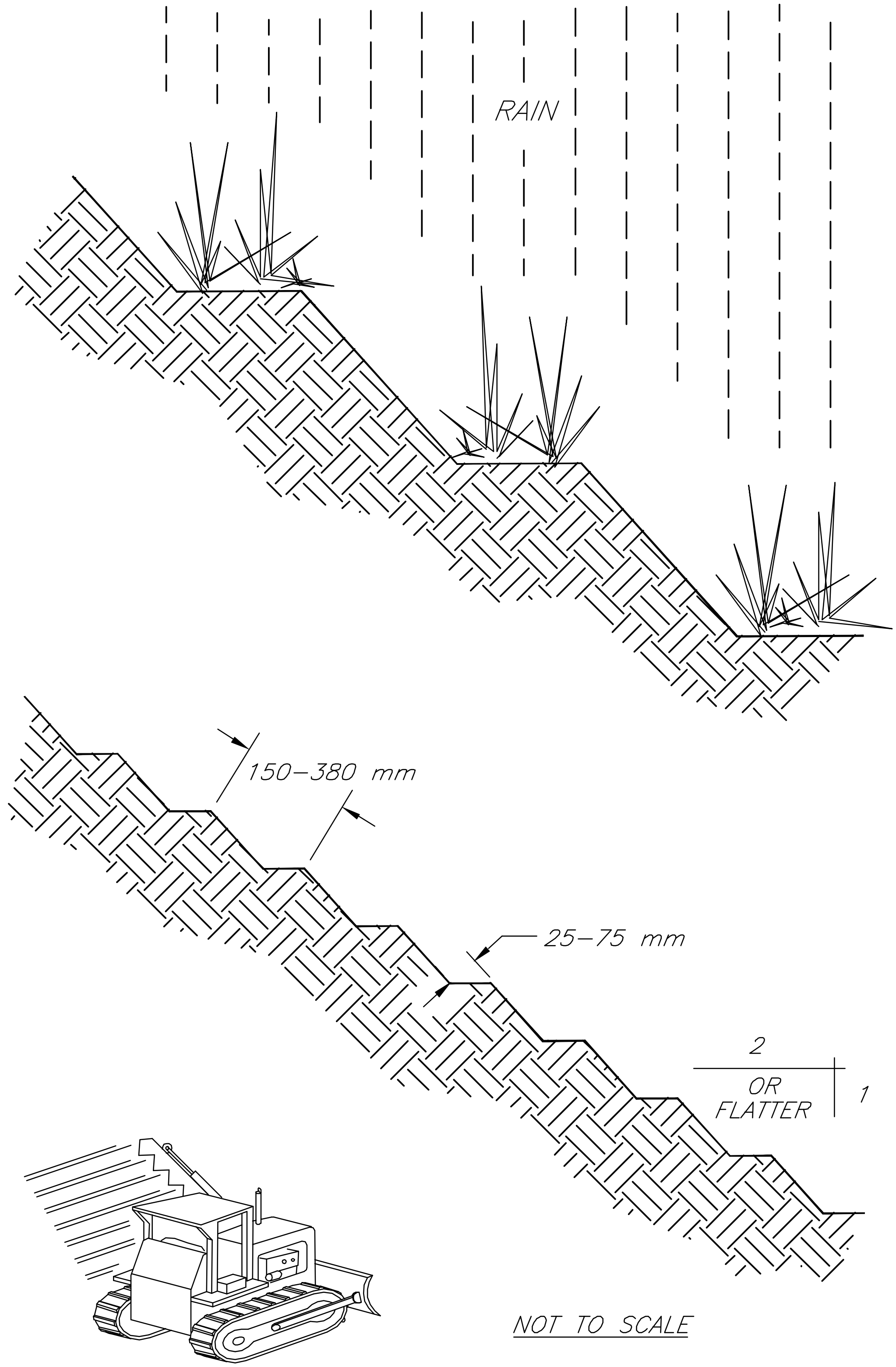
TRACKING



CONTOUR FURROWS

SURFACE ROUGHENING

FILE: SRFROUGH



NOTE:

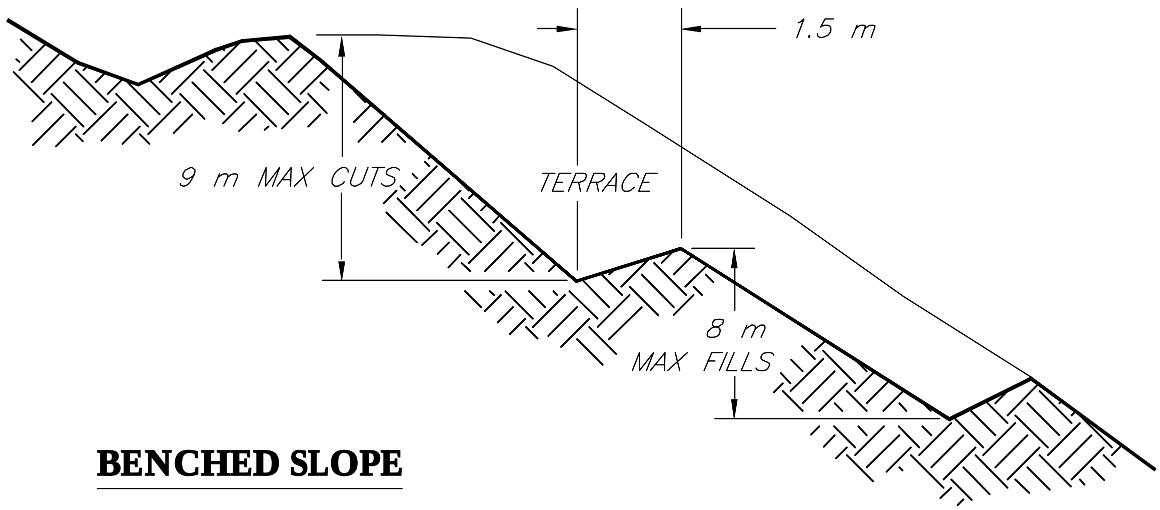
GROOVE BY CUTTING SERRATIONS ALONG THE CONTOUR. IRREGULARITIES IN THE SOIL SURFACE CATCH RAINWATER, SEED, MULCH AND FERTILIZER.

GROOVED OR SERRATED SLOPE

FILE: SERSLOPE

Government of Alberta ■
Transportation

B.M.P. #34b
Typical Section



BENCHED SLOPE

NOT TO SCALE

FILE: STPSLOPE

BENCHED SLOPE

Government of Alberta ■
Transportation

B.M.P. #34c
Typical Section

Straw Mulching & Crimping (Straw Anchoring) Sediment Control and Erosion Control	B.M.P. #35

Description and Purpose

- Straw mulch consists of placing a uniform layer of straw and incorporating it into the soil with a studded roller or anchoring it with stabilizing emulsion
- Protects the soil surface from the impact of rain drops, preventing soil particles from being dislodged

Applications

- Temporary measure
- Used for soil stabilization as a temporary surface cover on disturbed areas until soils can be prepared for revegetation and permanent vegetation is established
- Also used in combination with temporary and/or permanent seeding strategies to enhance plant establishment

Advantages

- Relatively cheap method of promoting plant growth and slope protection

Limitations

- Availability of erosion control contractors and straw may be limited prior to the rainy season due to high demand
- There is a potential for introduction of weed-seed and unwanted plant material
- When straw blowers are used to apply straw mulch, the treatment areas must be within 45 m of a road or surface capable of supporting trucks
- Straw mulch applied by hand is more time intensive and potentially costly
- Wind may limit application of straw and blow straw into undesirable locations
- May have to be removed prior to permanent seeding or soil stabilization
- “Punching” of straw does not work in sandy soils
- Crimping will tend to leave an uneven surface
- Netting can become displaced and entangled in mowing equipment

Installation

- Apply loose straw at a minimum rate of 3,570 kg/ha, or as indicated in the projects special provisions, either by machine or by hand distribution
- If stabilization emulsion will be used to anchor the straw mulch in lieu of incorporation, roughen embankment or fill areas by rolling with a crimping or punching-type roller or by track walking before placing the straw mulch
- Track walking should only be used where rolling is impractical
- The straw mulch must be evenly distributed on the soil surface
- Anchor the mulch in place by using a tackifier or by “punching” it into the soil mechanically (incorporating)
- A tackifier acts to glue the straw fibres together and to the soil surface
- The tackifier shall be selected based on longevity and ability to hold the fibres in place
- A tackifier is typically applied at a rate of 140 kg/ha
- In windy conditions, the rates are typically 2000 kg/ha
- Methods for holding the straw mulch in place depend upon the slope steepness, accessibility, soil conditions and longevity
- On small areas, a spade or shovel can be used to incorporate straw mulch
- On slopes with soils, which are stable enough and of sufficient gradient to safely support construction equipment without contributing to compaction and instability problems, straw can be “punched” into the ground using a knife-blade roller or a straight bladed coulter, known commercially as a “crimper”
- The mulch crimping device consists of a series of dull flat discs with notched edges spaced approximately 20 cm apart
- The mulch should be impressed in the soil to a depth of 3 to 8 cm
- Mechanical anchoring, or crimping, is recommended only for slopes flatter than 2:1
- Mulch on slopes steeper than 2:1 should be anchored to the soil with netting
- On small areas and/or steep slopes, straw can also be held in place using a plastic or jute netting
- The netting shall be held in place using wire staples, geotextile pins or wooden stakes

Straw Mulching & Crimping (Straw Anchoring) Sediment Control and Erosion Control	B.M.P. #35

Construction Considerations

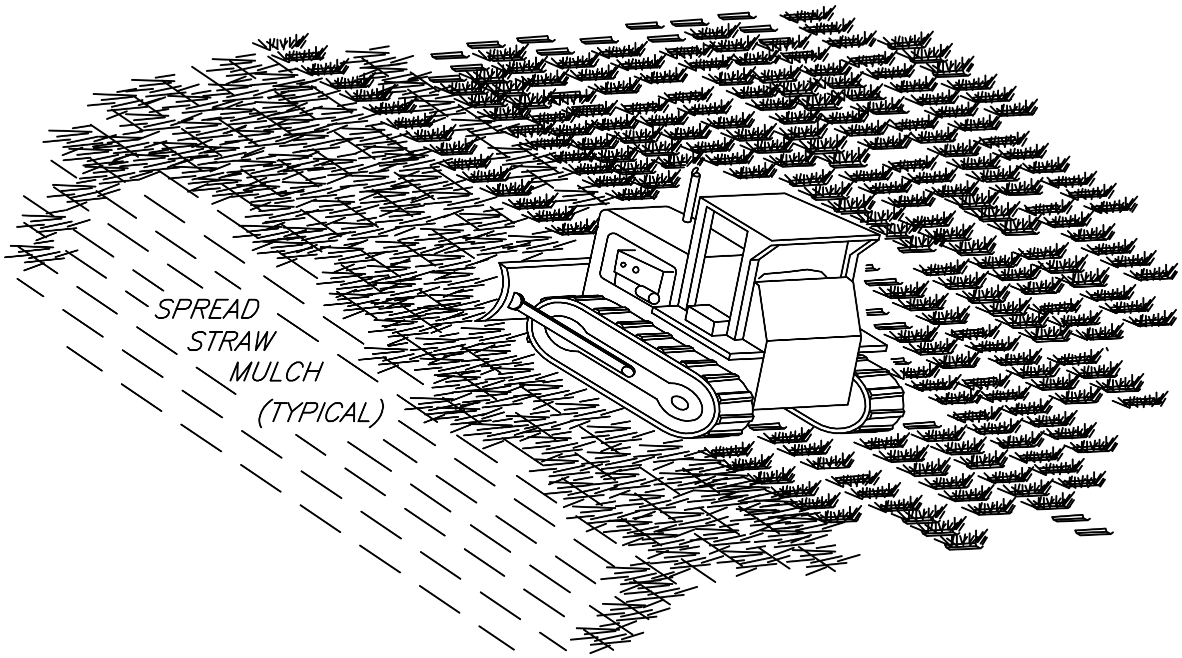
- Straw shall be derived from clean long stemmed grass hay or cereal shaft (e.g., wheat or barley), free from undesirable weed and seed
- A minimum of 65% of the mulch, by weight, should be 25 cm or more in length
- Expected longevity: < 3 months
- A tackifier is the preferred method for anchoring straw mulch to the soil on slopes
- Crimping, punch roller-type rollers, or track-walking may also be used to incorporate straw mulch into the soil on slopes
- Track walking shall only be used where other methods are impractical
- Avoid placing straw onto the traveled way, sidewalks, line drainage channels, sound walls, and existing vegetation
- Straw mulch with tackifier shall not be applied during or immediately before rainfall

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- The straw needs to last long enough to achieve erosion control objectives
- Areas where erosion is evident should be repaired and BMPs re-applied as soon as possible
- Care should be exercised to minimize damage to protected areas
- Repair any damaged ground cover and re-mulch exposed areas
- Re-application of straw mulch and tackifier may be required to maintain effective soil stabilization over disturbed areas and slopes
- Maintain all slopes to prevent erosion after any rainfall event

Similar Measures

- Mulching



'TRACKING' WITH MACHINERY ON SANDY SOIL PROVIDES ROUGHENING WITHOUT UNDUE COMPACTION.

STRAW MULCHING & CRIMPING

NOTES:

1. ROUGHEN SLOPE WITH BULLDOZER
2. BROADCAST SEED AND FERTILIZER.
3. SPREAD STRAW MULCH 76mm THICK. (2 1/2 TONS PER ACRE)
4. PUNCH STRAW MULCH INTO SLOPE BY RUNNING BULLDOZER UP AND DOWN SLOPE.

STRAW MULCHING & CRIMPING

FILE: STRWANCH

Polyacrylamide (PAM) Erosion Control	B.M.P. #36

Description and Purpose

- The land application of product containing anionic polyacrylamide (PAM) as temporary soil binding agents to reduce soil erosion
- To reduce erosion from wind and water on construction sites and agricultural lands

Applications

- This temporary practice is intended for direct soil surface application to sites where the timely establishment of vegetation may not be feasible or where vegetative cover is absent or inadequate
- Such areas may include construction sites where land-disturbing activities prevent the establishment or maintenance of a vegetative cover

Advantages

- Enhances terrestrial and aquatic habitat with vegetation growth re-establishment
- Aesthetically pleasing with vegetation cover
- Improved water quality, infiltration, soil fertility and visibility

Limitations

- This temporary practice is not intended for application to surface waters
- It is intended for application within construction storm water ditches and storm drainages which feed into pre-constructed sediment ponds or basins

Installation

- **Only the anionic form of PAM shall be used. Cationic PAM is toxic and shall NOT be used**
- PAM and PAM mixtures shall be environmentally benign, harmless to fish, wildlife and plants
- PAM and PAM mixtures shall be non-combustible
- When applying ensure uniform coverage to the target and avoid drift to non-target areas including waters
- Anionic PAM, in pure form, shall have less than or equal to 0.05% acrylamide monomer by weight
- To maintain less than or equal to 0.05% of acrylamide monomer, the maximum application rate of PAM, in pure form, shall not exceed 227kg/ha/year

- Do not over apply PAM
- Seeding rate for all mixes should be 25 kg/ha minimum

Design Considerations

- Excessive application of PAM can lower infiltration rate or suspend solids in water, rather than promoting settling
- Users of anionic PAM shall obtain and follow all Material Safety Data Sheet requirements and manufacturer’s recommendations
- Obtain written application methods and rate for PAM and PAM mixtures
- Additives such as fertilizers, solubility promoters or inhibitors, etc., to PAM shall be non-toxic
- Gel bars and logs of anionic PAM mixtures may be used in ditch systems
- Anionic PAM is available in emulsions, powders and gel bars or logs
- The use of seed and mulch for additional erosion protection beyond the life of the anionic PAM is recommended
- Use setbacks when applying anionic PAM near natural waterbodies
- Consider that decreased performance can occur due to ultra-violet light and time after mixing when applying anionic PAM
- In flow concentration channels, the effectiveness of anionic PAM for stabilization decreases
- Never add water to PAM; add PAM slowly to water. If water is added to PAM, “globs” can form which can clog dispensers, signifying incomplete dissolving of the PAM and therefore increasing the risk of under application
- Not ALL polymers are PAM

Inspection and Maintenance

- Reapplying anionic PAM to disturbed areas including high use traffic areas

Similar Measures

- Hydraulic seeding and mulching
- Compost

Compost Blanket Erosion Control	B.M.P. #37

Description and Purpose

- Compost is the product resulting from the controlled biological decomposition of organic material, occurring under aerobic conditions
- Compost has been sanitized through the generation of heat and stabilized to the point that it is appropriate for its particular application
- Active composting is typically characterized by a high temperature phase that sanitizes the product and allows a high rate of decomposition
- It is followed by a lower temperature phase that allows the product to stabilize while still decomposing at a slower rate
- Compost should possess no objectionable odours or substances toxic to plants
- Compost contains plant nutrients but is typically not characterized as a fertilizer
- May derive from agricultural, forestry, food or industrial residues, bio-solids, leaf and yard trimmings, manure, tree wood, or source-separated or mixed solid waste

Applications

- Compost blanket are commonly used for temporary erosion and sediment control
- The technique is appropriate for slopes up to 2H:1V grade and on level surface
- Only used in areas that have sheet flow drainage patterns (not for areas that receive concentrated flows)
- Compost used on AT projects must meet Canadian Council of Ministers of the Environment (CCME) Guidelines for Compost Quality (trace elements, maturity/stability, pathogens), which are adopted by Alberta Transportation and found on AT Products List (www.transportation.alberta.ca)

Advantages

- Relatively cheap method of promoting plant growth and slope protection

Limitations

- Application of compost may be difficult on steep slopes
- May require spray-on method to apply compost to steep slopes
- Requires specialized blower truck, hose and attachments for blanket installation

Installation

- Slightly roughen (scarify) slopes and remove large clods, rocks, stumps, roots larger than 50 mm in diameter and debris on slopes where vegetation is to be established
- Apply compost at the rates as follows:

Annual Rainfall/Flow Rate	Total Precipitation	Application Rate for Vegetated Compost Surface	Application Rate for Unvegetated Compost Surface
Low	25 mm – 635 mm	12.5 mm – 19 mm	25 mm – 37 mm
Medium	635 mm – 1270 mm	19 mm – 25 mm	37 mm – 50 mm
High	>1270 mm	25 mm – 50 mm	50 mm – 100 mm

- Compost shall be uniformly applied using an approved spreader, e.g., bulldozer, site discharge manure spreaders
- A pneumatic blower unit propels the compost directly at the soil surface, thereby preventing water from moving between the soil-compost interface
- Seeding can be incorporated during the compost application

Construction Considerations

- Use higher blanket application rate in high rates of precipitation and rainfall intensity, and snow melt
- Compost may be used in conjunction with a compost blanket, especially in regions with spring melt, and sites with severe grades and long slopes
- In regions subjecting to wind erosion, a coarser compost product or higher blanket application rate is preferred
- Use lower blanket application rate in lower precipitation rates and rainfall intensity regions

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by washout or rilling should be regraded if necessary and re-covered with compost immediately

Similar Measures

- Rolled erosion control products (RECP)
- Hydroseeding
- Hydromulching

Rolls a) Coir Roll b) Fibre Roll Streambank Stabilization Techniques and Erosion Control	B.M.P. #38

Description and Purpose

- Coir Rolls are long cylindrical tubes that are composed of interwoven coconut fibres which are bound together with durable coir netting. Coir rolls are particularly applicable for wetland, streambank, and shoreline projects. Coir rolls are most commonly available in 300mm diameters and 6m lengths. These rolls can be linked together to form longer tubes, and are often used in combination with other biotechnical techniques, such as brush layering or live siltation. Coir logs encourage siltation and wetland/floodplain creation
- Fibre rolls are installed across slope contours as a grade break to reduce erosion potential by reducing overland flow velocities
- Straw roll consists of bundled straw (or natural fibre) wrapped in photo-degradable open-weave plastic netting staked into the soil along slope contours as a grade break to reduce erosion potential
- Normally live staking can be installed to anchor the Fibre Rolls to provide deep root vegetation with potential favourable moisture retention provided by fibre roll
- Fibre Rolls also capture sediment, organic matter, and seeds carried by runoff

Applications

- The tough, long-lasting coconut fibres make coir rolls appropriate for wetland, streambank, and shoreline applications. Coir rolls work well when immediate erosion control is needed. Brushlayers work well with coir roll applications, adding further stabilization with a live root system, while also providing excellent habitat features. The coir roll provides a base for the brushlayer cuttings to be laid upon at an appropriate angle which benefits the growth of cuttings. The cuttings provide further protection from breaking waves and high flows
- Fibre Rolls may be used on slopes stable enough to support vegetation (steep, confined, slopes and channel banks with gradients greater than 1H:1V may have low success potential)
- Fibre Rolls may be used along long slopes as a grade break to shorten slope length between line of fibre rolls at different contour elevations
- Fibre Rolls may be used as grade breaks, where slopes transition from flatter to steep gradients

Advantages

- The coir material is natural and long lasting (5 to 7 years), and has high tensile strength

- The fibre rolls and mats accumulate sediment while the plants grow and the plant roots develop. Eventually the coir material biodegrades and the cohesive strength of the root systems and flexible nature of the plants become the primary stabilizing element
- The coir roll/brushlayering combination provides immediate shoreline and streambank protection, with additional benefits of riparian enhancement when the cuttings become established
- Coir Rolls address ecological concerns by encouraging vegetation and wildlife habitat, and are an alternative to stone revetments or other structural measures
- The high tensile strength coconut fibres, fibre netting and the wooden stakes used to anchor the material make up the initial structural components of the system, while plant root and top growth increase the strength and baffle effects of the structure
- Fibre Rolls can be used on slopes too steep for silt fences or straw bales sediment barriers
- In time, plastic netting will degrade due to the sunlight and straw will degrade and be incorporated into the soil
- Fibre Rolls primary purpose is erosion control, however fibre rolls do provide some sediment control

Limitations

- This technique should be implemented during the dormancy period of the cuttings used for brushlayering and staking
- Coir Rolls are relatively expensive
- Fibre Rolls are designed for low sheet flow velocities
- Fibre Rolls are designed for short slopes with a maximum gradient of 1H:1V
- Fibre Rolls may be labour intensive to install
- Straw rolls have short life span due to natural degradation
  - Usually only functional for two seasons
- Susceptible to undermining and failure if not properly keyed into the soil
- Labour intensive maintenance may be required to ensure rolls are in continuous contact with the soil, especially when used on steep slopes or sandy soils

Construction

- Determine annual water elevation
- Mark the annual water level on a stake driven into the substrate, 0.3 or 0.6 m offshore. Installing the materials and plants at the correct elevation is the most important aspect to assure success of the installation. Determine, on site, where the installation will begin and end
- Determine soil level by laying a straight cutting on the coir roll with approximately 20% of the cutting sticking out past the roll, and with the basal ends dipping down into the soil
- Begin installation at the downstream end (if using in a streambank project)
- Prepare the site for installation of coir roll and coir mats by removing any large rocks, obstructions or material that may prevent the coir from making direct and firm contact with the soil. Coir rolls must be level, installed along a horizontal contour. Place coir rolls parallel to the stream bank or shoreline. It is very important to key the ends of the coir rolls firmly into the shoreline or stream bank, so waves and flows will not scour behind the rolls and compromise the integrity of the structure
- Install the coir roll such that 50 mm of the roll extends above the annual water elevation
- Adjacent rolls shall be laced together, end-to-end, tightly and securely
- If using brushlayer cuttings prepare soil bed behind installed coir rolls for laying. It is important that the bud ends of the live cuttings angle up to some degree from the basal ends. Lay cuttings in this fashion, slightly crisscrossed for additional strength
- Next, backfill over cuttings with soil, covering the lower 80% of the branches. At this time, soil can be levelled and prepared for a soil wrap for additional height and soil stability
- If simply covering the cuttings with soil, compact slightly and grade slope to appropriate angle. Use water to wash soil in between branch layers
- If using plant materials, such as container-grown, pre-rooted plant plugs or willow stakes, they should be planted into the coir rolls and through the coir mats and netting
- To install plant plugs and willow stakes into the coir roll, use a planting iron or pilot bar into the roll and wedge it back and forth to create a hole for the plant. It is extremely important that the root system of the plant be placed below the water

level for certain species. All plants shall be checked to ensure that they have been firmly installed in the fibre material

- Mulch and seed exposed areas with native species
- Prepare slope face and remove large rocks or other deleterious materials
- Excavate small trenches a minimum of 0.15 m deep and 0.15 m wide across the width of the slope, perpendicular to slope direction, starting at the toe of the slope and working upwards towards crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place fibre rolls into trench ensuring continuous contact between fibre roll and soil surface
- Butt-joint adjacent fibre roll segments tightly against one another
- Use a metal bar to make pilot hole through middle of the fibre roll a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1 m apart
- Secure fibre roll to soil using wooden stake or other appropriate anchor; live stake may be used as alternate anchor
- Place soil excavated from trench on upslope side of fibre roll and compact to minimize undermining of fibre roll by runoff
- Seed the soil along the upslope and downslope sides of the fibre roll to promote vegetation growth

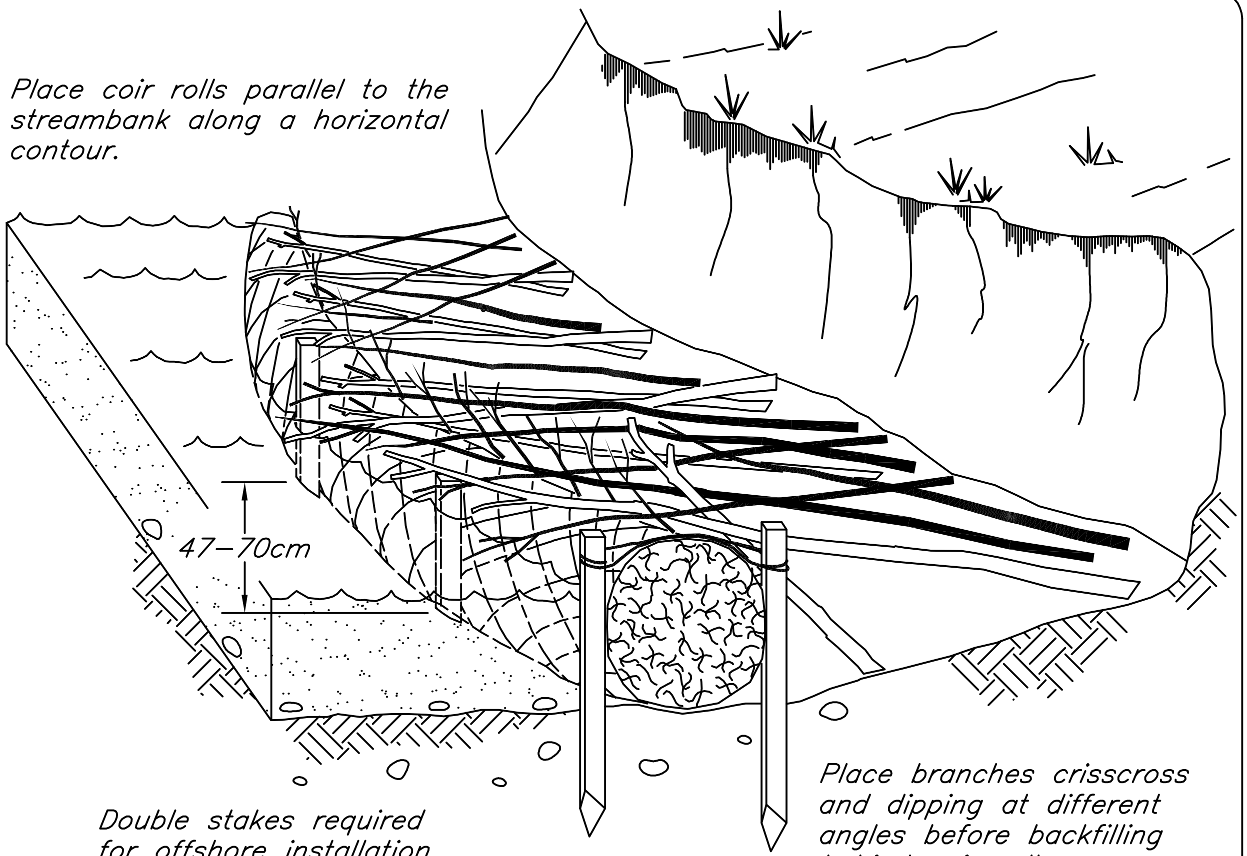
Construction Considerations

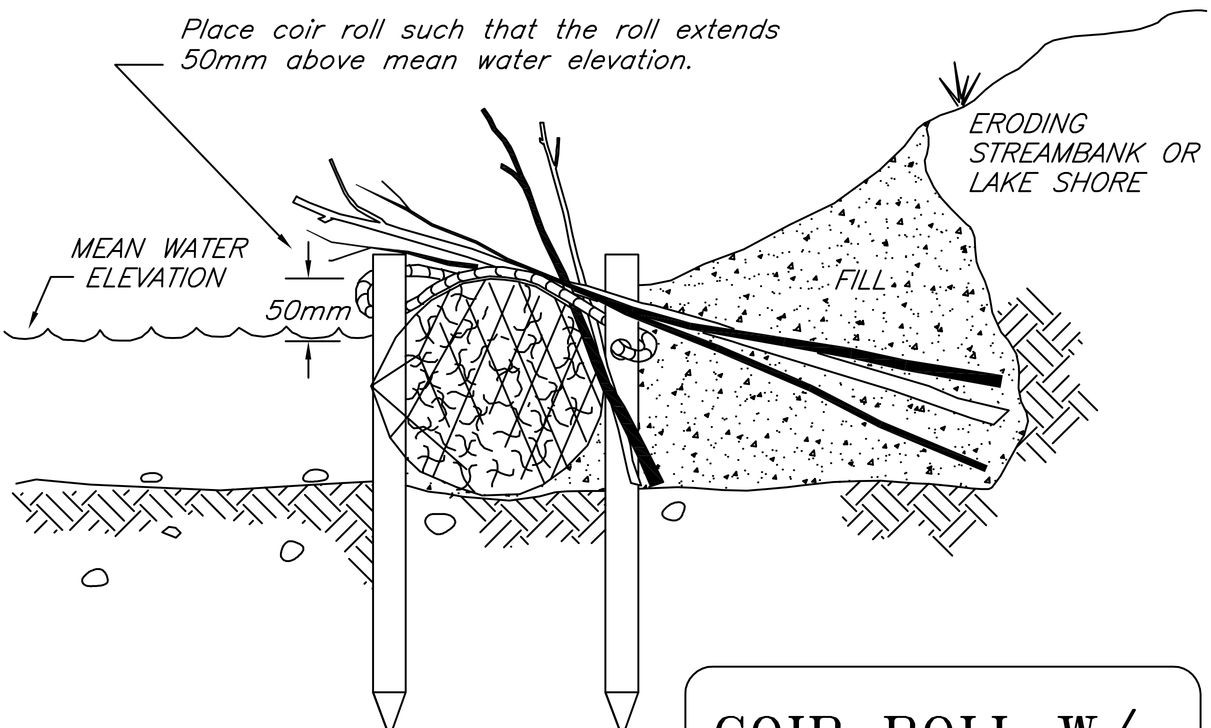
- All work site disturbance should be minimized. Protect any existing plant, when possible, and avoid additional disturbance that can lead to erosion and sedimentation
- Install additional erosion and sediment control measures such as temporary diversion dikes, silt fences and continuous berms, as needed, before beginning work
- Coir rolls can be used in the stream as a sediment barrier, silt curtain, and/or coffer dam to control sediment while work is being done in the water
- Topsoil should be saved, if possible, and replaced once the subsoil has been removed or regraded. Soil shall be stored away from the water's edge and it shall be moved to its final location and stabilized as quickly as possible

- For typical applications at the water's edge, coir rolls are held in place with a single row of stakes, 300 mm on center. Stakes may be driven through the netting on the outer edge of the roll. It is very difficult to drive stakes through the high-density rolls, however, a stake can be driven with the help of a pilot hole through the low density coir rolls
- Lacing among the stakes is recommended for coir mats exposed to extreme conditions such as ice, waves, or flooding
- Coir rolls shall be placed along streambanks or shorelines at a height sufficient to protect the bank from flows or waves. Additional coir rolls may be placed above the lower rolls, in a tile-like fashion, to protect the upper shore or stream bank
- Use live stakes in place of wooden stakes
- If the slope soil is loose and uncompacted, excavate trench to a minimum depth of 2/3 of the diameter of the fibre roll
- For steep slopes, additional anchors placed on the downslope side of the fibre roll may be required

Inspection and Maintenance

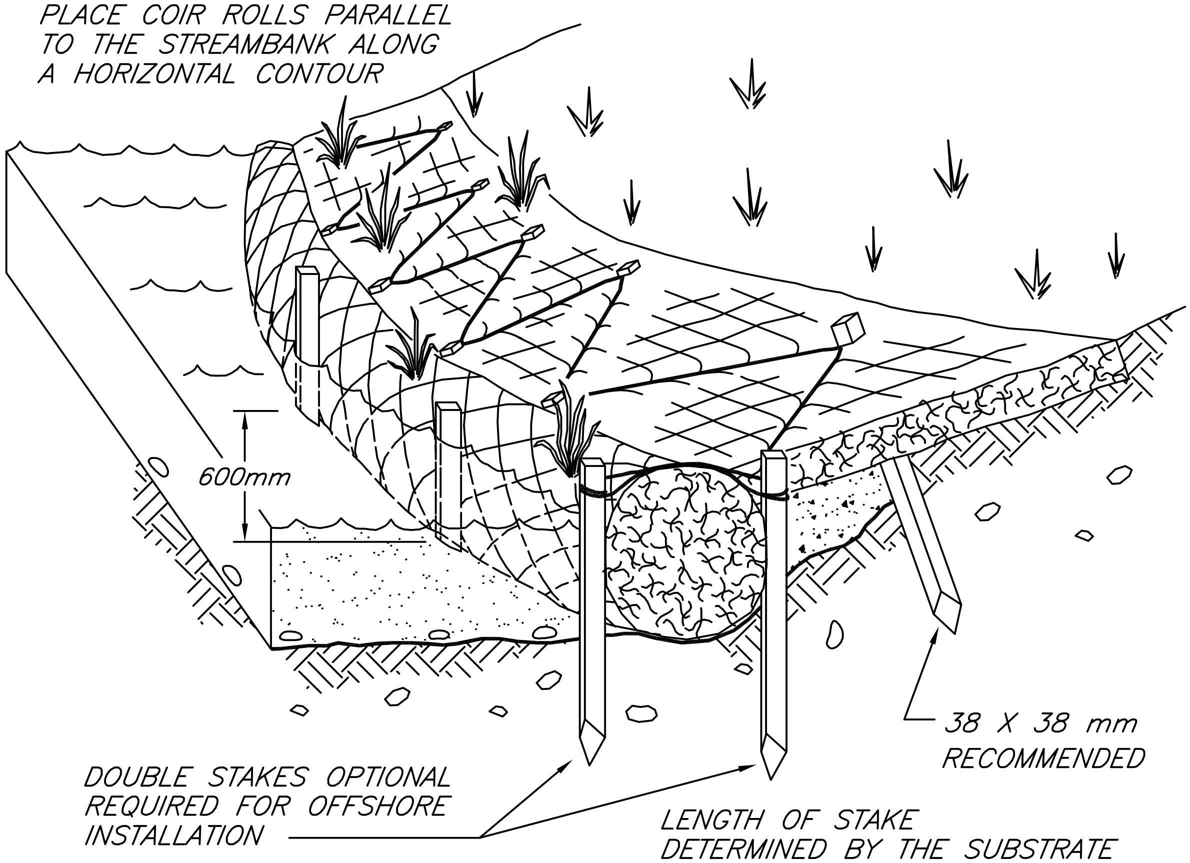
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Check plants to ensure that they have been firmly installed in the fibre material
- Water plants, if necessary, during the establishment phase
- Check all materials periodically or after storms to ensure they remain properly secured. Make necessary repairs promptly
- All temporary and permanent erosion control practices shall be maintained and repaired as needed to ensure continued performance of their intended use
- Areas damaged by washout or rutting should be repaired immediately
- Additional stormwater control measures should be considered for rilling areas damaged by runoff

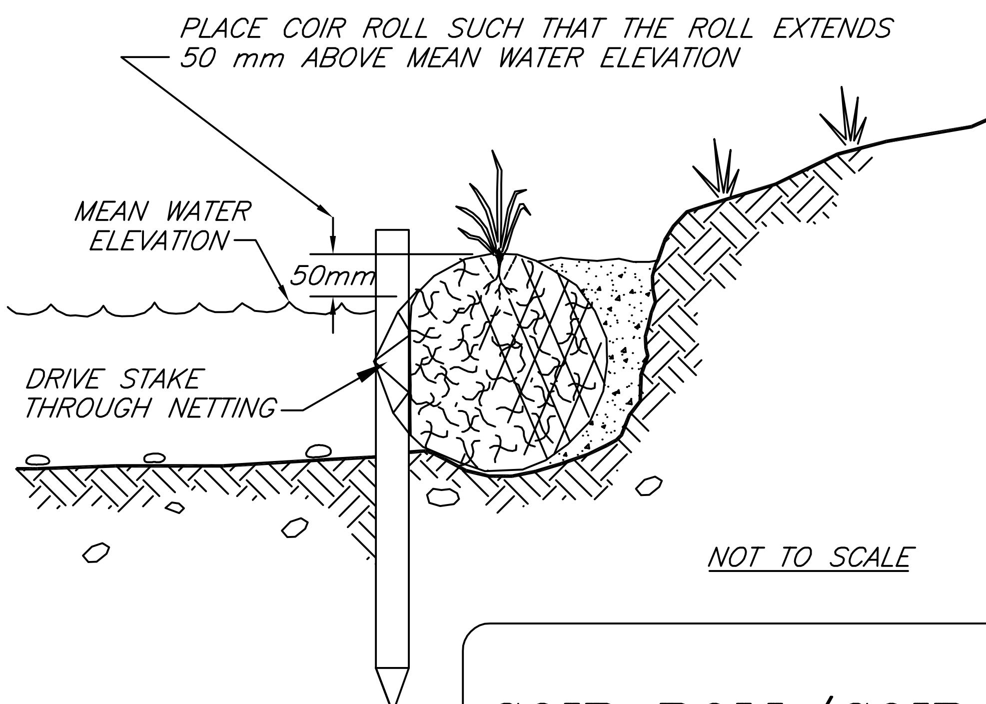




COIR ROLL W/ BRUSHLAYERING

FILE: COIRBRLY

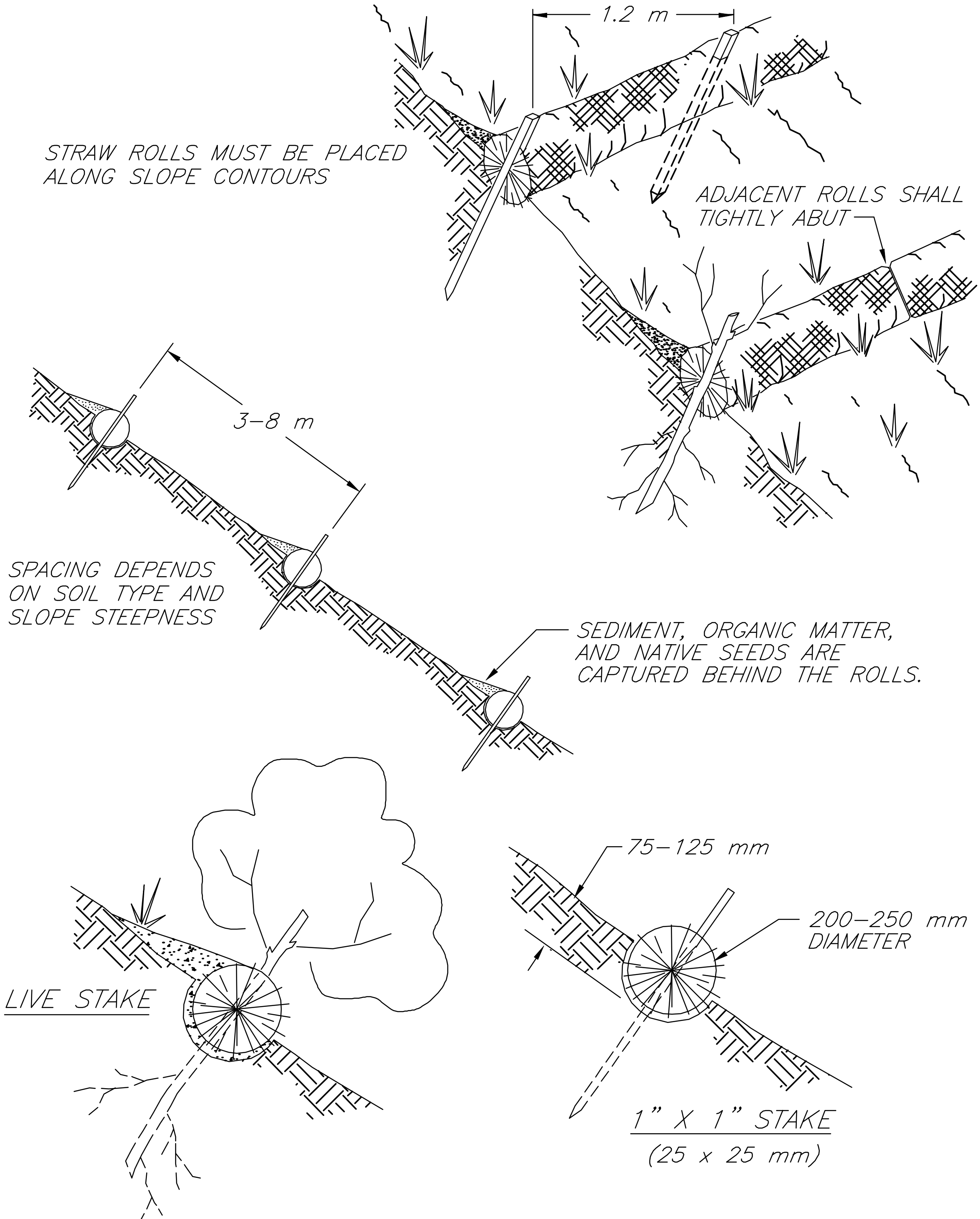




NOT TO SCALE

COIR ROLL/COIR MATS

FILE: COIRRM



NOT TO SCALE

NOTE:

1. STRAW ROLL INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE ROLL IN A TRENCH, 75–125 mm DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND ROLL.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

STRAW ROLLS

FILE: STRWROLL

Brush Mattress Streambank Stabilization Techniques	B.M.P. #39

Description and Purpose

- Consists of a thick (15 to 30 cm) blanket of living cuttings and soil fill placed on a streambank or lake shore to simultaneously re-vegetate and armour the bank. It provides scour control and re-vegetation and is constructed using live willow branches or other species that root easily from cuttings. The dense layer of brush increases roughness, reduces velocities at the bank face, and protects the bank from scour, while trapping sediment and providing habitat directly along the waters' edge

Applications

- Appropriate for eroding streambanks or slopes where immediate protection is needed from flooding stream flows or wave-induced erosion
- Willow is the most common plant material used because of its rooting ability
- Suitable for streams where willow is naturally occurring and where the soil and moisture conditions are favourable
- Planted relatively shallow, as compared to brushlayering, therefore it is most successful on streams where the basal ends of the cuttings will be kept moist during most of the growing season, but flows do not exceed the tolerance of the structure

Advantages

- Provide a dense network of branches that quickly stabilize a slope or streambank
- As the live branches root and grow, not only do they provide cover, but the soil is reinforced with an underground matrix of spreading roots
- If used on streambanks, a brush mattress will trap sediments during high water and eventual plant growth will enhance aquatic habitat
- If used on slopes, a brush mattress collects soil, providing germination sites for other plants
- Well suited for combined installation with many other streambank or slope stabilization techniques
- Often combined with Vegetated Riprap, Live Stakes, Live Fascines, Rootwad Revetment, Live Siltation, and Coconut Fibre Rolls
- Provides immediate surface protection against floods, greatly reducing water velocity at the soil surface
- Well-anchored mattress provides some resistance to scour
- Cuttings are usually available locally

- Relatively economical technique
- Captures sediment during floods, assisting in rebuilding of bank
- Produces riparian vegetation rapidly
- Enhances wildlife habitat value

Limitations

- Does not show high success on streams where basal ends cannot be kept wet for the duration of the growing season
- They should be installed during the dormant season for woody vegetation
- Installation is labour intensive

Construction

- Prepare the slope or streambank by clearing away large debris and grading the slope so the branches will lay flat on the bank
- If bank is not graded evenly, air pockets will form during backfilling, causing poor stem to soil contact, and ultimately resulting in poor sprouting
- Do not compact the slope over 85%, as it will inhibit rooting
- Excavate a horizontal trench, 20 to 30 cm deep at the toe of the streambank
- Lay the cuttings flat against the graded slope, slightly crisscrossed, with the basal ends placed as deeply into the trench as possible, and just below any toe protection to be installed
- Continue to lay the cuttings along the face of the bank or slope until 80% groundcover is achieved
- The mattress will be about 6-30 cm thick
- It will take 10 to 50 branches per m of mattress
- Pound a grid of stakes, 60 to 90 cm long, into the mattress at 0.9 to 1.2 m centers
- Do not pound the stakes completely in, as this will be done after tying
- Longer stakes can be used in sandy soil and shorter stakes in heavy soils
- Secure the brush mattress by using cord, rope, or 10 to 12 gauge galvanized annealed wire, tied with clove hitches in a diamond pattern between each row of stakes
- After securing the mattress with cord or wire, drive the stakes in further to compress the mattress tightly against the slope

- Secure the toe of the mattress using a suitable technique such as Vegetated Riprap, Live Fascines, Rootwad Revetments or Coconut Fibre Rolls
- Backfill around and in between the branches of the mattress by using material excavated from the trench, and additional soil if needed
- Work the soil in well around the branches
- Tamp soil by walking on it, and lightly water the soil with buckets or a hose to wash it down into the stems, and ensure good stem to soil contact
- It is necessary for the thicker, basal ends of the mattress to get good soil cover for rooting; at least 1/4 of the depth of the mattress is recommended
- Leaving some branches exposed above the soil will facilitate sprouting

Construction Considerations

- Brushy cuttings (stems having leaves and twigs) of tree and shrub species capable of propagating from cuttings, typically willow species
- 10 to 50 branches per m of bank to be protected should be harvested
- The cuttings should be long (1.5 to 3 m), straight, brushy, 2 to 3 year old branches up to 4 cm in diameter
- For optimum success, the fascines should be soaked for 24 hours or installed on the same day they are harvested and prepared
- Wooden construction stakes and/or live stakes will be needed
- The length of stakes will vary based on soil conditions
- Biodegradable natural fibre or polypropylene rope is usually preferable to wire
- A sledgehammer will be needed for driving in wooden stakes, or a dead-blow mallet and pilot bar (rebar) for live stakes

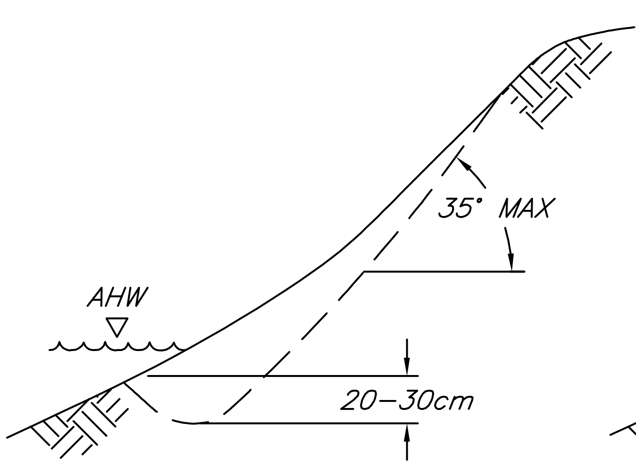
Inspection and Maintenance

- During the first growing and flood season, periodic maintenance is necessary to make sure the stakes and cord/wire are still securing the mattress to the streambank, and to verify that flows are not getting behind the mattress
- Inspect for flanking or undermining of the revetment

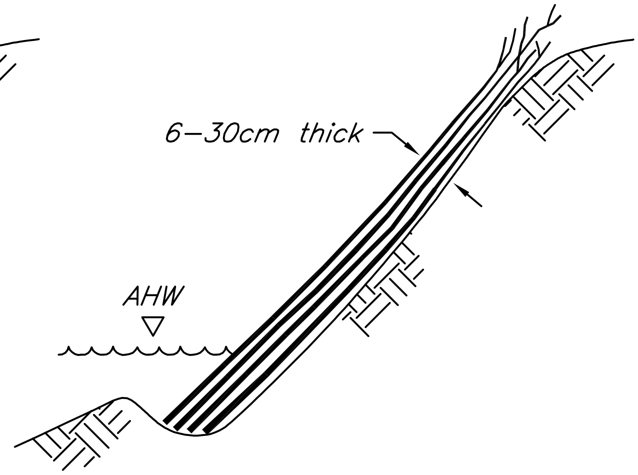
Design Considerations

- The optimal bank slope for brush mattresses is 1V:2H, because stem to soil contact can be maximized at that angle; however, mattresses can successfully be installed at angles of 1V:1.25H or steeper, but sprouting will occur mostly at the basal ends

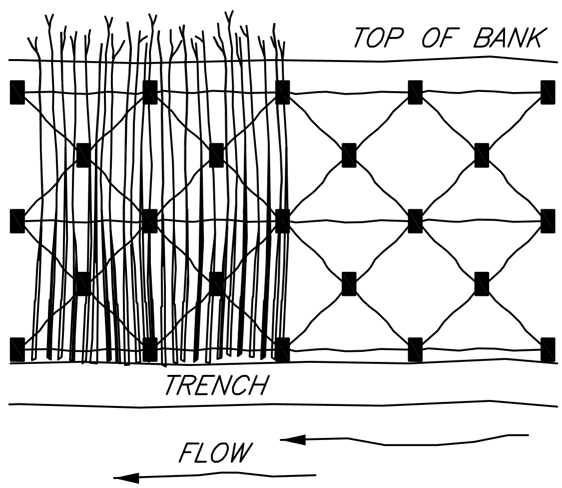
- In some cases, fill will be required to bring the bank to the desired grade
- If rock fill is used, at least 45 cm of soil should be placed over the rock to ensure proper stem to soil contact for the cuttings
- It is important to protect the brush mattress against flanking and undermining
- Some type of toe protection is necessary, and depending upon the erosivity of the bank, keys or refusals may be necessary at upstream and downstream ends
- Rock toe protection is useful with brush mattresses
- If there is any overbank runoff occurring, flows should be diverted around the brush mattress and outleted in a stable area
- If piping is evident, a granular filter should be installed underneath the brush mattress
- The survival of cuttings that do not have their basal ends near the annual low water level is questionable in arid and semi-arid environments
- Studies have shown that brush mattresses have stabilized a bank in a test flume against velocities exceeding 7 m/s



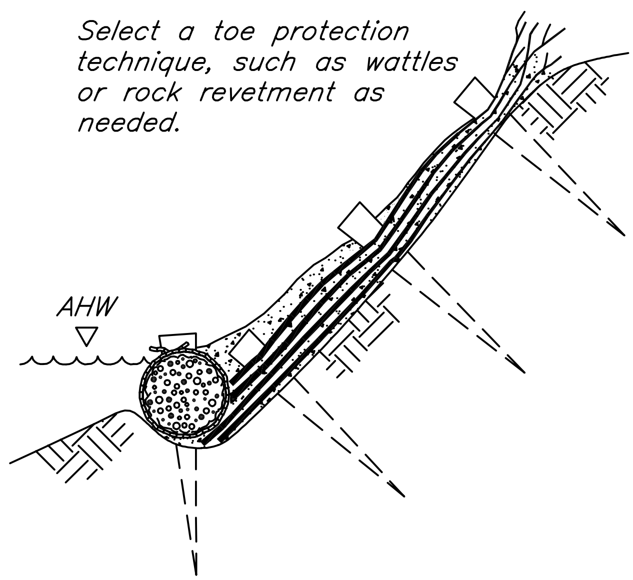
Step 1: Excavate trench and grade bank.



Step 2: Place willow branches making sure that the butt ends reach the bottom of the excavated trench, and are below the mean low water level.



Step 3: Place notched stakes on 1.0m centers, and secure the mattress by lacing twine, rope or wire in a diamond pattern between the stakes.



Step 4: Drive the stakes deeply into the bank to tightly compress the branches against the soil. Cover and partially bury the mattress to encourage rooting.

BRUSH MATTRESS

FILE: BRSHMATT

Live Siltation Streambank Stabilization Techniques	B.M.P. #40

Description and Purpose

- A re-vegetation technique used to secure the toe of a streambank, trap sediments, and create fish rearing habitat. It can be constructed as a living or a non-living brushy system at the water's edge and helps to secure the toe of a streambank

Applications

- An appropriate practice along an outer bend with sufficient scour or toe protection

Advantages

- Can be constructed in combination with rock toes, Rootwad Revetments, Coconut Fibre Rolls, Live Fascines, and Brush Mattresses
- A very effective and simple conservation method using local plant materials
- Valuable for providing immediate cover and fish habitat while other re-vegetation plantings become established
- The protruding branches provide roughness, slow velocities, and encourage deposition of sediment
- The depositional areas are then available for natural recruitment of native riparian vegetation

Limitations

- If using a living system, cuttings must be taken during the dormancy period

Construction

- Construct a V-shaped trench at the annual high water (AHW) level, with hand tools or a backhoe
- Excavate a trench so that it parallels the toe of the streambank and is approximately 0.6 m deep
- Lay a thick layer of willow branches in the trench so that 1/3 of the length of the branches is above the trench and the branches angle out toward the stream
- Place a minimum of 40 willow branches per m in the trench
- Backfill over the branches with a gravel/soil mix and secure the top surface with large washed gravel, bundles/coir logs, or carefully placed rocks
- Both the upstream and downstream ends of the live siltation construction need to transition smoothly into a stable streambank to reduce the potential for the system to wash out

- More than one row of live siltation can be installed
- A living and growing siltation system typically is installed at AHW
- A non-living system can be constructed below AHW during low water levels
- If it is impossible to dig a trench, the branches can be secured in place with logs, armour rock, bundles made from wattles, or coir logs

Construction Considerations

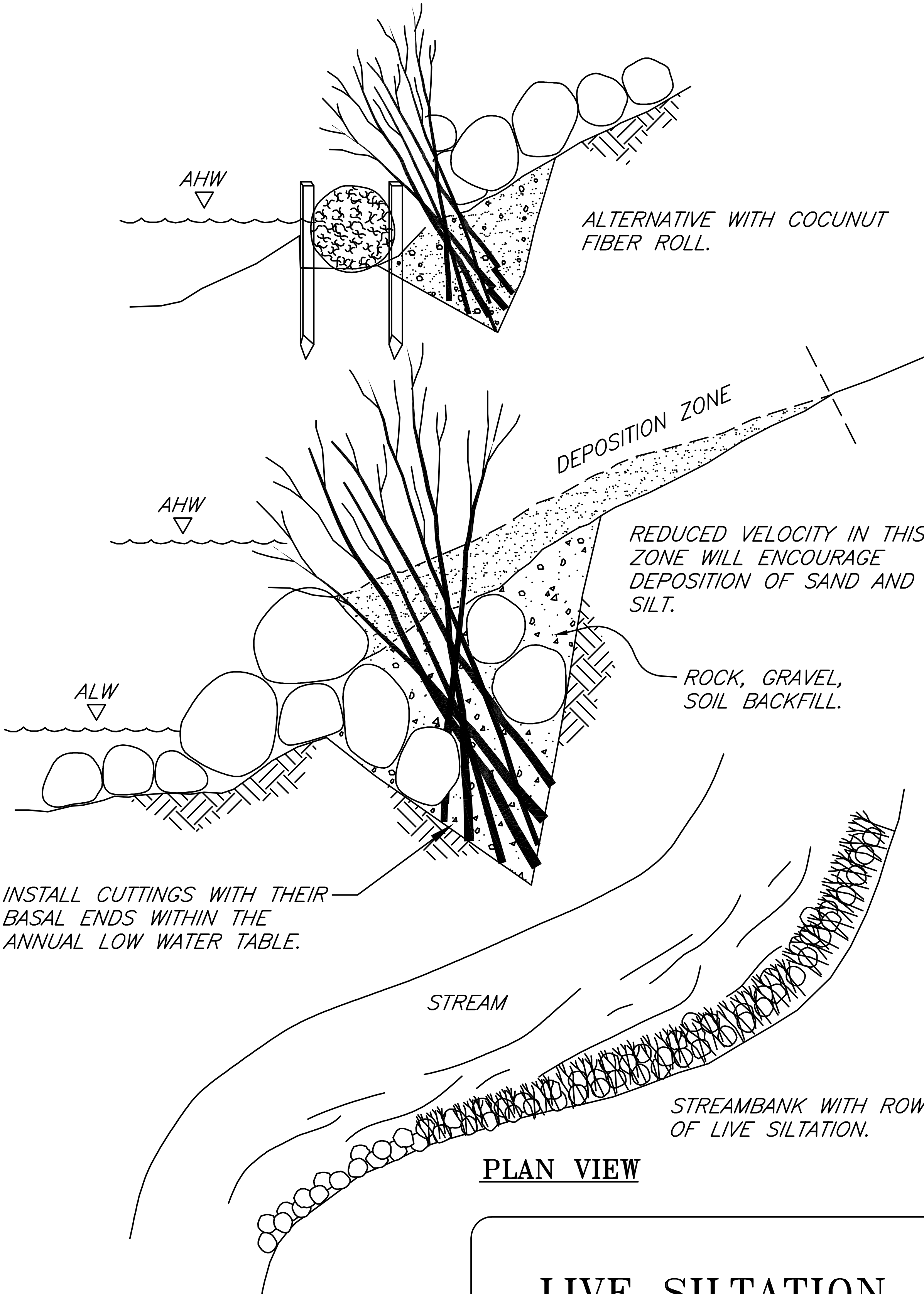
- Natural stone, willow wattles, logs or root wad revetments are needed for toe and scour protection
- The live siltation will require live branches of shrub willows 1 to 1.5 m in length
- Branches should be dormant, and need to have the side branches still attached
- Any woody plant material, such as alder, can be installed for a non-living system

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- During the first year, the installation should be checked for failures after all 1-year return interval and higher flows, and repaired as necessary
- During summer months of the first year, ensure that cuttings are not becoming dehydrated
- Cuttings will not promote siltation if not located at the water’s edge
- If located further up the bank, cuttings may dry out, and will only trap sediments and slow velocities during high flows
- Cuttings may not grow well if not handled properly prior to installation

Design Considerations

- Cuttings should be placed adjacent to the water’s edge to ensure effective sediment trapping and velocity reduction at the toe of slope
- At least 40 branches per m should be installed
- This technique may be used for velocities up to 2 m/s, but velocities should be at least 0.25 m/s for the system to function properly



LIVE SILTATION

FILE: LIVESILT

Willow Posts & Poles Streambank Stabilization Techniques	B.M.P. #41

Description and Purpose

- Willow trees and shrubs may be propagated by planting cuttings
- Although smaller (<4 cm) diameter cuttings (stakes) grow more vigorously than older, larger materials (posts and poles), larger materials provide mechanical bank protection during the period of plant establishment
- Dense arrays of posts or poles reduce velocities near the bank or bed surface, and long posts or poles reinforce banks against mass instabilities occurring in shallow failure planes
- Willow posts and poles can be used in most areas in need of re-vegetation
- Those most conducive to this practice are midbank areas on banks with a 1V:2H slope or shallower
- Although posts and poles can be planted in the toe and upper bank areas, vigorous growth is rare, due to drowning and desiccation of the poles, respectively

Applications

- Willow species are lead pioneers in riparian zones throughout much of North America
- Once established, they provide cover and create conditions conducive to colonization by native species that comprise the riparian community
- Functional riparian zones provide habitats for a wide range of aquatic and terrestrial plants and animals, generally improve bank stability, mediate water quality, and improve visual resources

Advantages

- Willow posts and poles are excellent additions to any technique that requires excavation, particularly when the depth and location of the excavation intercepts soils conducive to willow growth
- Willow posts and poles may be inserted into stone or soil backfill and thus become incorporated with the structure as they root
- They can also be incorporated into many techniques during construction (e.g., Vegetated Riprap**,** Vegetated Gabions)**,** and can be planted in the keyways of many structures
- When placed along a channel with perennial flow, willows generally will not survive when planted at the toe, but may serve as short-term sacrificial protection for plantings at higher elevations

- If permanent protection is needed, structural measures like stone toe are recommended
- Willow posts and poles are inexpensive to acquire, install, and maintain
- Willow posts and poles provide long-term protection
- The mature willows provide canopy cover for aquatic and terrestrial fauna, which also lowers stream temperatures
- Aquatic and terrestrial habitat is provided and/or improved
- Willows act as pioneer species, and allow other plant species to colonize the area after the willows have become established

Limitations

- Willows generally do not grow into the stream or above the top of bank
- Willow posts and poles have higher survival rates when planted during their dormant season, so planning should be adjusted accordingly
- Optimum stabilization is not achieved until the willows become established, typically at least one season after installation, although they provide some reinforcement immediately following installation

Construction

- Poles and posts should be deeply (1 to 2 m) planted in holes created using a metal "stinger" mounted on a hydraulic hoe, or an auger

Construction Considerations

- Willow poles, approximately 5 to 15 cm in diameter, and 1.8 to 3 m in length
- Optimum hole digging equipment is a backhoe with "Waterjet Stinger", normal Stinger or auger
- An excavator bucket can also be used

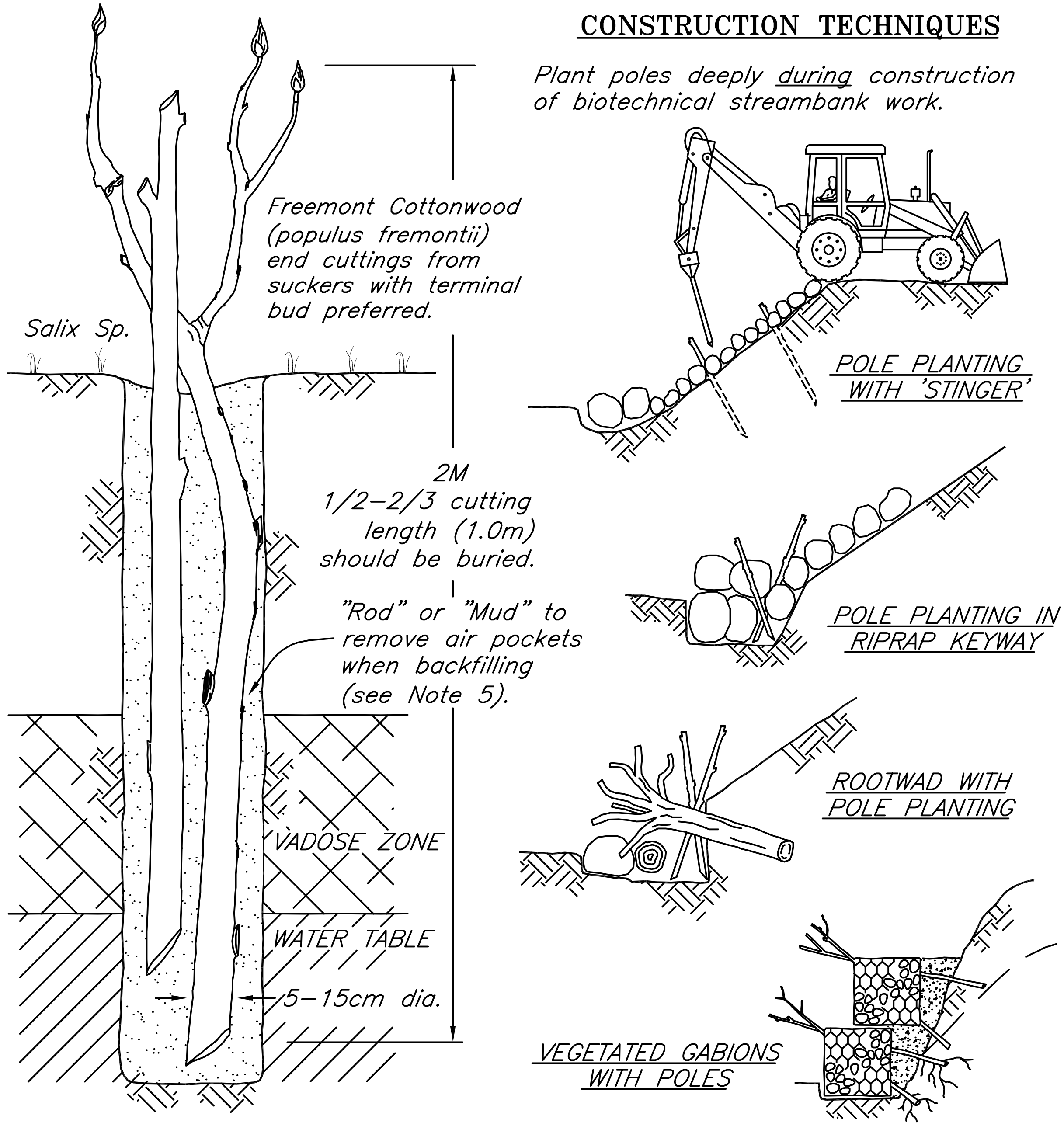
Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Willow posts should be inspected for vigor, dehydration, and animal browsing problems
- Desiccation and browsing are the two biggest reasons for failure
- Often, willow post installations need to be fenced for a year or so, especially in agricultural areas, to allow the willows to get established

- Willows that are not planted deeply enough, have too much of their stem exposed, or do not have good stem to soil contact can dry out and die before getting established

Design Considerations

- Willow cuttings should be planted while dormant, and care should be taken to prevent desiccation or dormancy break of cuttings between harvest and planting
- Poles and posts should be deeply (1 to 2 m) planted in holes created using an auger or metal "stinger" mounted on a hydraulic hoe, or an excavator bucket
- Poles should be planted to such a depth that desiccation does not occur during summer (for sites with water tables lower than the stream) and poles are not undermined by local scour during high flows
- Augered holes offer the advantage that soils adjacent to the planted stem are not compacted
- Good contact between the plant stem and soils is essential, so holes that do not collapse must be refilled with compacted soil to prevent desiccation of the plants due to air pockets
- High flows that occur shortly after planting can ensure collapse of the holes and filling of air pockets
- Water jetting, in which stems are rapidly inserted into soils that are locally liquefied using a high-pressure stream of water, offers many advantages over other planting techniques when applied to sandy soils
- Only a small portion of the pole should remain above the surface of the ground – about 80% of the cutting should be buried, to prevent desiccation and ensure good stem to soil contact
- Willow success is governed by soil texture and moisture regime
- Workers in drier climates have stressed the importance of planting willow posts deeply enough to maintain contact with groundwater throughout the growing season



NOTES:

1. Pole cuttings of willow or cottonwood are longer and have a larger diameter than branch cuttings or live stakes.
2. Larger diameter cuttings have a greater supply of stored energy (stored photosynthesis) than smaller diameter cuttings.
3. Pole cuttings are better suited for highly erodible areas and sites with fluctuating water levels.
4. The pole cuttings should extend through the vadose zone and into the permanent water table. At least 1/2 to 2/3 of the pole should be below the ground, at least 1.0m, and long enough to emerge above adjacent vegetation.
5. "Muddying" – filling the hole with water and then soil to make a mud slurry can remove air pockets.

WILLOW POSTS & POLES

POLEPLNT

Rock Vanes Streambank Stabilization Techniques	B.M.P. #42

Description and Purpose

- Vanes are redirective, discontinuous, transverse structures angled into the flow in order to reduce local bank erosion by redirecting flow from the near bank to the center of the channel
- The instream tips of the structures are typically low enough to be overtopped by all flows and crests slope upward to reach bankfull stage elevation at the bank
- Structures angled upstream redirect overtopping flows away from the protected bank
- Vanes are installed to provide toe protection and rectify lateral instability by redirecting flow away from eroding banks, while providing greater environmental benefits than stone blanket or revetment
- Vanes can increase scour at the tips, backwater area, edge or shoreline length, and the diversity of depth, velocity and substrate
- When properly positioned, a vane deflects flow away from the bank and induces deposition upstream and downstream of the structure
- This redirection of flow reduces velocity and shear stress along the bank while creating a secondary circulation cell that transfers the energy toward the middle of the channel
- Rock vanes, protruding 1/3 bankfull width into the channel and oriented at an upstream angle between 20° and 30°, move the thalweg an average of 20% bankfull width away from the eroding bank. Therefore, vanes, whether made of rock and/or logs, redirect water away from streambanks into the center of the channel
- This serves to decrease shear stress on banks, as well as creating aquatic habitat in the scour pools formed by the redirected flow
- By increasing shear stress in the center of the channel, the vanes create a stable width/depth ratio, maintain channel capacity and maintain sediment transport capacity and competence
- J-hook vanes can also be paired and positioned in a channel reach to initiate meander development or migration

Rock Vanes Streambank Stabilization Techniques	B.M.P. #42

Applications

- Vanes are installed on the outside of stream bends where high velocity and shear stress is causing accelerated bank erosion
- Can often be used at sites where riprap revetments are traditionally applied but greater environmental benefits are desired
- Vanes and other redirective, discontinuous practices should be applied with caution to project sites where infrastructure is immediately adjacent to the protected bank
- Can be combined with longitudinal stone toe or toe or vegetated riprap if continuous resistive protection is also necessary
- Vanes have been successfully installed in rivers and streams with bankfull widths ranging from 9 m to 150 m, with gradients between 0.05 to 0.0003, and in a variety of bed materials
- The ability of vanes to redirect flows and shift local scour and stream power to the center of the channel makes the technique particularly effective where bridge infrastructure is threatened by scour or flanking
- Vanes can be used where it is necessary to preserve as much of the existing bank vegetation as possible, and where aquatic habitat and substrate complexity is an important consideration
- Unlike riprap revetment, which requires reshaping of the bank for installation, vanes require bank disturbance only where keys are placed. This provides opportunities for using vanes in combination with soil bioengineering techniques

Advantages

- Since rock vanes can successfully reduce near-bank velocities and shear stress, vegetation establishment is greatly improved
- Vanes are often combined with other biotechnical soil stabilization measures for bank areas between the vanes
- Vegetated ground cover techniques such as Turf Reinforcement Mats, Erosion Control Blankets, Live Stakes, Live Brush Mattress, and Vegetation Alone are appropriate candidates for combination
- Rock vanes are sometimes used in conjunction with continuous and resistive armouring measures, such as Cobble or Gravel Armour, Vegetated Riprap or Longitudinal Stone Toe, when additional protection between the vanes is required
- Live Brushlayering, Willow Poles, and Live Siltation are extremely effective when implemented at the bank during excavation of the keyways

- Posts and Poles can be used to create overhanging cover for pools up- or downstream from cross vanes
- Intermittent structures such as vanes provide aquatic habitats superior to resistive, continuous structures like Riprap and Longitudinal Stone Toe
- Controlled scour at the vane tip, the creation of pool/riffle bed complexity, and increased deposition of the upstream end are the major environmental benefits of vanes
- Vanes provide fish rearing and benthic habitat, creates or maintains pool and riffle habitat, provides cover and areas for adult fish, and velocity refugia
- Using a redirective measure instead of a continuous, resistive bank armouring technique has several advantages
- Vane installation can often be accomplished from the top of the bank, and does not require bank regrading, which minimizes the impacts to existing vegetation and reduces the amount of site disturbance needed for installation
- The redirection of impinging flows away from the bank and the sedimentation on the upstream side of the vane creates areas where vegetation can effectively re-establish. Thus, areas of active bank erosion become depositional, vegetate, and subsequently, become permanently stable
- Vanes can be used to reduce streambank erosion, rectify lateral instability, and modify flow direction and local scour, while simultaneously gaining environmental benefits
- The technique is appropriate under a range of flow conditions and bed materials and can be used in series to redirect flows around bends
- Vane installation does not require extensive bank reshaping, and most heavy equipment work can be done from the top of the bank, further reducing site disturbance
- Vanes require less rock and heavy equipment than riprap for a similar length of protected bank
- When used to protect bridge infrastructure, vanes placed upstream of abutments force the thalweg toward the center of the channel

Limitations

- Unintended impacts can result from improper design and construction
- If the vane is not properly keyed into the bank, it is likely to fail, creating new localized erosion problems

- Improper vane angle and crest elevation can redirect flow in unintended directions, triggering downstream erosion

Construction

- Construction will require excavation of a key into the bank at minimum of 3 m to a height of bankfull elevation
- If the bank is higher than bankfull, a bench at bankfull elevation can be built to key in the vane
- The keyways should be constructed by digging a trench, placing rock and installing vegetation, and backfilling
- If vegetative techniques are used, such as Willow Post and Poles or Live Siltation, the chances of successful establishment can be increased by "watering in" the cuttings
- Self launching rock can be placed on the existing substrate, however, if footer rocks are necessary, then excavation of the trench for the footer rocks will be required
- The depth of the trench varies depending on bed material
- For a gravel or cobble bed stream, a depth of twice the diameter of the average vane rock is recommended for the footer trench
- The footer rocks should be placed with a gap between the stones equal to 1/3 their diameter which allows them to interlock as the vane adjusts and equilibrates
- In sandy bed material, or where excessive scour is predicted, the trench depth should be four times the diameter of the average vane rock and the gaps between the rocks should be eliminated
- It may be feasible to place a filter fabric geotextile under the footer stones on sand-bed streams

Construction Considerations

- Vanes are generally constructed with graded rock; however, successful vanes have also been constructed from single logs and log cribs with stone fill
- An excavator or backhoe is usually needed to construct the keyways and place the vane rocks

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- The vane should be inspected regularly

- Maintenance staff should determine:
  - Is the vane intact?
  - Are flows being redirected where expected?
  - Is there any unintended scour?
  - Is there deposition on the upstream side of the vane?
  - Has the vane (or vane series) created or exacerbated erosion or lateral instability downstream of the structure?
- If the vane is not properly keyed into the bank, it is likely to fail, creating new localized erosion problems
- Improper vane angle and height can redirect flow to unintended places, creating further bank erosion downstream of the structures

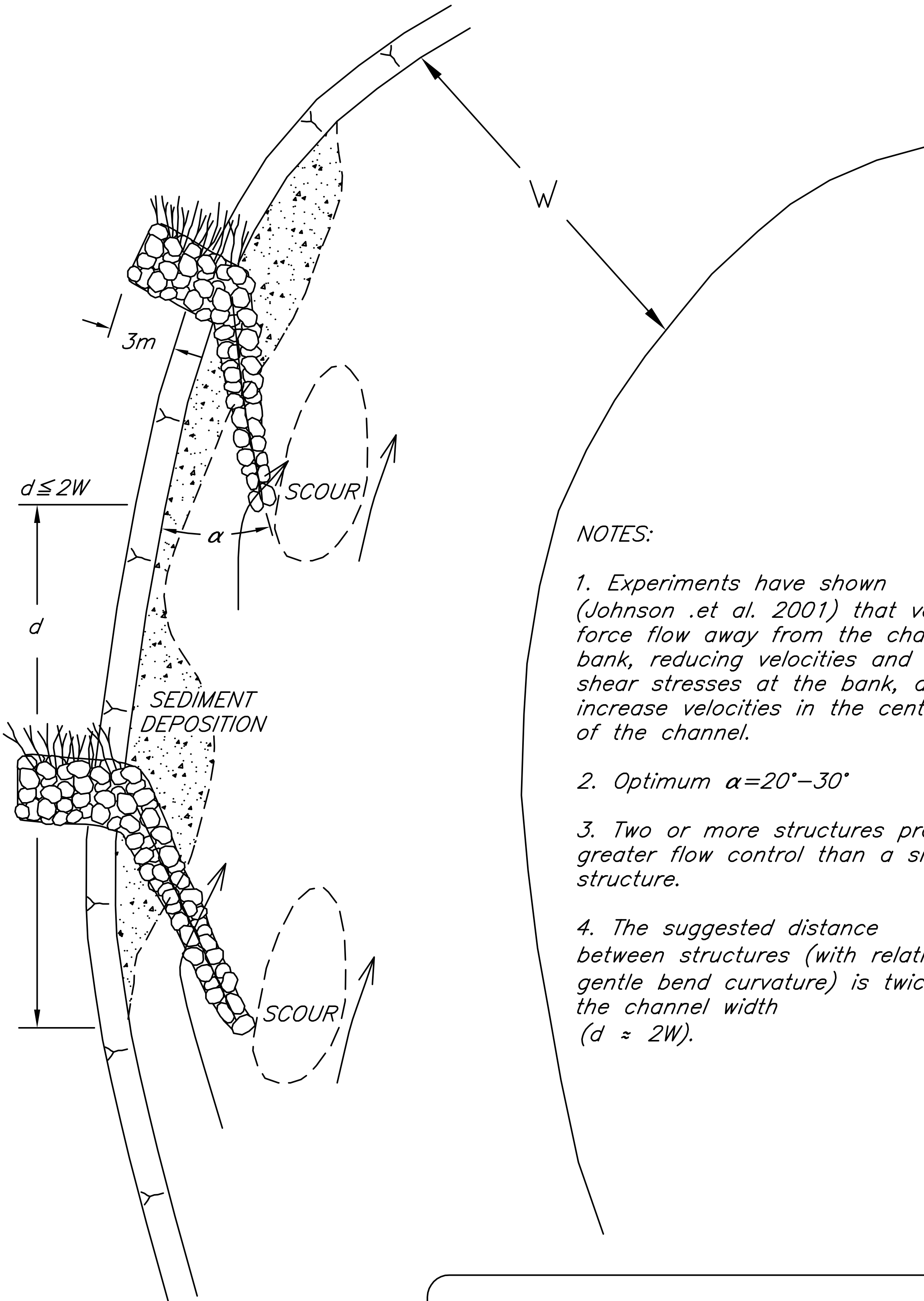
Design Considerations

- Regardless of project goals, the key design/construction elements of vanes are length, angle, crest elevation, slope, rock size, the placement of appropriate footer rocks, and vane spacing if using the structures in series
- ***Hydraulic Considerations****:*
  - The primary hydraulic design consideration for vanes is the water surface elevation of bankfull stage
  - Cross vanes are independent of design high-water and freeboard and vegetation establishment is the most common bank protection from bankfull stage to top of bank.
- ***Length***:
  - The vane should extend 1/4 to1/3 the bankfull width of the channel
  - However, this maximum applies to small streams; the larger the channel, the shorter the vane should be relative to the channel width.
- ***Angle***:
  - Optimum results are obtained when the vane is oriented upstream at an angle with the protected bank between 20° and 30°. A 20° angle requires a longer vane, but protects a greater length of bank
  - When orienting vanes for the specific goal of protecting bridge infrastructure, i.e., directing flow through and reducing scour at bridge abutments, a 30° angle is generally more effective at reducing scour at the abutment and moving maximum scour depth toward the center of the channel than the 20° angle

- ***Height***:
  - – The crest elevation of the bank end of the vane should be equal to the bankfull or AHW stage elevation
  - – The key into the bank is also designed to bankfull elevation
  - – The vanes must be keyed into the bank at least 3 m
  - – If the bank is higher than bankfull, build a bench at bankfull elevation to key in the vane
- ***Crest Slope***:
  - – Vanes are designed to be overtopped at the tip by all but the lowest flows and should pitch from the bank to the tip of the vane with a 3 to 7% slope
  - – Steeper vanes act more like spurs or barbs and have different effects on scour and velocity
- ***Rock Gradation and Shape***:
  - – When possible, vanes should be constructed with graded (self-launching) stone. Self-launching stone will automatically stabilize the toe of the structure in any scour holes that form
  - – Where additional scour is anticipated, more stone may be added to widen the weir crest
  - – In this way, stone may be sacrificed without modifying the crest elevation
  - – Weirs and vanes placed on sand beds devoid of gravel may subside as sand is washed from beneath the stone; this problem may be addressed by placing filter fabric or a filter layer of finer stone underneath the stone spur
  - – In very sandy-bottomed streams, it is advantageous to build vanes using "shot rock" or well-graded stone that includes fines, as they prevent ‘through-flow’ of sand, and subsequent scour
- ***Rock Size:***
  - – The size of the rock will depend upon the stream size and shear stress
  - – See comments below under "Hydraulic Loading" on rock sizing.
- ***When to use footers***:
  - – The footer rocks should be heavier, longer, and flatter than the average vane rocks

- As a rule of thumb, the weight of the heaviest footer rock is comparable to the heaviest rock used for riprap for the design flow
- In sandy streams an extra layer of footer rocks may be necessary to compensate for the additional scour
- Even in small sand bed streams, 2 m of scour next to a structure like this is not uncommon

- ***Spacing***:
  - The distance from the convergence point of impinging flows along the eroding bank (or upstream corner of a bridge abutment) to the upstream tip of the vane should be twice the channel width
  - When using vanes in series, the spacing between the upstream tips of the vanes should also be twice the channel width
  - When using vanes in a series along an outer bend, the upstream vane should be located at the point where impinging flows are first causing erosion
  - The second vane is to be located at the point on the bank that will be impacted by the redirected flows
  - This method of spacing requires that the design be based the on the flow angles, flow depth and flow direction from the anticipated design storm stage
  - As a general rule, small to moderate rivers, less than 20 m wide and where the vane projects approximately 1/3 the width, require spacing that is approximately twice the channel width
  - Permissible shear and velocity for rock vanes is related to the size of rock used in construction
  - Other factors, such as the angularity of the stone, the thickness of the layers of stone, and the angle at which the faces of the stone structure are constructed also come into play
  - The Maynord (1995) equation gives a D_{50} stone size for an angular stone riprap revetment of 0.875 m if the near-bank vertically-averaged velocity is 3.5 m/s, and flow depth = 1 m, and stone is placed on a bank slope of 1V:1.5H
  - Use of riprap larger than this is unusual



NOTES:

1. Experiments have shown (Johnson .et al. 2001) that vanes force flow away from the channel bank, reducing velocities and shear stresses at the bank, and increase velocities in the center of the channel.

2. Optimum $\alpha = 20^\circ - 30^\circ$

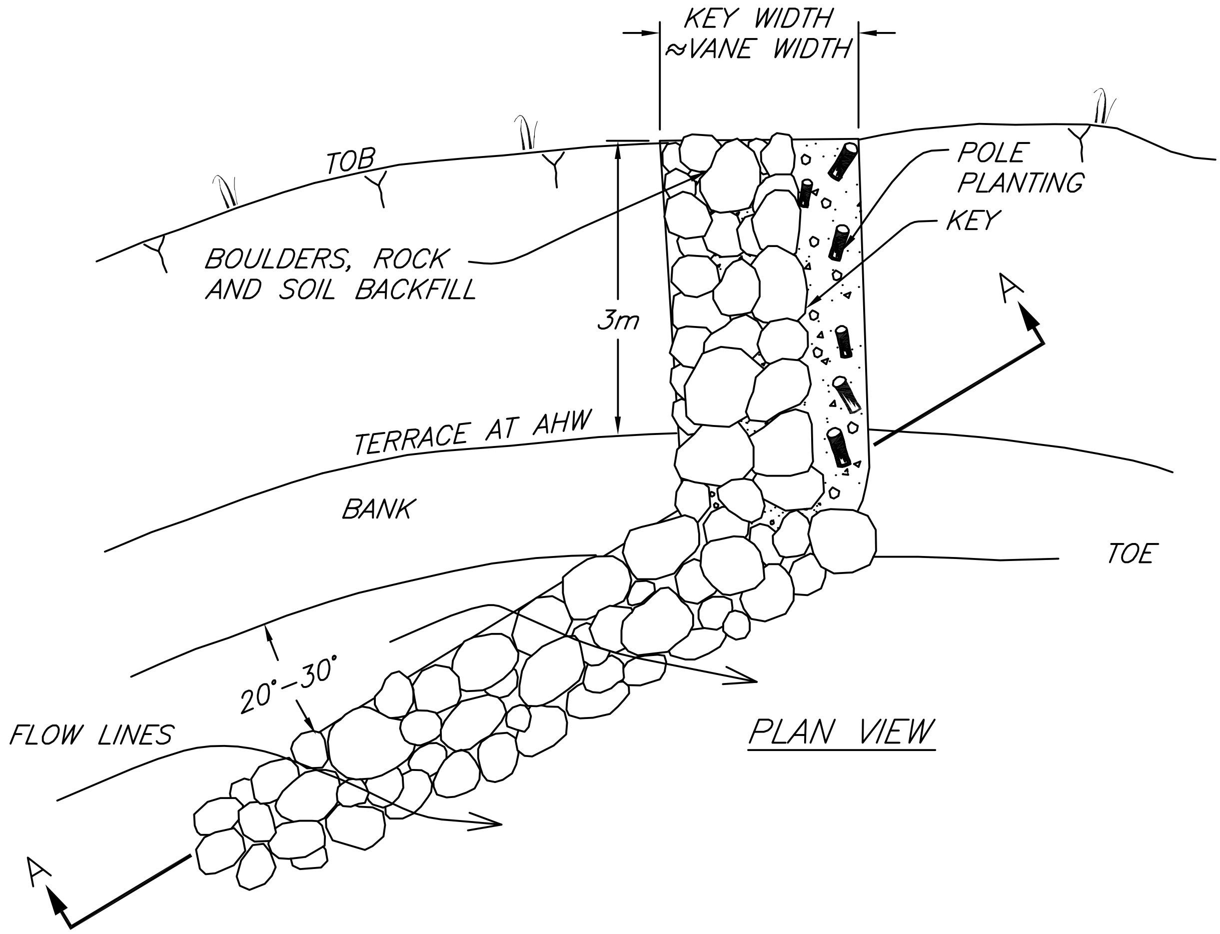
3. Two or more structures provide greater flow control than a single structure.

4. The suggested distance between structures (with relatively gentle bend curvature) is twice the channel width ($d \approx 2W$).

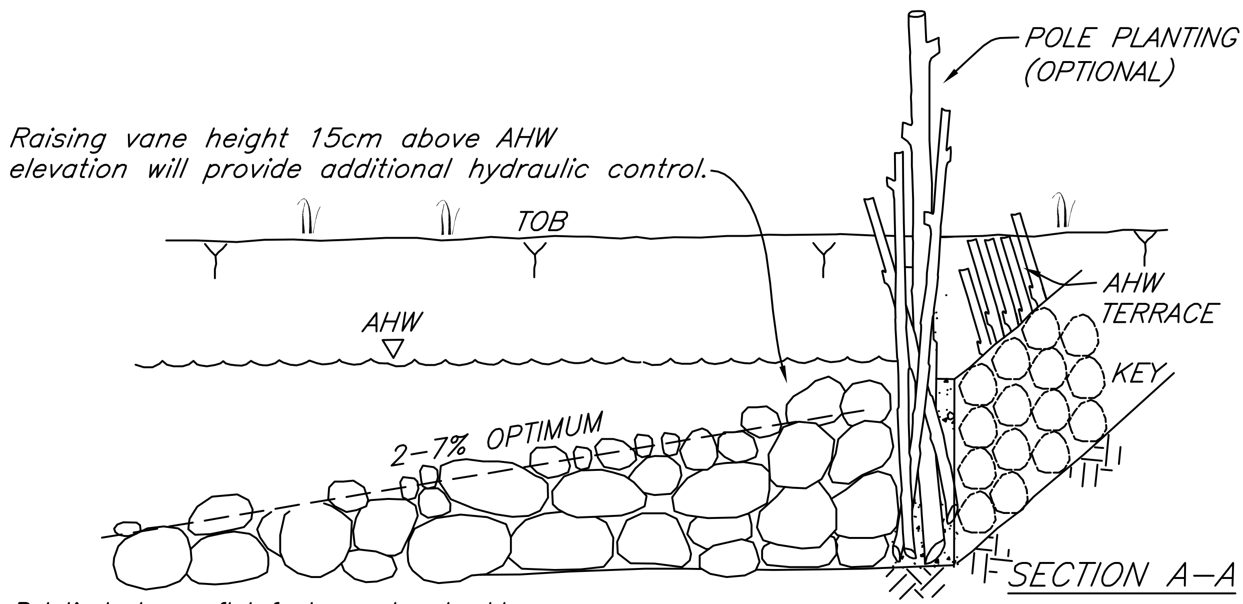
TYPICAL VANE

FILE: ROCK VANE

Government of Alberta ■ Transportation



PLAN VIEW



SECTION A–A

Relatively large, flat footer rocks should be placed as deep as the deepest anticipated scour along the thalweg, or 2 vane rock diameters below the vane rocks, whichever is greater. Inordinate scour can be mitigated by placing a stone or geotextile under layment, or by using self–launching (graded) stone.

TYPICAL VANE BANK KEY DETAIL (WITH POLE PLANTING)

FILE: ROCK VANE–BANK KEY DETAIL

Longitudinal Stone Toe Streambank Stabilization Techniques	B.M.P. #43

Description and Purpose

- Stone toe is continuous bank protection consisting of a stone dike placed longitudinally at, or slightly streamward of the toe of an eroding bank
- Cross-section of the stone toe is triangular in shape
- Success of this method depends upon the ability of stone to self-adjust or "launch" into any scour holes formed on the stream side of the revetment
- Does not need to follow the bank toe exactly, but should be designed and placed to form an improved or "smoothed" alignment through the stream bend. The "smoothed" longitudinal alignment results in improved flow (less turbulence) near the toe of the eroding bank
- It is especially effective in streams where most erosion is due to relatively small but frequent events
- It protects the toe so that slope failure of a steep bank landward of the stone toe will produce a stable angle
- Such a bank is often rapidly colonized by natural vegetation

Applications

- Longitudinal stone toe can be applied in some situations where the bankline needs to be built back out into the stream, where the existing stream channel needs to be realigned, where the outer bank alignment makes abrupt changes (scallops, coves, or elbows), or where the stream is not otherwise smoothly aligned

Advantages

- A variety of techniques can be used with Longitudinal Stone Toe
- Willow posts and poles may be incorporated into key sections and used to re-vegetate the middle and upper bank above stone toe
- Longitudinal stone toe has proven cost-effective in protecting lower banks and creating conditions leading to stabilization and re-vegetation of steep, caving banks
- Live Siltation, Live Brushlayering, Live Brush Mattresses, Live Staking, Live Fascines, Turf Reinforcement Mats, Erosion Control Blankets, Geocellular Containment Systems, Vegetated Articulated Concrete Blocks, Vegetated Riprap, Soil and Grass Covered Riprap, and Vegetated Gabion Mattress may all be used to provide rapid re-vegetation and additional protection on middle and upper banks
- Cobble or Gravel Armour, Vanes with J Hooks, Cross Vanes, Boulder Clusters, and Newbury Rock Riffles may be used to enhance benthic and water column habitats

- Longitudinal Stone Toe with Spurs is a variation on this technique
- It has documented environmental benefits, especially for aquatic habitat
- Stone interstices provide cover and habitat for smaller fish and other organisms, and rocky surfaces provide stable substrate for benthic invertebrates. However, fish habitat provided by Longitudinal Stone Toe has been found generally inferior to that provided by intermittent, redirective measures like Spur Dikes, Vanes, or Bendway Weirs
- Vegetative cover can become established, even growing through the rock, and can provide canopy and a source of woody debris
- Bank grading, reshaping, or sloping is usually not needed (existing bank and overbank vegetation need not be disturbed or cleared), nor is a filter cloth or gravel filter needed
- If stone is placed from the water side, existing bank vegetation need not be disturbed
- It is very cost-effective and is relatively easy to construct
- It is simple to design and specify
- It is easily combined with other bank stability techniques that provide superior habitat compared to pure riprap

Limitations

- Only provides toe protection and does not protect mid- and upper bank areas
- Some erosion of these areas should be anticipated during long-duration, high energy flows, or until the areas become otherwise protected
- Stone toe is not suitable for reaches where rapid bed degradation (lowering) is likely, or where scour depths adjacent to the toe will be greater than the height of the toe

Construction

- Longitudinal stone toe should be constructed in an upstream to downstream sequence
- Requires heavy equipment for excavation of the keys (tie-backs) and efficient hauling and placement of stone
- Can be constructed from within the stream, from roadways constructed along the lower section of the streambank itself, or from the top

- The preferred method is from the point bar side of the stream (especially possible with ephemeral or intermittent streams), as this causes the least disturbance of existing bank vegetation
- The least preferred is from the top of the bank, as it disturbs or destroys more bank vegetation and the machine operator's vision is limited
- Usually, the keyways are excavated first and rock is dumped into the key
- The rock is then formed into tie-backs (if needed) and finally the stone toe is constructed along a "smoothed" alignment, preferably with a uniform radius of curvature throughout the bend
- In a multi-radius bend, smooth transitions between dissimilar radii are preferred

Construction Considerations

- Stone for the structure should be well graded and properly sized
- The Maynord (1995) equation gives a D_{50} stone size for an angular stone riprap revetment of 0.875 m if the near-bank vertically averaged velocity is 3.5 m/s, and flow depth = 1 m, and stone is placed on a bank slope of 1V:1.5H

Inspection and Maintenance

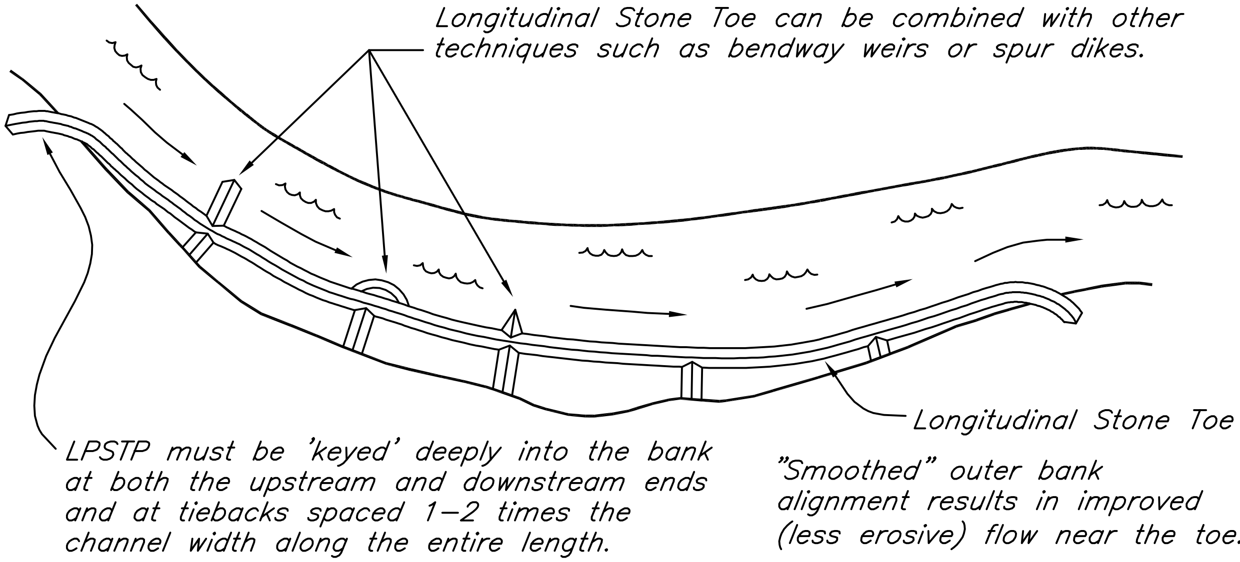
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Stone toe structures rarely require maintenance
- Maintenance and monitoring requirements should be linked to consequences of failure
- Features that should be monitored are similar to those for all stone structures:
  - Loss of stone due to subsidence, leaching of underlying sediments, ravelling or excessive launching
  - Extreme scour or bed lowering on the stream side of the toe can cause the entire mass of stone to launch, creating an opening or gap in the longitudinal structure
  - If this situation is anticipated or encountered, the problem can be remedied by adding more rock for additional width
  - Longitudinal stone toe may be flanked during extremely high flows if the key trenches are incorrectly built or if the tiebacks are spaced too widely or are constructed with inadequate amounts of stone
  - These terminal key trenches at the upstream and downstream ends should be excavated into the bank at an angle of approximately 30° with the primary flow

direction and of sufficient length that flows will not be able to get around them during the design storm

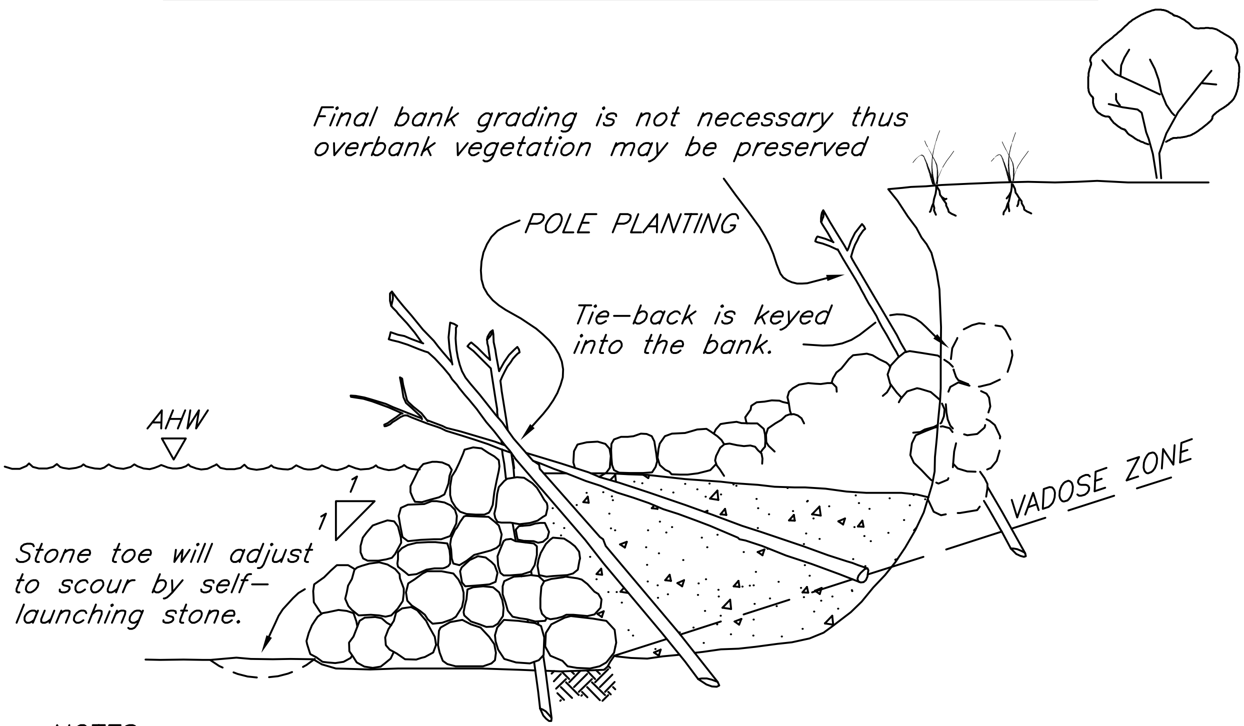
Design Considerations

- Longitudinal stone toe can be specified by weight per unit length or to a specific crest elevation
- A specific crest elevation may be specified when the bed of the stream is uneven or deep scour holes are evident
- Longitudinal fill stone toe or weighted riprap toe are similar to stone toe except that the cross-section may be rectangular rather than triangular or peaked
- The dimensions for the weighted riprap toe are based on projected scour depth and a minimum "thickness", which corresponds to stone toe height of 2.5 to 4 times the maximum stone diameter - about 1 to 1.5 m
- Longitudinal stone toe side slopes should be equal to the angle of repose
- Typically stone toe applied at a rate of 3 metric tons of stone per lineal m of protected bank will have a height of approximately 1 m
- Stone toe constructed with 6 metric tons/m stands approximately 1.5 m tall, whereas 1.5 metric tons/m is approximately 0.6 m tall
- Longitudinal stone toe must be keyed deeply into the bank at both the upstream and downstream ends and at regular intervals along its entire length
- On small streams, 25 to 30 m spacing between keys (tie-backs) is typical, while on larger streams and smaller rivers, one or two multiples of the channel width can be used as a spacing guide
- Excavation of trenches for keys provides a good opportunity for deep planting willow posts or poles
- The toe itself does not need to be keyed into the streambed because of its ability to "self-launch"
- However, in areas where the bed of the stream is uneven or deep scour holes are evident, the crest of the structure should be constructed to a specific elevation
- The key trenches at the upstream and downstream ends should be excavated into the bank at an angle of approximately 30°, with the primary flow direction and of sufficient length that flows will not be able to get around them during the design storm
- A gentle angle is important for the end keyways, often referred to as "refusals", because it allows for smooth flow transitions coming into and flowing out of the treated reach

- Tiebacks or "refusals" oriented at 90° to the bank have resulted in many failures at the downstream end of the structure, due to flow expansion at that point
- Permissible shear and velocity for longitudinal stone toe is related to the size of rock used in construction
- Other factors, such as the angularity of the stone, the thickness of the layers of stone, and the angle at which the faces of the stone structure are constructed also come into play



TYPICAL LPSTP CONTINUOUS BANK PROTECTION



NOTES:

1. Longitudinal stone toe is a good choice when continuous bank protection is needed for the toe, but the mid and upper banks are relatively stable and/or biotechnical practices are suitable.
2. The success of Longitudinal Stone Toe depends on the ability of the well–graded stone to self adjust or "launch" into any scour holes formed on the stream side of the stone toe.

LONGITUDINAL STONE TOE

FILE: LPSTP

Vegetated Mechanical Stabilized Earth (VMSE) Streambank Stabilization Techniques	B.M.P. #44

Description and Purpose

- Vegetated Mechanically Stabilized Earth (VMSE) technique consists of live cut branches (brushlayers) interspersed between lifts of soil wrapped in natural fabric, e.g., coir, or synthetic geotextiles or geogrids
- The live brush is placed in a criss-cross or overlapping pattern atop each wrapped soil lift in a manner similar to conventional brushlayering
- The fabric wrapping provides the primary reinforcement in a manner similar to that of conventional mechanically-stabilized earth
- The live, cut branches eventually root and leaf out, providing vegetative cover and secondary reinforcement as well
- In some cases, the vegetative treatment may consist of using a coarse netting for the soil wraps and establishing a herbaceous or grass cover by hydroseeding through the openings in the fabric
- VMSE can be viewed as a union between conventional, mechanically stabilized earth methods that utilize inert, tensile inclusions, and brushlayering, a soil bioengineering technique that utilizes live, cut branches as the tensile soil inclusions
- Fabric wraps provide the primary reinforcement and mechanical stabilization, permitting much steeper slopes to be constructed than would be possible with live brushlayers alone

Applications

- This technique provides an alternative to vertical retaining structures, e.g., timber pile walls, and to techniques that require slope flattening or bank lay back, which results in excessive right-of-way encroachment at the top of bank
- The use of synthetic geotextiles or geogrids provides greater long-term durability and security
- The fabric or geotextile wrap also provides additional protection to upper portions of streambanks that are subject to periodic scour or tractive stresses
- If either steady, long term seepage or temporary bank return flows after flood events are a problem, the brushlayers act as a drainage layer or conduits that relieve internal pore water pressure, and favourably modify the groundwater flow regime within the slope to minimize slope stability problems

Vegetated Mechanical Stabilized Earth (VMSE) Streambank Stabilization Techniques	B.M.P. #44

Advantages

- The presence of vegetation mutes or softens the stark visual appearance of conventional mechanically stabilized earth structures and provides potential habitat for riparian wildlife
- Overhanging branches of the live brushlayers provide shade for fish and a substrate for insects and other organisms that the fish feed upon
- Branches also input leaves and twigs into the stream
- Since the inert fabric wraps or geosynthetic tensile inclusions provide reinforcement and mechanical stabilization, they permit much steeper slopes to be constructed than would be possible with live brushlayers alone
- Brushlayering treatment by itself is normally restricted to slopes no steeper than 1V:2H. VMSE can be constructed with a slope as steep as 1V:0.5H
- The vegetation shields the fabric against damaging UV radiation, and provides visual and riparian habitat benefits
- In addition, when live brushlayers are used, they provide secondary reinforcement, both from the stems themselves, and from rooting along their imbedded lengths
- The brushlayers act as horizontal drains that favourably modify the groundwater regime in the vicinity of the slope face, thereby improving stability against mass slope failure

Limitations

- A VMSE structure must be constructed during the dormancy period to insure good vegetative propagation and establishment
- Alternatively, the live cuttings may be harvested during dormancy, and placed in temporary cold storage until they are ready for use during an out-of-dormancy period, i.e., during the summer months (increases the cost)
- Materials procurement is more demanding, and installation more complex, because of the blending of two distinct methods, i.e., conventional MSE and live brushlayering, into a single approach
- Costs will also be more than brushlayering used alone, because of the added expense of the geotextile and the additional labour required to handle and construct the wraps
- VMSE streambank structures must be constructed during periods of low water because of the need to excavate and backfill a trench with rock in the streambed to provide a stable foundation

Construction

- A VMSE installation begins at the base of the slope and proceeds upwards
- The structure should be supported on a rock toe or base and be battered or inclined at an angle of at least 10 to 20° to minimize lateral earth forces
- The following guidelines and procedures apply:
  - Excavate a trench to a competent horizon below the likely depth of scour, and backfill it with rock to provide a base for the VMSE structure
  - The top surface of the rock should be inclined with the horizontal to establish the desired minimum batter angle for the overlying structure
  - Construct an earthen structure reinforced with either polymeric geogrids (or coir fabric) and live brush on top of the rock base
  - Place select fill material on the geogrid (or fabric) and compact it in 7.5 cm lifts to a nominal thickness ranging from 30 to 76 cm
  - Thinner lifts are used at the base of the structure, where shear stresses are higher
  - Temporary batter boards may be required at the front face to confine the select fill during the installation process and to form an even face
  - When geogrids are used, burlap strips at least 1.2 m wide can be inserted between the earthen fill and the geogrids at the front face to contain the fines and prevent initial ravelling of the fill through the apertures in the geogrid
  - The geogrid or fabric sheet should be allowed to drape down or protrude beyond the front edge of each underlying lift of earthen fill to create at least a 0.9 m overlap when it is pulled up and over the next lift
  - The exposed sections of geogrid or fabric layers are pulled up and over the faces of the fill layers and staked in place
  - The geogrids should be pulled as uniformly as possible before staking to develop initial tension in the geogrid or fabric. A tractor or winch pulling on a long bar with hooks or nails along its length works well for this purpose
  - The tensioned geogrid overlap sections should be secured in place using wood construction stakes spaced every 0.9 m
  - Layers of live cut branches are then placed criss-crossed atop the underlying wrapped soil lift
  - 25 to 50 mm of topsoil should be mixed in with the cut branches

- The top soil can be placed beforehand or spread over the top of a brushlayer
- Up to three layers of live, cut branches interspersed with 25 to 50 mm of topsoil can be placed in this manner
- The process is repeated with succeeding layers of earth fill, live brush and geogrids (or fabric) until the specified height or elevation is reached

- The recommended earthen lift thickness between geogrid (or fabric) layers depends on various soil and site variables, properties of the reinforcements, and desired safety factor
- The maximum vertical spacing and imbedded length of successive geogrid or reinforcement layers are determined from the specified safety factor, slope angle, soil shear strength, allowable unit tensile strength, and interface friction properties of the reinforcement layer

Construction Considerations (Materials and Equipment)

- The technique can also be used in conjunction with other techniques, particularly resistive techniques, designed primarily to protect the bank toe (Vegetated Riprap and Rootwad Revetments) and redirective techniques (Bendway Weirs, Spur Dikes, and Vanes)
- If excessive seepage daylights from or exits the bank, then a vertical drainage course can be interposed between the bank and the VMSE structure
- Select long branches of native tree species that are capable of vegetative propagation. Willows are the most commonly used plant material, because they generally root well from cuttings.
- Alder, cottonwood *(Populus deltoides)*, and dogwood *(Cornus)* can also be used effectively, particularly when mixed in with willow
- The length of the branches will vary depending upon the desired depth of reinforcement, but they should be long enough to reach the back of an earthen buttress placed against a streambank while protruding slightly beyond the face
- The diameter of the live cuttings will also vary depending on their length, but typically should range from 19 to 51 mm at their basal ends.

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- There are no compelling maintenance requirements in the case of VMSE installed along a streambank
- The vegetation should establish successfully without irrigation requirements given the proximity to water
- Monitoring should consist of inspecting the geogrids (or fabric) for signs of breakage or tearing from scour damage or possibly from excessive tensile stresses due to higher than expected lateral earth pressures
- Signs of uncontrolled seepage, such as weeping or wet spots in the structure, should also be noted
- The site should be examined for possible signs of flanking erosion, which must be addressed with ancillary protective measures lest the flanking threaten the integrity and effectiveness of the VMSE structure itself
- Common modes of failure:
  - Inadequate primary reinforcement from the inert tensile inclusions (fabric or geotextile), i.e., improper vertical spacing or lift thickness, insufficient allowable unit tensile resistance in the selected fabric or geotextile, too short an embedment length, etc., for the given soil and site conditions, i.e., slope height, slope angle, and soil shear strength properties
  - Failure to properly consider seepage conditions and install adequate drainage measures, e.g., chimney drain behind VMSE structure
  - Inadequate attention to construction procedures and details

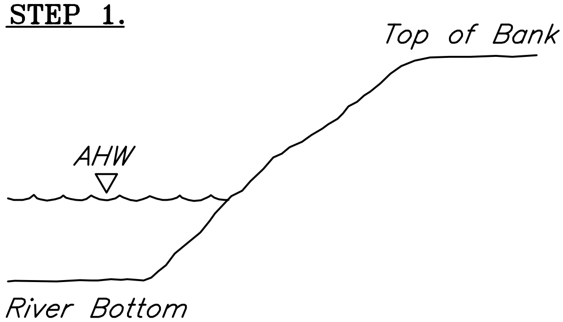
Design Considerations

- It is critical that factors such as scour depth be determined for each particular project and be incorporated into project design
- Many different types of inclusions with various shapes and properties can be used to reinforce and buttress earthen slopes. These inclusions range from imbedded metal strips, geogrids fabricated from polymeric nets, and natural or synthetic geotextiles or fabrics
- Shear stresses that develop in the soil matrix are transferred into tensile resistance in the imbedded inclusions via friction along the soil-inclusion interface

Vegetated Mechanical Stabilized Earth (VMSE) Streambank Stabilization Techniques	B.M.P. #44

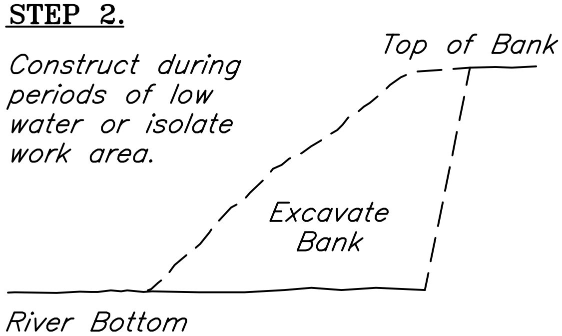
- Mechanically stabilized earth retaining structures must satisfy external stability requirements, i.e., have adequate resistance to sliding, overturning, and bearing capacity failure
- The tensile inclusions or reinforcements in these structures must have a sufficient unit tensile resistance and/or be placed in sufficient numbers to resist breaking in tension
- The inclusions must also be sufficiently long and "frictional" enough to resist failure by pullout
- Synthetic geogrids fabricated from high-tensile strength polymeric materials are widely used in reinforced earth embankments and retaining walls. Geogrids tend to have superior pullout resistance compared to geotextile or fabric sheets. They can be used either in a wrap-around fashion to provide both backfill reinforcement and containment at the front face
- Live cuttings act as tensile inclusions and help to stabilize a slope, embankment, or structural fill
- The main considerations in the design of geogrid or geotextile reinforced earthen slopes and embankment fills is the required vertical spacing (d) and total length (L) of the reinforcing layers
- The total length (L) is comprised of a length or distance required to reach the expected failure surface in the backfill and an additional length, the effective or imbedment length (L_E), extending beyond the failure surface required to prevent pullout
- The reader should consult with a geotechnical engineer

STEP 1.

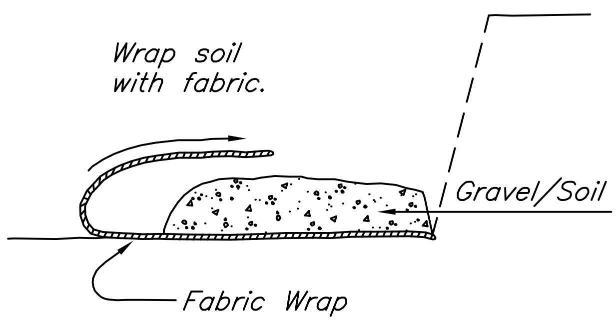


STEP 2.

Construct during periods of low water or isolate work area.

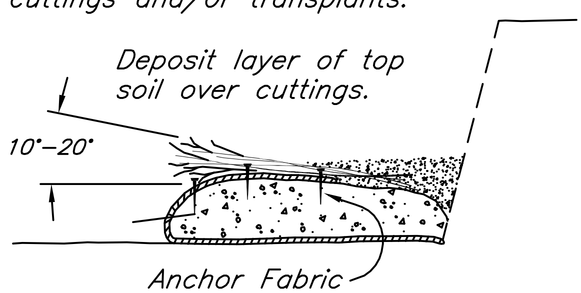


STEP 3.

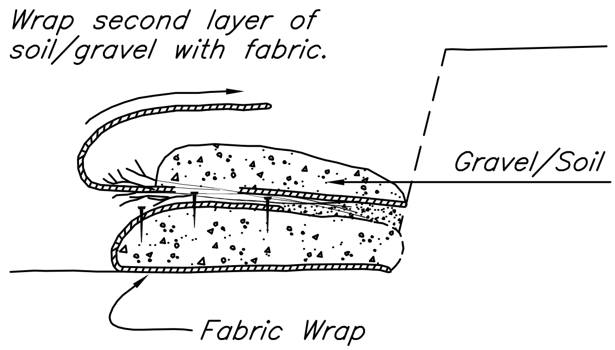


STEP 4.

Crisscross layers of dormant cuttings and/or transplants.

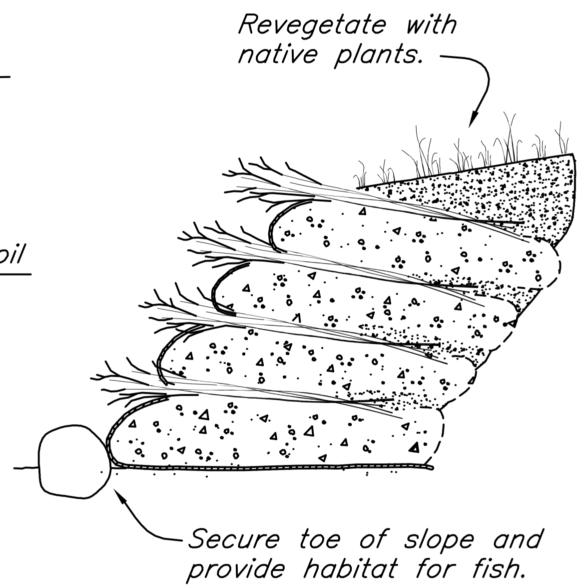


STEP 5.



STEP 6.

Repeat steps 3, 4, 5 until desired height of bank is reached.



VEGETATED MECHANICALLY STABILIZED EARTH STEP BY STEP

FILE: LAYERSXS

Vegetated Riprap Streambank Stabilization Techniques	B.M.P. #45

Description and Purpose

- Vegetative Rip-Rap combines the widely-accepted, resistive, and continuous rock revetment techniques with vegetative techniques. It consists of a layer of stone and/or boulder armouring that is vegetated, optimally during construction, using pole planting, brushlayering and live staking techniques
- Continuous and resistive bank protection measures, such as riprap and longitudinal rock toes are primarily used to armour outer bends or areas with impinging flows
- The stream energy is resisted by the continuous protection, and is subsequently directed downward into the streambed
- The riprap will resist the hydraulic forces, while roots and branches increase geotechnical stability, prevent soil loss (or piping) from behind the structures, and increase pull-out resistance
- The roots, stems, and shoots will help anchor the rocks and resist ‘plucking’ and gouging by ice and debris

Applications

- Vegetated Rip-Rap is appropriate where infrastructure is at risk, and where redirective and discontinuous bank protection measures have been rejected or deemed inappropriate
- Vegetative Rip-Rap techniques are sometimes considered mitigation for some of the impacts caused by riprap
- Incorporating large and dense trees may be beneficial where thermal pollution is occurring, along north-facing banks (trees will cast shade) and where cover is necessary to protect fish (rearing habitat)

Advantages

- Correctly designed and installed, Vegetated Rip-Rap offers an opportunity for the designer to attain the immediate and long-term protection afforded by riprap with the habitat benefits inherent with the establishment of a healthy riparian buffer
- Above ground components of the plants will create habitat for both aquatic and terrestrial wildlife, provide shade (reducing thermal pollution), and improve aesthetic and recreational opportunities
- When graded or "self-launching" stone is used, riprap is self-adjusting to small amounts of substrate consolidation or movement
- The revetment can sustain minor damage and still continue to function adequately without further damage

- The rough surface of the riprap dissipates local currents and minimizes wave action more than a smooth revetment (like concrete blocks)
- Stones are readily available in most locations, and materials are less expensive than many other "hard armouring" techniques
- The rock provides a large amount of aquatic habitat
- Rip-Rap is easily repaired by placing more rock where needed
- The fibrous roots of the chosen vegetation prevents washout of fines, stabilizes the native soil, anchors armour stone to the bank, and increases the lift-off resistance
- The vegetation also improves drainage of the slope by removing soil moisture for its own use
- Vegetated Rip-Rap has a more natural appearance, and is therefore more aesthetically pleasing, which is frequently a matter of great importance in high-visibility areas
- In addition, environmental clearances are frequently easier to obtain if the project has biotechnical and habitat enhancement benefits incorporated into the design
- There are many environmental benefits offered by Vegetated Rip-Rap, most of which are derived from the planting of willows or other woody species in the installation
- The willow provides canopy cover to the stream, which gives fish and other aquatic fauna cool places to hide
- The vegetation also supplies the river with carbon-based debris, which is integral to many aquatic food webs, and birds that catch fish or aquatic insects will be attracted by the increased perching space next to the stream
- An additional environmental benefit is due to the use of rock, as the surface area of the rocks is substrate that is available for colonization by invertebrates
- The small spaces between the rocks also provide benthic habitat and hiding places for small fish and fry
- The brushlayering methods reach out over the water, and provide shade and organic debris to the aquatic system

Limitations

- Vegetated Rip-Rap may be inappropriate if flow capacity is an issue, as bank vegetation can reduce flow capacity, especially when in full leaf along a narrow channel
- In remote areas large rocks may be difficult to obtain and transport, which may greatly increase costs

- Riprap may present a barrier to animals trying to access the stream

Construction

The vegetation obtained should be poles of adventitiously-rooting native species (such as willow, cottonwood or dogwood), with a minimum diameter of 38 mm, and be sufficiently long to extend into the vadose zone below the riprap.

Vegetated Rip-Rap with Willow Bundles

- Grade the bank to the desired slope where the riprap will be placed, such that there is a smooth base
- Dig a toe trench for the keyway (if required) below where the riprap will be placed
- Place 10 to 15 cm (5 to 8 stem) bundles on the slope, with the butt ends placed at least 30 cm in the low water table
- This will probably involve placing the poles in the toe trench before the rock is placed, if standard riprap rock is being used
- Digging shallow trenches for the willows prior to placing them on the slope will decrease damage to the cuttings from the rocks, and may increase rooting success because more of the cuttings will be in contact with soil
- The bundles should be placed every 1.8 m along the bank, and be pointed straight up the slope
- Once the bundles are in position, place the rock on top of it to the top of the slope
- The bundles should extend 0.3 m above the top of the rock
- If the bundles are not sufficiently long, they will probably show decreased sprouting success, and therefore, a different technique should be chosen

Vegetated Rip-Rap with Bent Poles

- Grade back the slope where the riprap will be placed, such that there is a smooth base
- Dig a toe trench for the keyway (if required) below where the riprap will be placed
- If non-woven geotextile is being used, lay the fabric down on the slope, all the way into the toe trench, and cut holes in the fabric about 0.6 to 0.9 m above the annual low water level
- Slip the butt ends of the willow poles through the fabric and slide them down until the bases are at least 15 cm into the perennial water table, or at the bottom of the toe trench, whichever is deepest

- If using filter gravel, lay it down on the slope, and place a layer of willow poles on top of the gravel, with the bases of the cuttings at least 15 cm into the perennial water table, or at the bottom of the toe trench, whichever is deepest
- Place the largest rocks in the toe trench
- Ensure that they lock together tightly, as they are the foundation for the structure
- Place the next layer of boulders such that it tapers back slightly toward the streambank
- Bend several willow poles up, such that they are perpendicular to the slope, and tight against the first layer of rocks
- Now place the next layer of rocks behind these poles
- Placement will require an excavator with a thumb, as someone will have to hold the poles while the rocks are placed
- As the poles are released, they should be trimmed to 30 cm above the riprap
- This last step should be repeated until all the poles have been pulled up, and the entire slope has been covered

<u>Vegetated Rip-Rap with Brushlayering and Pole Planting</u>

There are two methods of constructing brushlayered riprap; one involves building up a slope, and the other works with a pre-graded slope – neither method can be used with non-woven geotextile

Method 1 (building up a slope):

- Lay the bank slope back to somewhat less than the desired finished slope
- Dig a toe trench, if needed, and lay the key rocks into the trench. Pack soil behind these rocks, with filter gravel in between the soil and rocks
- Continue installing riprap 0.9 to 1.2 m up the bank
- Slope the soil back into the bank at a 45° angle, such that the bottom of the soil slope is in the vadose zone
- Place a layer of willow cuttings on top of the soil, with the butt ends extending into the vadose zone, and the tips of the branches sticking out 30 to 60 cm
- Place the next layer of stones on top of the initial rocks, but graded slightly back, and repeat the soil and brush layering process
- When finished, trim the ends of the willow branches back to 30 cm
- Do not cut shorter than 30 cm, as the plant will have difficulty sprouting

Method 2 (pre-graded slope):

- Lay the bank slope back to the desired finished grade, and dig a toe trench if self-launching stone is not being used
- Place the largest rocks in the key-way, and fill in behind with filter gravel and soil
- Continue installing riprap 0.9 to 1.2 m up the bank
- Place the bucket of an excavator just above the layer of rocks at a 45° angle
- Pull the bucket down, still at a 45° angle, until the water table is reached, or the stream is dry, to the elevation at the bottom of the key trench
- Pull up and back on the bucket; this will provide a slot in the bank into which willow poles can be placed
- Throw in some willow poles (about 18 poles per linear m), ensuring that the butt ends are at the bottom of the trench
- Release the scoop of earth, and allow it to fall back in place on the slope
- Then place the next layer of rock on top of the branches, flush with the slope
- If self-filtering stone is not being used, filter gravel should be placed behind the rocks
- Repeat the process, beginning again with pulling back a scoop of soil
- Continue this process to the top of the slope, or if preferred, use joint-planted riprap on the upper slope, where it is difficult to reach the perennial water table with the excavator bucket
- When finished, trim the ends of the branches back such that only 30 cm extends beyond the revetment

Construction Considerations

- The technique can also be used in conjunction with other techniques, particularly resistive techniques, designed primarily to protect the bank toe (Vegetated Rip-Rap and Rootwad Revetments) and redirective techniques (Bendway Weirs, Spur Dikes, and Vanes)
- While riprap is very effective at arresting bank erosion and providing relatively permanent bank protection the environmental consequences can be less than desirable and should, therefore always be taken into account when selecting an environmentally-sensitive streambank stabilization treatment
- Scour counter-measures are sometimes required for continuous and resistive rock bank protection
- One alternative is a rock-filled key trench, designed with appropriate scour analysis

- Another counter-measure that may be employed is the use of graded, self-launching stone

Filter Material:

- Some sort of filter material is typically used to prevent piping of fine soils from below the riprap, if self-launching stone is not used
- There are two choices: non-woven geotextile fabric or graded filter gravel
- Non-woven geotextile fabrics are not recommended for use in Vegetated Rip-Rap, as roots have difficulty penetrating the fabric
- If non-woven geotextile fabric is required, one can cut holes in the fabric where the vegetation is placed
- Small slits in the fabric are especially appropriate with the bent pole method
- Filter gravel is the preferred filter media for Vegetated Rip-Rap

Rock Size:

- There are two options for rocks – self-launching/self-filtering rock or standard riprap
- The advantage of self-launching/self-filtering rock is that the revetment will build its own toe, by self-launching, in any scour hole that forms
- The different sizes of rock act as their own filter medium, so no geotextile fabric or filter gravel is needed
- This decreases cost, and also makes installation less labour-intensive for two of the three methods of installation
- Using self-launching stone is dependent on a source of graded rock, which is not always available

Inspection and Maintenance

- Riprap should be visually inspected as frequently as outlined in the PESC and TESC Plans, with focus on potential weak points, such as transitions between undisturbed and treated areas
- Soil above and behind riprap may show collapse or sinking, or loss of rock may be observed
- Inspect riprap during low flows annually, to ensure continued stability of the toe of the structure
- Treat bank or replace rock as necessary

Design Considerations

- It often takes many years for riprap to become vegetated if vegetation is not integrated into its design and construction at the outset
- Flanking, overtopping or undermining of the revetment due to improperly installed or insufficient keyways is one of the biggest reasons for failure of riprap
- Improperly designed or installed filter material can also cause undermining and failure of the installation
- Undersized stones can be carried away by strong currents, and sections of the revetment may settle due to poorly consolidated substrate
- Vegetation may require irrigation if planted in a nondormant state, or in extremely droughty soils

Vegetated Rip-Rap with Willow Bundles

Is the simplest to install, but it has a few drawbacks:

- This technique typically requires very long (3 to 7m) poles and branches, as the cuttings should reach from 15 cm below the low water table to 30 cm above the top of the rock
- Only those cuttings that are in contact with the soil will take root, and therefore, the geotechnical benefits of the roots from those cuttings on the top of the bundle may not be realized

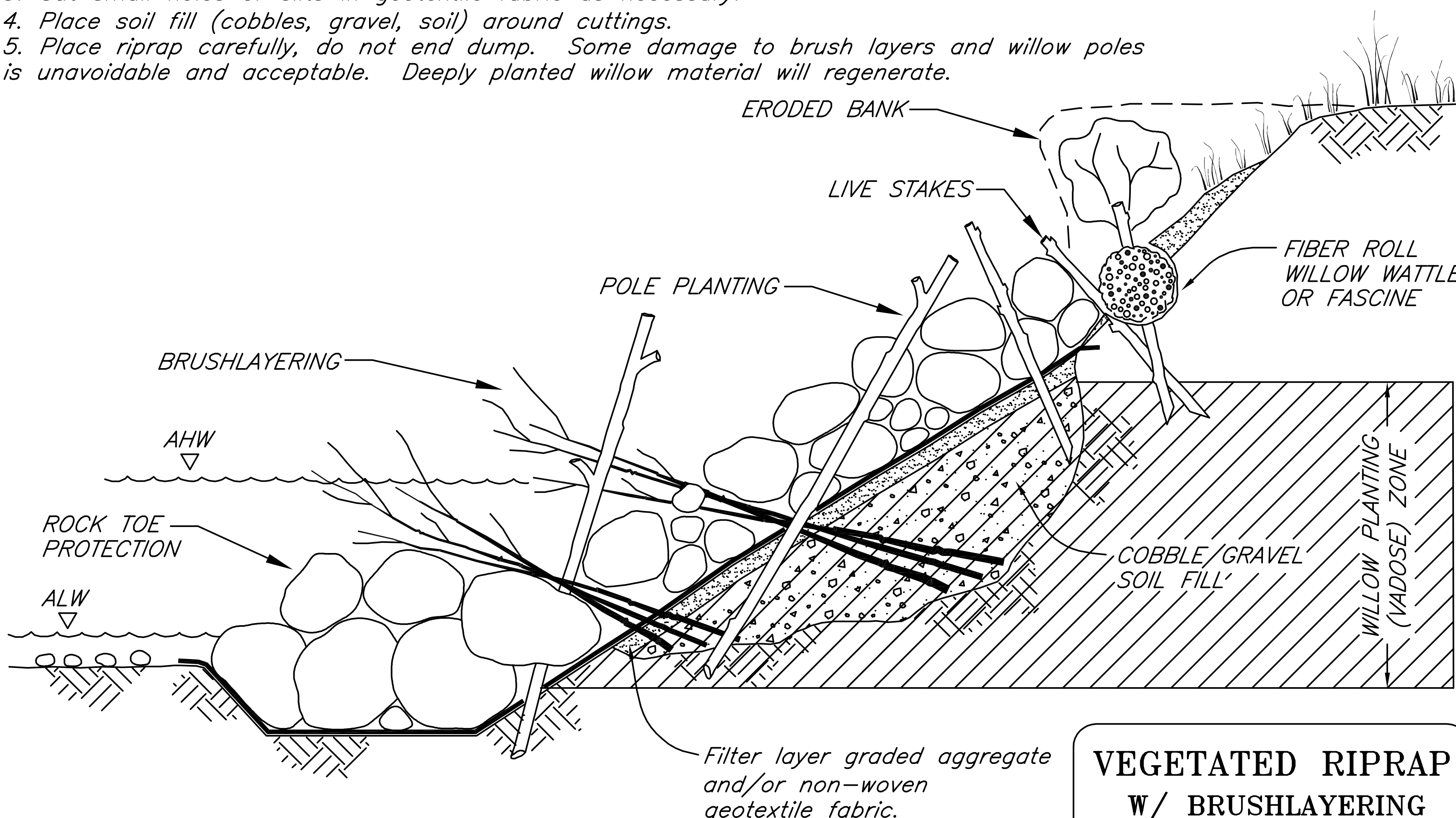
Vegetated Rip-Rap with Bent Poles

- Is slightly more complex to install
- A variety of different lengths of willow cuttings can be used, because they will protrude from the rock at different elevations
- The angle can be three to one, or forty-five degrees
- A tree and root growth will develop the entire length of each pole planted

Vegetated Rip-Rap with Brushlayering and Pole Planting

- Is the most complex type of riprap to install, but also provides the most immediate habitat benefits
- The installation of this technique is separated into 2 methods; one method describes installation when building a bank back up, while the other is for a well-established bank
- If immediate aquatic habitat benefits are desired, this technique should be used
- May not provide the greatest amount of root reinforcement, as the stem-contact with soil does not extend up the entire slope

NOTES:
1. Install willow pole planting and brushlayering during bank grading and riprap placement to ensure good contact with 'native ground' and/or soil fill.
2. Willow poles and brush layers shall extend down into expected soil moisture zones (vadose).
3. Cut small holes or slits in geotextile fabric as necessary.
4. Place soil fill (cobbles, gravel, soil) around cuttings.
5. Place riprap carefully, do not end dump. Some damage to brush layers and willow poles is unavoidable and acceptable. Deeply planted willow material will regenerate.



VEGETATED RIPRAP
W/ BRUSHLAYERING & POLE PLANTING

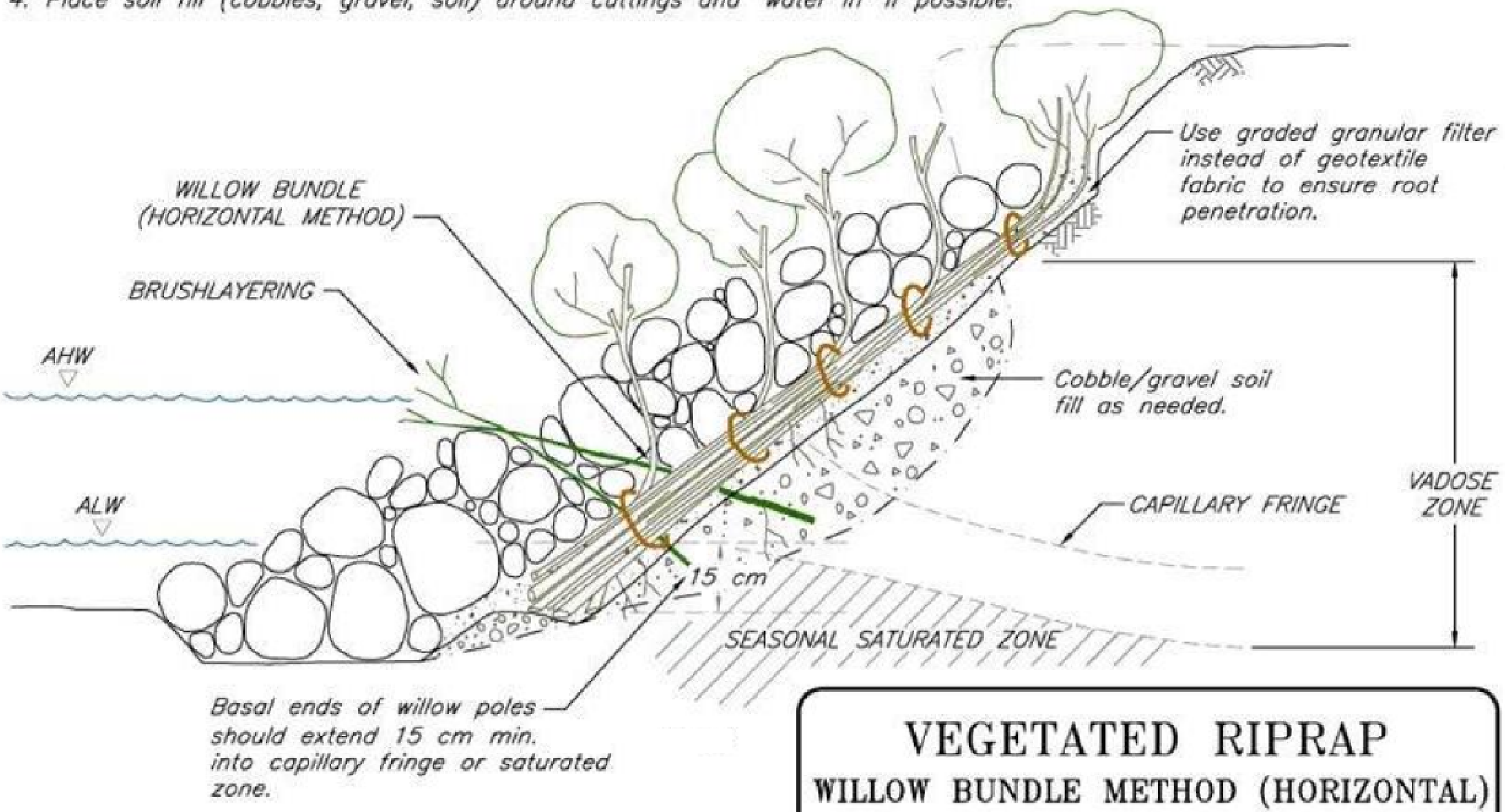
VGRIPRAP

Government of Alberta
Transportation

B.M.P. #45a
Typical Section

NOTES:

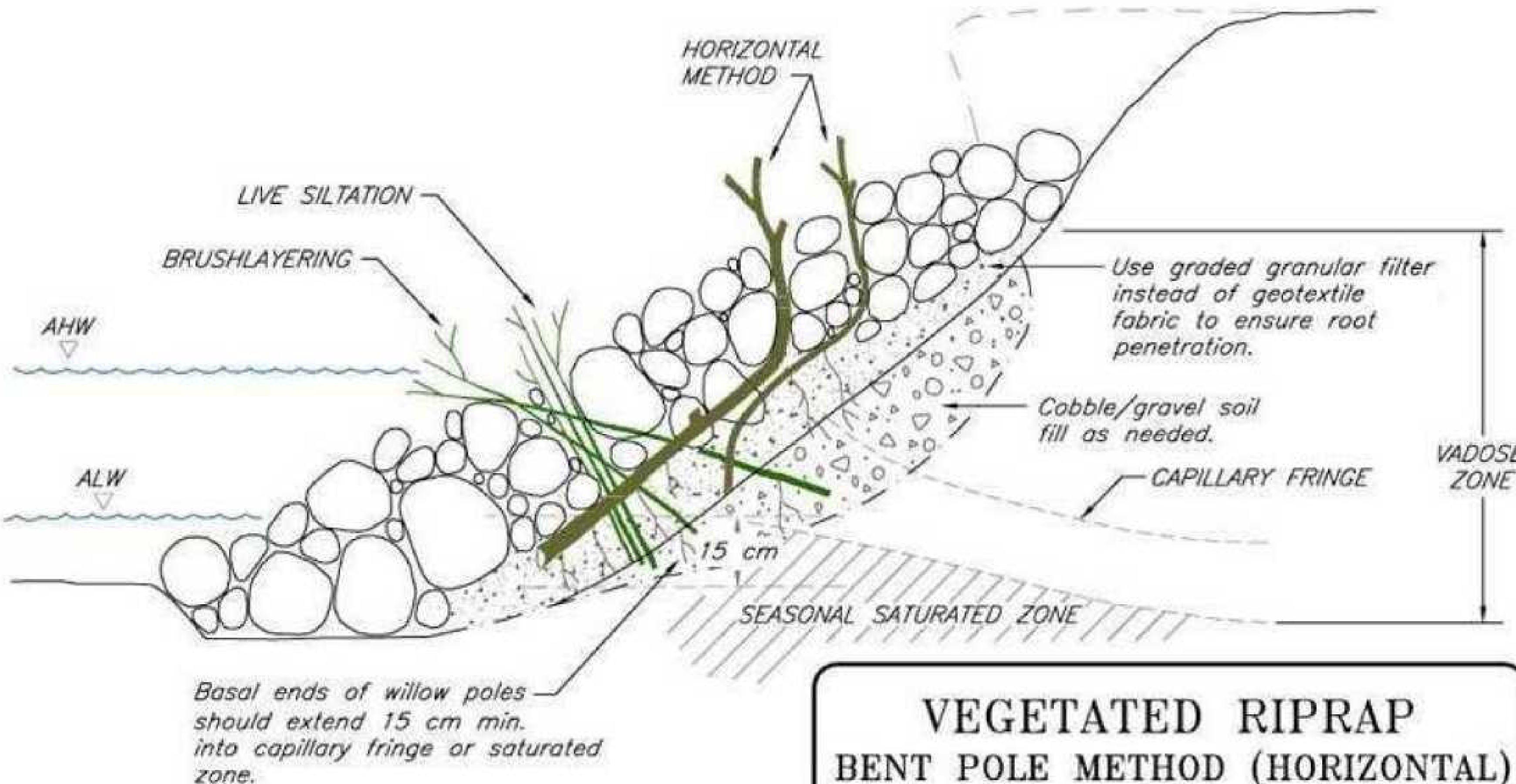
1. As a general rule, place basal ends of the cuttings 15 cm into the capillary fringe or seasonal saturated zone.
2. Bend individual poles up through the riprap during placement while ensuring contact of the stem with native ground. Laying poles 'horizontally" is an efficient and cost-effective way to maximize rooting.
3. Graded, granular filter is preferable to geotextile fabric to improve root penetration or slip poles through slits cut into fabric.
4. Place soil fill (cobbles, gravel, soil) around cuttings and 'water in' if possible.



FILE: VRBND

NOTES:

1. Integrate brushlayering, pole planting and live siltation techniques during rock placement to ensure contact with native ground. Laying poles "horizontally" is an efficient and cost-effective way to maximize rooting.
2. As a general rule, place basal ends of the cuttings 15 cm into the capillary fringe or seasonal saturated zone.
3. Graded, granular filter is preferable to geotextile fabric to improve root penetration or slip poles through slits cut into fabric.
4. Place soil fill (cobbles, gravel, soil) around cuttings and 'water in' if possible.

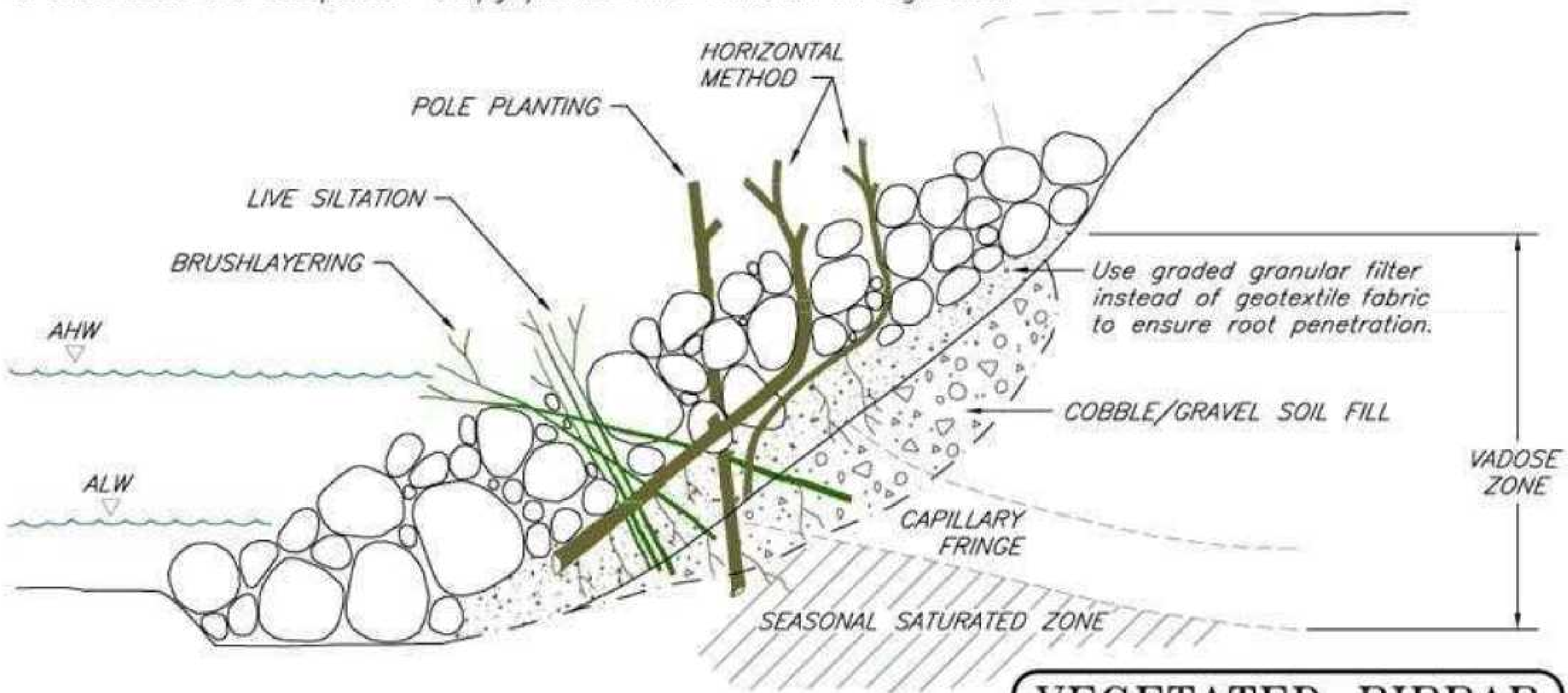


VEGETATED RIPRAP
BENT POLE METHOD (HORIZONTAL)

FILE: VRBP

NOTES:

1. Integrate brushlayering, pole planting and live siltation techniques during rock placement to ensure contact with native ground.
2. Plant deeply if possible. Place cuttings deeply into vadose zone, into the capillary fringe or 15 cm into the seasonal saturated zone (water table).
3. Graded, granular filter is preferable to geotextile fabric to improve root penetration or slip poles through slits cut into fabric.
4. Place soil fill (cobbles, gravel, soil) around cuttings and 'water in' if possible.
5. Place riprap carefully, do not end dump. Some damage to brush layers and willow poles is unavoidable and acceptable. Deeply planted willow material will regenerate.



VEGETATED RIPRAP
DURING CONSTRUCTION
SUMMARY OF TECHNIQUES

FILE: VRDC

APPENDIX D

- **INSPECTION AND MAINTENANCE FORM**
- **CHECKLIST FOR EROSION AND SEDIMENT CONTROL PLAN DEVELOPMENT**

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INSPECTION AND MAINTENANCE FORM

AT Contract Number: ____________________
Construction Site Location: ____________________
Heavy Equipment on Site: ____________________
Date: __________ mm of rain in last week: __________
Date of Last Inspection: __________ mm of rain in last 24 hours: __________

Contractors on Site: ____________________
Construction Activities on Site: ____________________
Current Weather: ____________________
Weather Forecast: ____________________

Type of Measure (BMP)	Location on Construction Site	Intended Function	Sediment Levels	General Condition	General Performance	Maintenance Required	Type of Maintenance Required	Site Manager Notified	Date Repairs to be Completed By
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	
			0 – 1/4 - 1/2 – 3/4 Full not applicable	poor fair good	poor fair good	yes no		yes no	

Notes:

Inspectors Signature: ____________________ Inspectors Name: ____________________

Copies to: AT Designated Inspector: ____________________ Contractors Site Designate: ____________________ ESC Plan Designer: ____________________

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CHECKLIST FOR EROSION AND SEDIMENT CONTROL (ESC) PLAN DEVELOPMENT

The following checklist may be used to ensure that Erosion and Sediment Control Plans follow the method and structure outlined in the Guide. For small, low-risk roadway construction projects that only require the application of procedural BMPs, it may not be necessary to undertake detailed BMP design. Refer to Section 8 for guidance regarding the appropriate level of effort to be applied.

DATA COLLECTION

- ☐ Identify and initiate contact with other members of the ESC team:
  - ☐ Owner or owner's representative
  - ☐ Project designer
  - ☐ Contractor and site inspector (if selected)
- ☐ Identify and initiate contact with applicable regulatory agencies (establish information needs)
- ☐ Compile relevant site information as applicable:
  - ☐ Construction drawings, design data and construction schedule
  - ☐ Geotechnical investigation reports
  - ☐ Aerial photography/imagery
  - ☐ Surficial geology maps
  - ☐ Vegetative cover maps
- ☐ Site inspection by ESC Plan Designer:
  - ☐ Photographs to document existing site conditions
  - ☐ Regulatory requirements
  - ☐ Fisheries assessments

Site Erosion Potential and Evaluation

- ☐ Assess the site-specific erosion potential
- ☐ Assess the risk of erosion due to roadway construction activities
- ☐ Determine appropriate level of effort, performance goals and evaluation measures

Erosion and Sediment Control Plan Design

- ☐ Develop an erosion and sediment control plan that is effective and coordinated with construction activities
- ☐ Define the areas of concern for the project
- ☐ Divert upstream water around the construction site (where applicable)
- ☐ Evaluate the construction site drainage:

- ☐ Define drainage areas within the construction site
- ☐ Define drainage patterns within each drainage area
- ☐ Determine drainage channel alignments
- ☐ Determine channel tributary areas and drainage channel characteristics

☐ Based on drainage characteristics, specify Best Management Practices (BMPs)

- ☐ Incorporate procedural BMPs
    - ☐ Promote good housekeeping measures to reduce the amount of erosion during construction
    - ☐ Consider minimizing exposed soils, using existing drainage pathways, reducing runoff from stockpiles, and installing signage around sensitive areas
    - ☐ Consider working during relatively dry conditions, installing erosion and sediment control measures early, and revegetating exposed soils early
- ☐ Incorporate appropriate erosion control BMPs
    - ☐ Prevent erosion at its source
    - ☐ Consider factors such as flow, soil characteristics, topography, climate, season, permanence, accessibility and cost when choosing erosion control measures

☐ Consider factors such as flow, soil characteristics, topography, climate, season, permanence, accessibility and cost when choosing sediment control measures

Report Requirements

☐ Provide a project description

☐ Describe erosion and sediment control objectives

☐ Document existing site conditions

☐ Identify critical areas of concern

☐ Include a section on erosion and sediment control accountability and administration

- ☐ Provide a list of emergency and non-emergency contacts

☐ Describe BMPs to be used

- ☐ Include details on installation locations and alignments
- ☐ Include an inspection and maintenance plan for all BMPs

☐ Provide a series of construction drawings illustrating and describing mitigation measures to be undertaken during all phases of the project

APPENDIX E

ESTIMATING RUNOFF FROM SMALL WATERSHEDS

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TABLES

E.1 Introduction

Drainage areas along rural highways are typically small (less than 20 ha) and can have long flow lengths. Rural highway catchments have relatively low imperviousness levels that generate lower runoff rates than similarly sized urban catchments. Runoff does, however, become concentrated along ditches and near outlet points, thus increasing erosion potential. Estimating peak runoff flow rate from small watersheds on a highway construction site is a key activity in the design of suitable erosion and sedimentation control measures. Using estimates of peak runoff flows, channels and control structures can be adequately sized to prevent overtopping and washout.

This chapter focuses on runoff calculation methods for highway construction sites in rural conditions. The estimation of runoff for urban highway construction sites is complicated by the effects of urbanization and development. As such, urban runoff flow rate estimation methods are not presented in this document. Reference should be made to Design Bulletin #16 for information relating to drainage for Provincial Highways in urban areas (www.transportation.alberta.ca/649.htm).

The objective of utilizing flow estimates is to provide a stable and economical erosion protection design. It is of paramount importance that the erosion and sedimentation control strategy withstand the design runoff flow rates during its lifespan. Generally, it is usually most cost-effective to utilize the existing drainage pattern as much as possible. In terms of design frequency, different road types have specific purposes and require different design standards. Table E.1 summarizes the general design levels for runoff capacity for several road service levels.

Table E.1: Return Frequencies for Roadway Drainage Design

Road Classification (RTAC 1976)	Return Period or Other Criteria for Storm Drainage System		
	Minor System	Major System	Stream Channels
Freeway urban arterial	10 year	100 Year	10 year
Rural arterial collector	2 to 5 year	100 Year	2 to 5 year
Local	2 year	100 Year	2 year
Depressed roadways	10 to 25 year		

Notes:

1. The flood frequencies for storm drainage systems may be modified to reflect local municipal requirements and adjacent land uses.
2. The minor system comprises the road gutters, inlets, storm sewers, and minor ditches. The major system is the route followed by runoff waters when the capacity of the minor system is exceeded and generally includes the roadway surface itself and major channels.

The amount of time involved in carrying out an economic analysis often cannot be justified when implementing small temporary or permanent erosion and sedimentation control measures. Guidelines are thus established by various jurisdictions for the choice of an appropriate event to be used in design based on experience. Erosion control work of a permanent nature should thus be designed for a runoff event that corresponds to a return period of at least once in 10 years (a 1:10 year event). Furthermore, provision should be made for safe overflow or bypass in more extreme events. Temporary erosion control work may be designed for a runoff event that corresponds to a return period of at least twice in 5 years (a 2:5 year event).

Permanent vegetative or bio-engineered measures that will replace any temporary measures should be capable of withstanding at least a 1:10 year runoff event.

Economic analyses are appropriate for large temporary or permanent structures. Costs associated with various structure sizes are estimated and are compared with the benefits to be derived, including the benefit of having a reduced probability of failure and reduced maintenance effort. The frequency of the event chosen for design is then based on an optimization of investment expenditure. However, major roadways required for emergency purposes will always be designed to withstand runoff events of 1:100 years. Therefore, erosion protection measures for these roadways should have a similar standard.

Designs should be based on professional judgement and should be performed by a qualified professional.

E.2 Approaches to Runoff Estimation

There are several different approaches to estimating peak runoff flow. The main categories for estimating peak runoff flow are listed as follows:

- Rational Method;
- Flood frequency analysis;
- Hydrologic modeling; and
- Empirical formulae.

Of these methods, only the Rational Method will be discussed in this document. The Rational Method provides reasonable peak runoff flow estimates for small watersheds. The use of this procedure assumes that precipitation events of a given frequency produce runoff events of similar frequency.

The individual or firm responsible for designing erosion and sedimentation control measures must use their judgement and experience in determining the most appropriate means for estimating runoff flow rates.

E.2.1 Rational Method

The Rational Method is widely practiced in determining peak runoff flows for small to moderately sized catchments and can be applied to rural basins up to 25 km^2 (MTO 1984). However, it is considered to be most applicable to basin sizes under 100 ha where storage and channel routing effects are small. It is understood that there is no specific design manual for use of the Rational Method in Alberta, but there are complete reference documents in several other Provinces and from the United States. Caution should be exercised where lake storage and attenuation effects are significant within a basin. This does not generally apply to roadway areas where grading is continuous. The procedure is simple and relies on a minimal amount of local data. The formulation for the Rational Method is presented as follows:

$$Q = 0.00278 \, C \times I \times A \qquad \text{(Equation E.1)}$$

Where: Q = peak flow (m^3/s)

C = runoff coefficient (dimensionless)

I = precipitation intensity (mm/hr)

A = effective drainage area (ha)

The simplicity of the equation has resulted in the method gaining widespread usage for more than 100 years. However, such simplicity was achieved by lumping the effects of a number of variables, namely soil conditions, surface cover, antecedent moisture, depression storage and land slope into a single input parameter referred to as the runoff coefficient. Extreme care should therefore be taken in the choice of the coefficient if reasonable accuracy is to be obtained. The Rational Method has been determined through comparisons, to typically overestimate flows so it is suitable for the design of erosion and sedimentation control measures. It is not applicable for bridge file designs.

The major limitation of the Rational Method is the output. While some other methods produce a runoff-time curve or hydrograph, the Rational Method produces only an estimate of the peak runoff. For erosion control works along roadways, this limitation is not significant, as all designs are done taking into consideration the peak discharge from an event having a particular design frequency. However, for larger sediment control structures, the peak inflow into the sediment basin may be modified by the storage effect of the reservoir resulting in a peak outflow that will be smaller than the inflow. In such a case, routing the inflow hydrograph through the basin will produce an outflow hydrograph that will be more appropriate for design. Routing procedures are not simple and should be performed by a qualified engineer.

E.2.1.1 Key Assumptions

Inherent in the use of the Rational Method are a number of key assumptions. Understanding these assumptions will lead to a better appreciation of the results provided by this method. These assumptions are presented as follows:

1. The rainfall intensity is uniform over the catchment for the duration of the storm. Rainfall events actually vary in both space and time. With very small catchments, the assumption may be true, but for larger catchments there will be a spatial variation in rainfall intensity and hence a tendency to overestimate runoff.
2. Maximum runoff occurs when rainfall lasts as long as or longer than the time of concentration (t_c). The t_c is the time for runoff to travel from the hydrologically most distant point in the watershed to the outlet or point of interest. The assumption is that every point within the catchment is contributing to runoff to the point under consideration. Again with small catchments, the assumption is likely to be true, but with larger catchments, there may be a divergence from the assumption due to channel routing and storage effects.
3. The design precipitation event has the same frequency as the runoff event being estimated. This is not necessarily true, as identical storm events can produce highly variable runoff hydrographs over the same catchment when conditions such as antecedent moisture, are different.

4. The effective drainage area should be used and it includes all areas that contribute runoff during major runoff events. Some areas of the province are internally draining sloughs and only evaporate or infiltrate runoff. These areas do not contribute runoff flows to the basin outlet.

E.2.1.2 Runoff Coefficient

Table E.2 provides guidelines for evaluating the value of the runoff coefficient, C. In areas having more than one soil type or land use, the effective coefficient is obtained by evaluating a coefficient for each sub-area and computing a "weighted" average for the entire catchment based on area served.

E.2.1.3 Rainfall Intensity

Statistical information relating to the intensity, duration, and frequency of rainfall events is currently collected at more than 150 stations within Alberta that record daily rainfall amounts. However, only about 20% of them continuously record rainfall data from which IDF curves can be derived. The locations of the recording stations are available through Environment Canada - Atmospheric Environment Service. Design intensity values for any selected duration and frequency can be read directly from the curves for the selected station. Locations in close proximity to any recording station can use the identical information extracted from the IDF curves. However, as important as close proximity is, the selected station should also have a similar elevation and surrounding terrain, as mountain and valley effects greatly influence precipitation data. Other sites may have to linearly interpolate data from two or more nearby sites. An alternative and more compact form of the information given by the IDF curves was published in 1985 by the AES as the Rainfall Frequency Atlas for Canada.

The rainfall intensity to be used in the design of erosion and sedimentation control measures is taken from a nearby intensity-duration-frequency (IDF) curve, t, for the particular watershed. Available methods to determine t_c from an IDF curve include the Airport Method, SCS Upland Method and Branby-Williams Method.

Table E.2: Rational Method Values

LAND USE	C	LAND USE	C
BUSINESS		**LAWNS**	
Downtown areas	0.70-0.95	Sandy soil, flat 2%	0.05-0.10
Neighbourhood areas	0.50-0.70	Sandy soil, average 2-7%	0.10-0.15
		Sandy soil, steep 7%	0.15-0.20
RESIDENTIAL		Heavy soil, flat 2%	0.13-0.17
Single family areas	0.30-0.50	Heavy soil, average 2-7%	0.18-0.22
Multi units, detached	0.40-0.60	Heavy soil, steep	0.25-0.35
Multi units, attached	0.60-0.75		
Suburban	0.25-0.40	**AGRICULTURAL LAND, 0-30%**	
		BARREN PACKED SOIL	
INDUSTRIAL		Smooth	0.30-0.60
Light areas	0.50-0.80	Rough	0.20-0.50
Heavy areas	0.60-0.90		
Parks, cemeteries	0.10-0.25	**CULTIVATED ROWS**	
Playgrounds	0.20-0.35	Heavy soil, no crop	0.30-0.60
Railroad yard areas	0.20-0.40	Heavy soil, with crop	0.20-0.50
Unimproved areas	0.10-0.30	Sandy soil, no crop	0.20-0.40
		Sandy soil, with crop	0.10-0.25
STREETS			
Asphalt	0.70-0.95	**PASTURE**	
Concrete	0.80-0.95	Heavy soil	0.15-0.45
Bricks	0.70-0.85	Sandy soil	0.05-0.25
Drives and walks	0.75-0.85	Woodlands	0.05-0.25
Roofs	0.75-0.95		
		BARREN SLOPES > 30%*	
		Smooth, impervious	0.70-0.90
		Rough	0.50-0.70

Note: The Designer must use judgment to select the appropriate value of C within the range. Generally, large areas with permeable soils, flat slopes and dense vegetation should have lowest C values. Smaller areas with dense soils, moderate to steep slopes and sparse vegetation should be assigned highest C values.

* From Portland Cement Association, *Handbook of Concrete Culvert Hydraulics*, 1964, p.45.

APPENDIX F

GUIDELINES FOR DESIGN OF OPEN CHANNELS

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FIGURES

TABLES

F.1 Introduction

An open channel is any water conveyance route which allows a free passage of runoff, i.e., the surface is exposed to the atmosphere and hence at atmospheric pressure. Closed pipes, not flowing full, are also considered to act as open channels from a hydraulic perspective. Examples are all channels associated with roadway drainage, culverts flowing less than full and storm sewers flowing in a similar manner. Appropriate professionals should be consulted in the determination of channel flow.

F.2 Type of Flow

Flow variations result from changes in runoff rate due to changes in rainfall intensity, snow melt rate or ground water seepage. Similarly, variations in flow depth occur along the length of the channel. Factors accounting for these variations are inflow from the sides and changes in channel characteristics such as roughness, cross-section and bed slope.

In attempting to simplify the approach to hydraulic problems, two states of flow are defined - unsteady and steady. Unsteady flow occurs whenever there is a variation in the quantity of water flowing along the channel.

Steady flow requires the flow rate to be constant with time. Except under controlled laboratory conditions, most flows are unsteady. However, many hydraulic calculations can be simplified by assuming a steady flow state. This steady flow is taken as the maximum flow that the facility can reasonably be expected to handle without incurring excessive costs. For roadway erosion control work, the peak discharge from a 1:10 year storm is typically used when permanent structures are designed. Temporary structures require less stringent conditions for which a 1:5 year storm or even a 1:2 year storm will suffice for the less important ones.

Steady flow is further subdivided into uniform and non-uniform flow modes. With uniform flow, the depth of water and the mean velocity are constant along every section of the channel possessing such a condition. The depth is referred as the normal depth, d_n, shown in Figure F.1.

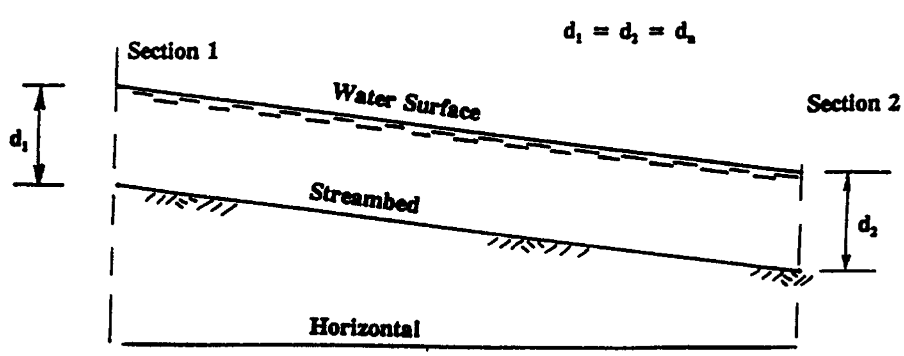


Figure F.1: Water Surface Profile of Channel with Uniform Flow

Uniform flow will occur when the following conditions are satisfied (otherwise the flow will be non-uniform).

- Channel cross-sectional area constant (including bottom width and sideslopes);
- Bed slope constant;
- Channel roughness uniform; and
- Steady flow rate.

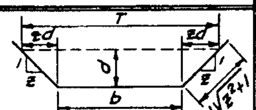
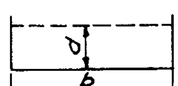
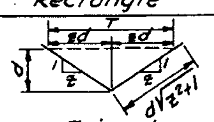
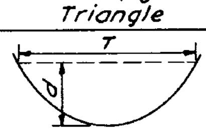
Even with the above conditions satisfied, there will still be non-uniform flow in the transition areas at the beginning and the end of the channel section.

While uniform flow conditions are rare, the simplification leads to channel sizes and flow depths that produce realistic design cross-sections and its use is therefore justified. Further, the error incurred as a result of the simplification of the flow is often small compared to errors built into estimating procedures for the other parameters required for design such as peak discharge rate and channel roughness. An appropriate freeboard allowance to road subgrade is typically added to peak channel flow elevations to further ensure flows remain in the channel under design conditions.

F.3 Geometric Properties of Channels

The solution of uniform flow problems and other hydraulic calculations require an input of various geometric properties of the conducting channel such as bottom width, sideslopes, wetted perimeter and hydraulic radius. The properties in frequent use are defined below while Table F.1 provides formulae for the estimation of some of the properties for typical cross-sections.

Table F.1: Formulae for the Geometric Properties of Channels

Section	Area a	Wetted Perimeter p	Hydraulic Radius r	Top Width T
 Trapezoid	$bd+zd^2$	$b+2d\sqrt{z^2+1}$	$\frac{bd+zd^2}{b+2d\sqrt{z^2+1}}$	$b+2zd$
 Rectangle	bd	$b+2d$	$\frac{bd}{b+2d}$	b
 Triangle	zd^2	$2d\sqrt{z^2+1}$	$\frac{zd}{2\sqrt{z^2+1}}$	$2zd$
 Parabola	$\frac{2}{3}dT$	$T+\frac{8d^2}{3T}$ 1/	$\frac{2dT^2}{3T^2+8d^2}$ 1/	$\frac{3a}{2d}$

F.4 The Manning Equation for Uniform Steady Flow

A simple equation relating the velocity of flow under uniform conditions to the properties of a channel was developed by Robert Manning. The equation is:

$$V = (1 / n) \times R^{2/3} \times s^{1/2} \qquad \text{(Equation F.1)}$$

Where:
- V = velocity of flow (m/s)
- n = channel roughness (dimensionless)
- R = hydraulic radius, A/P (m)
- A = cross-sectional area of flow (m^2)
- P = wetted perimeter (m)
- s = channel bed slope (m/m)

From the above equation, the velocity of flowing water along the channel can be estimated under uniform flow condition. The importance of this estimation lies in the fact that the amount of water flowing along any channel can be evaluated using the cross-sectional area of flow and the estimated velocity.

F.5 Manning Roughness Coefficient, n

This parameter is dependent on the degree of retardance of a channel treatment. Estimates of the parameter have been made on an empirical basis for various materials and values obtained published for design purposes. Table F.2 provides a listing of values in current use for channels with various bed materials except vegetation. Roughness values for vegetation are obtained graphically as discussed below.

For most materials, the roughness value remains virtually constant when the flow depth exceeds 600 mm. However, in erosion control work along roadways, the flow depth is almost always less than 600 mm and appropriate ‘n’ values which change with flow depth must be used in design. In the case of rock riprap, gravels and many of the manufactured ditch lining materials, the change in n values with the flow depth is very pronounced.

Vegetation adds another dimension to the roughness problem along ditches. Stems projecting into the flow produce roughness as other materials do. The extent to which the vegetation allows the flow to go through varies with the magnitude of the flow and the type of vegetation. Thus the roughness of the ditch changes with the depth of flow through it and the type of vegetation along it.

Manning's n becomes an even more variable quantity with vegetated channels than with non-vegetated ones.

Table F.2: Manning's Roughness Coefficients (n)

Lining Category	Lining Type	n - value Depth Ranges		
		0-15 cms	15-60 cms	> 60 cms
Rigid	Concrete	0.015	0.013	0.013
	Grouted riprap	0.040	0.030	0.028
	Stone masonry	0.042	0.032	0.030
	Soil cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare soil	0.023	0.020	0.020
	Rock cut	0.045	0.035	0.025
Temporary*	Woven paper net	0.016	0.015	0.015
	Jute net	0.028	0.022	0.019
	Fibreglass roving	0.028	0.021	0.019
	Straw with net	0.065	0.033	0.025
	Curled wood mat	0.066	0.035	0.028
	Synthetic mat	0.036	0.025	0.021
Gravel riprap	D_{50} = 2.5 cm	0.044	0.033	0.030
	D_{50} = 5 cm	0.066	0.041	0.034
Rock riprap	D_{50} = 15 cm	0.104	0.069	0.035
	D_{50} = 30 cm	-------	0.078	0.040

Note: Values listed are representative values for the respective depth ranges. Manning's roughness coefficient, n, varies with the flow depth.
* Some "temporary" linings become permanent when buried.

Source: Chen & Cotton, 1988; R.L. Cox, et al., 1971; N. Kouwen, et al., 1980; J.C. McWhorter, et al., 1968; A.G. Anderson, et al., 1970; K.G. Thibodeaux, 1982-85

To resolve the problems associated with estimates of flow through vegetation-lined channels, the Soil Conservation Service (SCS) of the U.S. Department of Agriculture have identified five classes of vegetation, designated retardance classes A to E as shown in Tables F.3(a) and F.3(b). While Table F.3(a) shows a simplified generic classification, Table F.3(b) indicates the detailed classification proposed by the SCS. All types of vegetation are assigned a classification based on growth height and stand density, and this grouping is used to determine an appropriate roughness value.

Table F.3(a): Vegetation Retardance Classification

Vegetation Height and Density	Retardance Class
< 50 mm, good stand 50-150 mm, fair stand	E
50-150 mm, good stand 150-250 mm, fair stand	D
150-250 mm, good stand 250-600 mm, fair stand	C
250-600 mm, good stand > 600 mm, fair stand	B
> 600 mm, good stand	A

Table F.3(b): Classification of Degree of Retardance for Various Kinds of Grasses*

Retardance	Cover	Condition
A Very high	Weeping love grass	Excellent stand, tall (av. 760 mm)
	Yellow bluestem *ischaemum*	Excellent stand, tall (av. 760 mm)
	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (av. 300 mm)
	Native grass mixture (little bluestem, blue gramma and other long and short Midwest grasses)	Good stand, unmowed
B High	Weeping love grass	Good stand, tall (av. 510 mm)
	Lespedeza sericeus	Good stand, not woody, tall (av. 480 mm)
	Alfalfa	Good stand, uncut (av. 280 mm)
	Weeping love grass	Good stand, mowed (av. 330 mm)
	Kudzu	Dense growth, uncut
	Blue gramma	Good stand, uncut (av. 330 mm)
	Crab grass	Fair stand, uncut (250 - 1220 mm)
	Bermuda grass	Good stand, mowed (av. 150 mm)
	Common *lespedeza*	Good stand, uncut (av. 250 mm)
	Grass-legume mixture - summer (orchard grass)	
C Moderate	red top, Italian rye grass, and common *lespedeza*	Good stand, uncut (150 - 200 mm)
	Centipede grass	Very dense cover (av. 150 mm)
	Kentucky blue grass	Good stand, headed (150 to 300 mm)
	Bermuda grass	Good stand, cut to 64 mm height
	Common lespedeza	Excellent stand, uncut (av. 110 mm)
	Buffalo grass	Good stand, uncut (76 to 150 mm)
	Grass-legume mixture - fall (orchard grass)	
D Low	Red top, Italian rye grass, and common *lespedeza*	Good stand, uncut (100 - 130 mm)
		After cutting to 50 mm height
	Lespedeza sericeus	Very good stand before cutting
E Very low	Bermuda grass	Good stand, cut to 38 mm height
	Bermuda grass	Burned stubble

Note: Provided for design guidance only.

Source: U.S. Soil Conservation Service, 1986
Chen & Cotton, 1988

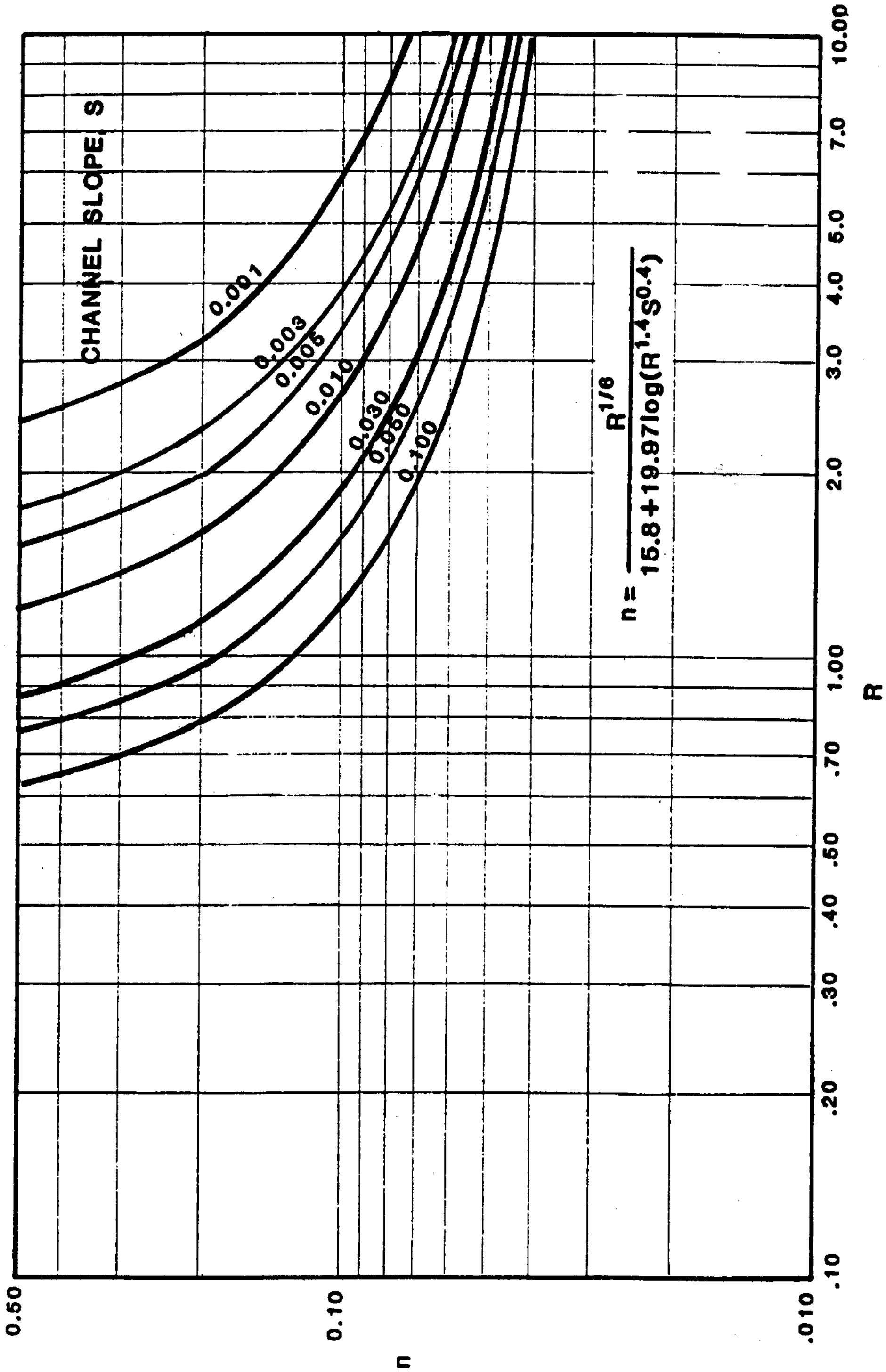


Figure F.2 Manning's n for Class A Vegetation
(Note: hydraulic depth (R) in feet)

Source: N. Kouwen, et al., 1980

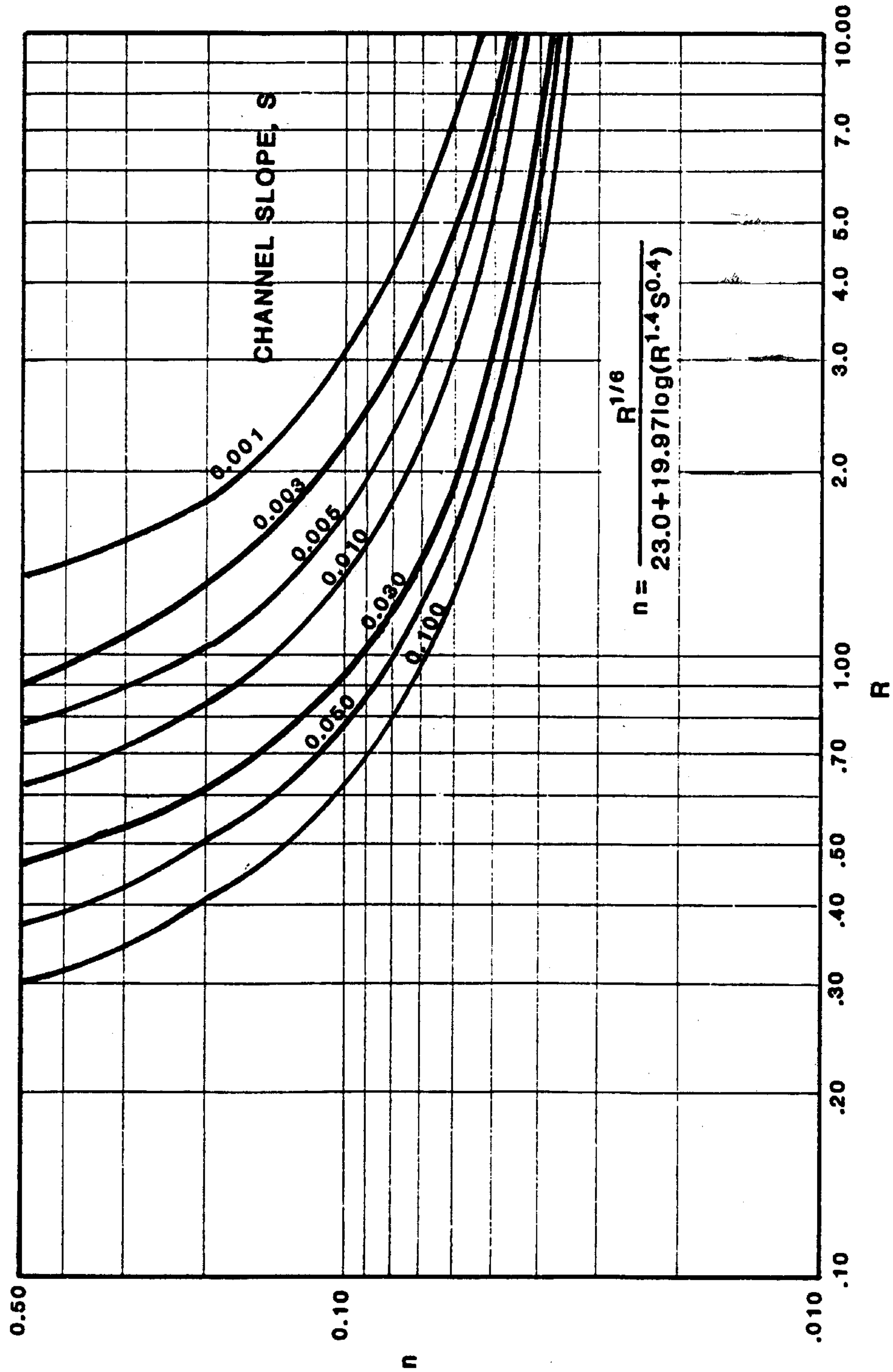


Figure F.3 Manning's n for Class B Vegetation
(Note: hydraulic depth (R) in feet)

Source: N. Kouwen, et al., 1980

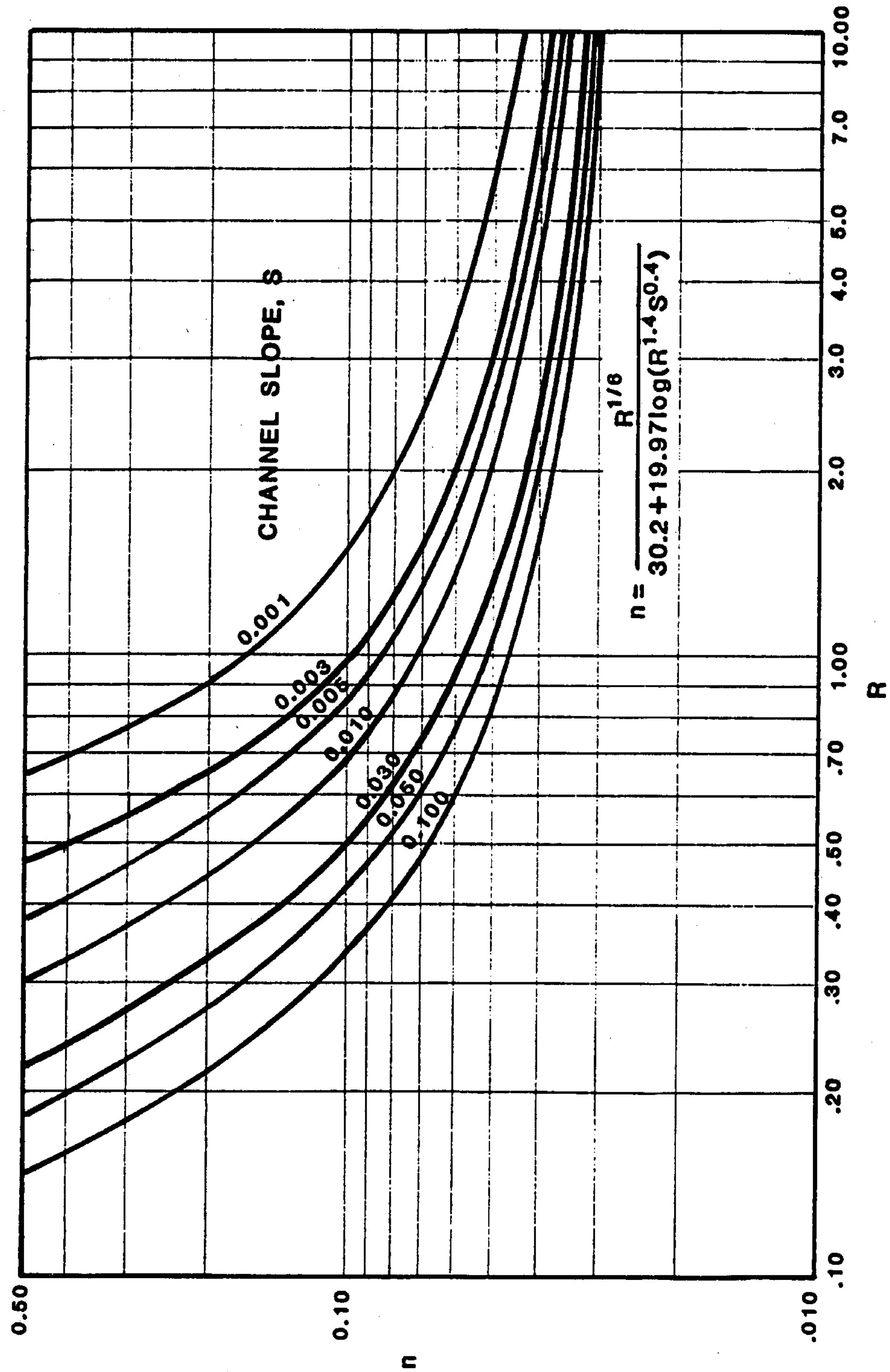


Figure F.4 Manning's n for Class C Vegetation
(Note: hydraulic depth (R) in feet)

Source: N. Kouwen, et al., 1980

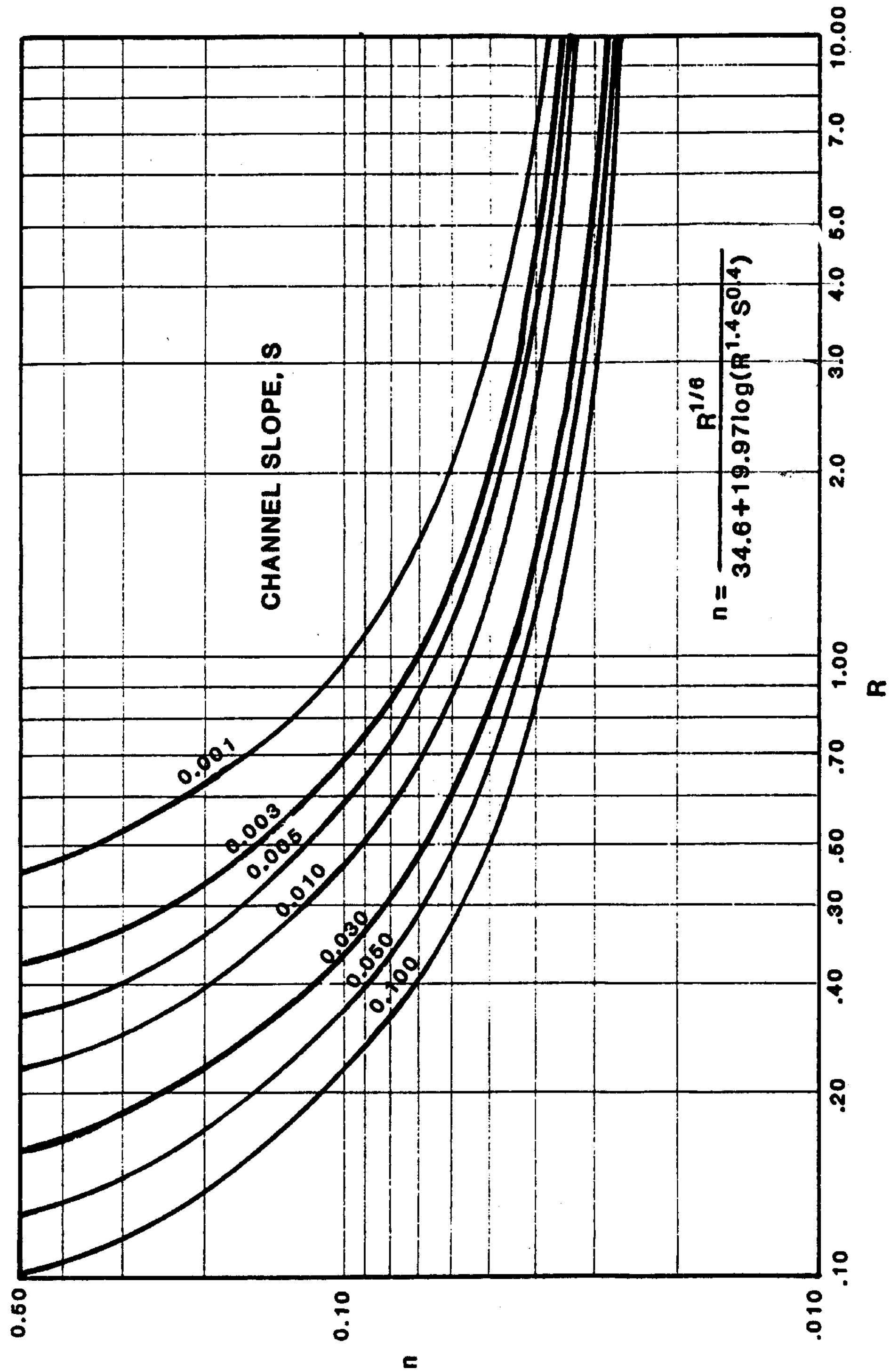


Figure F.5 Manning's n for Class D Vegetation
(Note: hydraulic depth (R) in feet)

Source: N. Kouwen, et al., 1980

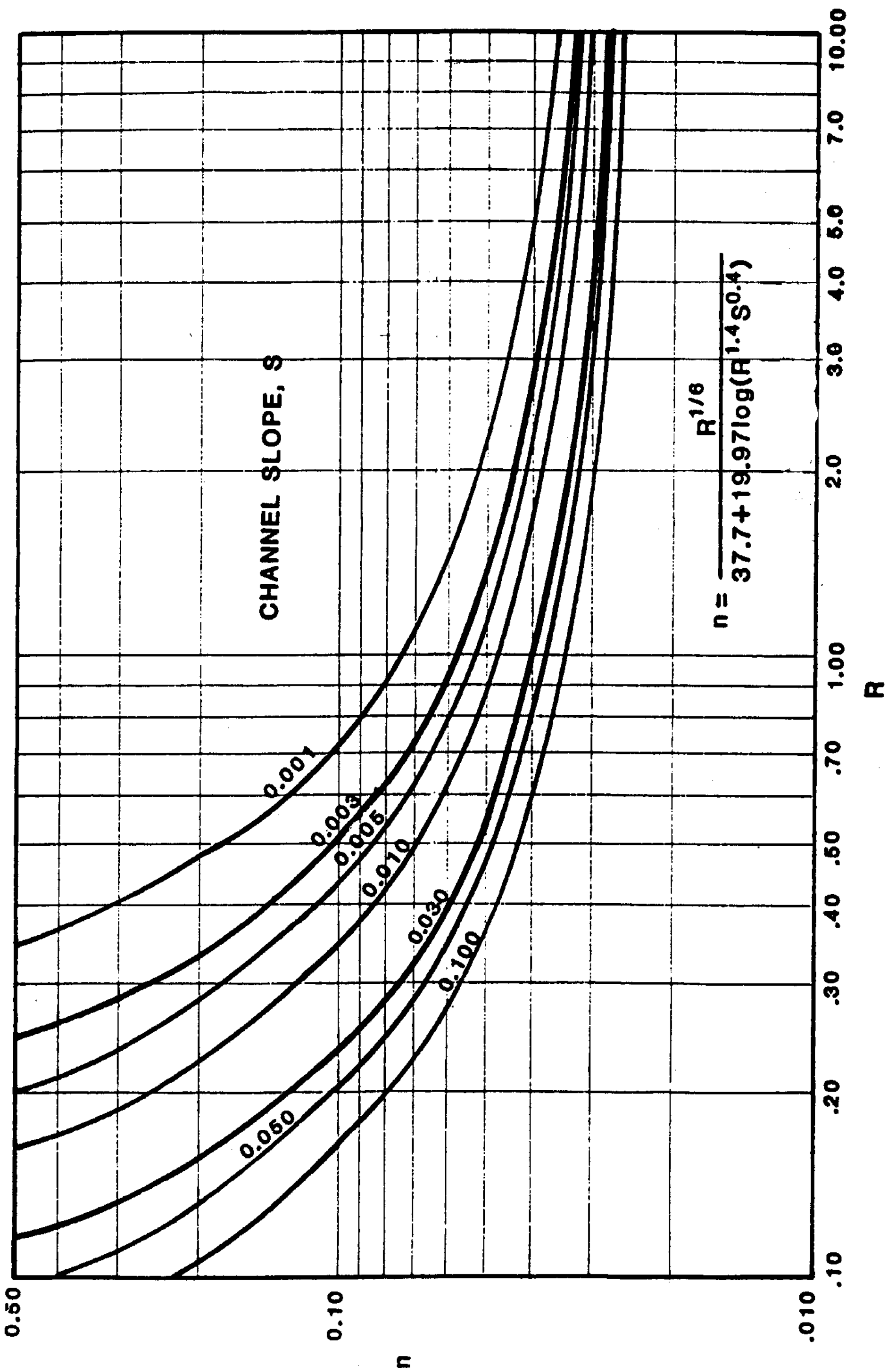


Figure F.6 Manning's n for Class E Vegetation
(Note: hydraulic depth (R) in feet)

Source: N. Kouwen, et al., 1980

Table F.3(c): Maximum Permissible Shear – Stress Values and Velocities for Various Materials

Materials	Test Time (hr)	Performance Properties: Maximum Permissible Shear Stress (N/m^2)	Performance Properties: Maximum Permissible Velocity (m/s)
Bare soil[a] (see Figure F.12) (*Table F.3d)			
Noncohesive (Dia. = 0.1 – 25 mm)	NDG	1.5 – 20	0.46 – 0.76*
Cohesive (P.I. = 4 – 50) (see Figure F.11) (Table F.3d)	NDG	0.5 – 38	0.52 – 1.13* 1.8 (hard pan)
Gravel riprap[a] (*Table F.3(d))			
D_{50} = 25 mm (thickness t = $2D_{50}$)	NDG	15.8	0.76 – 1.13*
D_{50} = 50 mm (thickness t = $2D_{50}$)	NDG	31.6	1.13 – 1.22*
Rock riprap[a] (** Table F.3(e))			
D_{50} = 150 mm (thickness t = $1.5D_{50}$)	NDG	95.8	2.2 **
D_{50} = 300 mm (thickness t = $2D_{50}$)	NDG	191.5	3.0 **
Gabion Mattress (*** Table F.3(f))			$V_{critical} – V_{limit}$
thickness = 0.25 m; D_{50} = 120 mm	NDG	200	4.5 – 6.1 ***
thickness = 0.30 m; D_{50} = 150 mm	NDG	230	5.0 – 6.4 ***
thickness = 0.50 m; D_{50} = 190 mm	NDG	250	6.4 – 8.0 ***
Grass (established)[a] (Table F.3g)	NDG	16.8 – 177.2	0.8 – 2.4
Vegetative			
Class A Retardance	NDG	177.2	
Class B Retardance	NDG	100.6	
Class C Retardance	NDG	47.9	
Class D Retardance	NDG	28.7	
Class E Retardance	NDG	16.8	
Fiberglass roving[a] (SOP)			
Single	NDG	28.7	NDG
Double	NDG	40.7	NDG
Straw (loose) covered with net[a]	NDG	69.4	NDG
EROSION CONTROL MAT (ECM)			
Coconut material[c]	0.5	143	3.0 – 4.6
Wood excelsior material[a]	NDG	74.2	NDG
Jute net[a]	NDG	21.5	NDG
Straw blanket with sewn net[c]	0.5	95.7 – 105	1.8 – 3.0
Straw/coconut blanket[c]	0.5	120	3.0
TURF REINFORCEMENT MAT (TRM)			
Bare ground conditions[a,b]	0.5	239 – 287	5.5 – 8.2
	50	95.6	2.4
Vegetation established[b]	0.5	100 – 380	5.5
growth period ≥ 36 mos. & growth density dependent	50	100 – 239	3.0
COMPOSITE TURF REINFORCEMENT MAT (C-TRM)			
Bare ground conditions[b]	0.5	239	3.7
	50	95.6	2.1
Vegetation established[b]	0.5	382	6.1
	50	239	4.3

[a] From Chen and Cotton (1988)

[b] From IECA (1991, 1992, 1995)

[c] As reported by manufacturer

Notes:

i) NDG = No data given

SOP = Spray-on-Product (s.a., mulch)

V_c = Critical Velocity

V_l = Limit Velocity

ii) RECP types include ECM, TRM, C-TRM

For use of RECP products, product certification on performance and physical properties are required from suppliers.

Performance of RECP will depend on Final Density of Vegetation Growth after installation and the growth period specified.

iii) Relationship of shear stress not linear with flow velocity; select lining based on permissible tractive resistance.

iv) Performance values given are limited to flow of 1.4 m^3/s.

F.6 Channel Discharge Equation

The discharge (Q) of a channel is related to the velocity and the cross-sectional area of flow through the continuity equation:

$$Q = A \times V \qquad \text{(Equation F.2)}$$

Where: Q = discharge (m^3/s)

A = cross-sectional area of flow (m^2)

V = velocity of flow (m/s)

With uniform flow, V in above equation can be replaced by Manning's expression to arrive at the following revised continuity equation for uniform flow.

$$Q = A[(1 / n) \times R^{2/3} \times s^{1/2}] \qquad \text{(Equation F.3)}$$

Knowing the geometric shape of a channel and the depth of flow, the cross-sectional area, A, and the hydraulic radius, R, can both be evaluated. Additionally, if the bed slope, s, and the channel roughness, n, are known, the entire right half of the equation can be quantified, providing an estimate for the discharge, Q.

F.7 Design Channel Dimensions

Channel design involves a reverse process to the discharge estimation procedure outlined above. The discharge is known from hydrological calculations and appropriate channel dimensions have to be determined to ensure satisfactory flow conveyance.

Inputting known values of Q, n and s into the revised continuity equation leads to a value of the quantity, $AxR^{2/3}$, which cannot be solved directly to provide flow depth and bed width estimates. Thus the design of channels using Manning's equation requires an iterative process. Briefly the procedure is as follows:

- An appropriate channel shape and bed width is chosen, taking into consideration the geometric and other requirements of the roadway;
- Evaluate channel discharge using Manning Equation (Equation F.1) based on the assumed geometric properties;
- Compare evaluated discharge with design discharge;
- Adjust original geometric parameter assumptions and recalculate channel discharge;
- Continue this procedure until congruence between calculated and design discharges occur.

This procedure is illustrated in Appendix H as design examples H.8 to H.10 and H.12. Various nomographs and computer program are available to assist in solving Manning's equation.

F.8 Approaches to Controlling Soil Erosion

There are two types of design approaches for the design of open channels depending on whether or not siltation or erosion are considerations in design. In the first approach, the material that comprises the channel and sideslopes is assumed to be in dynamic equilibrium with the silt laden water of the stream. A regime state prevails with erosion and deposition occurring at the same rate over the long-term resulting in a stable channel section with no real loss or gain of material. This approach is called the Permissible Velocity Method.

Such an approach is necessary when sediment laden water is required to be handled in earthen channels as unacceptable erosion or deposition of bed material can occur. Typically this approach is applicable to drainage and irrigation systems, and river realignments.

The second approach, called the Tractive Stress Method, assumes that the material that comprises the channel boundary is capable of resisting soil loss through erosion, and the channel size will be determined for carrying the design flow. Most open channels carrying clear water, including roadside ditches, are designed using this approach.

With erodible bed material such as some natural soils, the design is complete by checking the assumption of non-occurrence of erosion. If erosion is found likely to occur, the channel is redesigned using larger channel sizes, gentler bed slope if possible, or armouring along the bed and sideslopes to resist any erosion.

F.9 Permissible Velocity Method

The need to check whether or not soil erosion will occur was recognized early in the design of open channels. Engineers originally approached the problem by defining limiting velocities to which a bed material can be subject to. Channel design proceeded by limiting the flow velocities along them to values lower than the permissible velocities. Alternatively, protection of the channel was provided using some form of channel lining.

If it is possible to design the channel to flow with a velocity less than the competent mean velocity of the native soil, soil erosion should not be a major problem. However, there may be erosion of the exposed earth due to rainfall and other weathering processes. Due to potential problems with silt that can occur, unlined channels must be regularly maintained.

The permissible velocity method was historically adopted for channel assessment. Recent developments recognized and utilized tractive stress method as an acceptable hydraulic assessment method (see Section F.10).

Table F.4: Competent Mean Velocities for Cohesive Soils*

Depth of Flow (m)	Soil Scourability **			Remarks
	High (m/s)	Medium (m/s)	Low (m/s)	Normal Ditch Flow for Highway
1.0	0.5	0.9	1.6	0.3
1.5	0.6	1.0	1.8	N/A
3	0.6	1.2	2.0	N/A
6	0.7	1.3	2.3	N/A
15	0.8	1.5	2.6	N/A

Source: RTAC Drainage Manual 1987

Notes:

* Competent velocities should be based on local experience whenever possible, taking into account saturation and weathering.

** It is not considered advisable to relate the tabulated values to soil property indices because of the strong effect of saturation and weathering on the scourability of the soils. However, the following tentative relationship to consistency is offered as a rough guide.

High scourability	- very soft to soft clays
Medium scourability	- firm to stiff clays
Low scourability	- stiff to hard clays, some glacial tills

See Table F.5 for soil consistency determination.

F.10 TRACTIVE STRESS METHOD

In the 1950's, it was recognized that the permissible velocity approach, though successfully used in the design of open channels, does not reflect the physical phenomenon of soil erosion. It was postulated that erosion occurs as a result of the shear force exerted by water flowing over the bed and sideslopes of a channel. While the velocity of flow bears a relationship to the shear force exerted, the relationship is not linear, i.e., equal increases in velocities does not produce a corresponding increase in shear force.

Attention was then focused on the development of a method for the evaluation of the applied hydraulic shear and to ensure that the bed material is capable of withstanding the applied stress. This led to the development of the Tractive Stress Theory.

The Tractive Stress Theory, as related to open channels, simply states:

applied tractive shear stress $\leq$ critical shear stress

Under uniform flow conditions, the applied tractive stress exerted by flowing water is given by:

$$\tau = \delta \text{ x } R \text{ x } s \qquad \text{(Equation F.4)}$$

Where: τ = Tractive stress (kPa)

δ_w = Unit weight of water (kN/m^3)

R = Hydraulic radius (m)

s = Bed slope (m/m)

Maximum tractive stress induced by any flow occurs at the point of greatest depth or at the centre of any channel with horizontal bed is given by the equation:

$$\tau_{max} = \delta_w \text{ x } d \text{ x } s \qquad \text{(Equation F.5)}$$

Where: d = Depth of channel (m)

The critical shear stress is a property of the material comprising the channel boundary. It is defined as the limiting hydraulic shear stress that can be applied to a material to initiate significant soil erosion or material failure in the case of ditch linings.

Natural soils possess varying critical shear stress capacity and the process of design involves evaluating this capacity and limiting the tractive stress to a value less than the capacity evaluated. Similarly, various commercially available lining materials have differing critical shear stress capacities and hence the tractive stress must be limited in a similar manner to the critical stress of the lining.

The effect of concentrated flows in channels in terms of their erosion tendency on the materials (natural soil or erosion control lining) comprising the channel bed and sideslopes, is discussed in more detail in Sections F.12 to F.14.

F.11 Distribution of Tractive Stress

F.11.1 Straight Sections with Uniform Flow

In any given channel, the tractive stress is not uniform across the channel bed. Variations occur across the entire cross-section of the channel. Typically, for a trapezoidal channel, the stress variation occurs as shown in Figure F.2. Maximum values occur at the centre of the section and reduce gradually and then abruptly to zero at each corner. Along the sideslopes, maximum values occur at approximately two-thirds the depth of flow with magnitudes of $0.75\tau_{max}$.

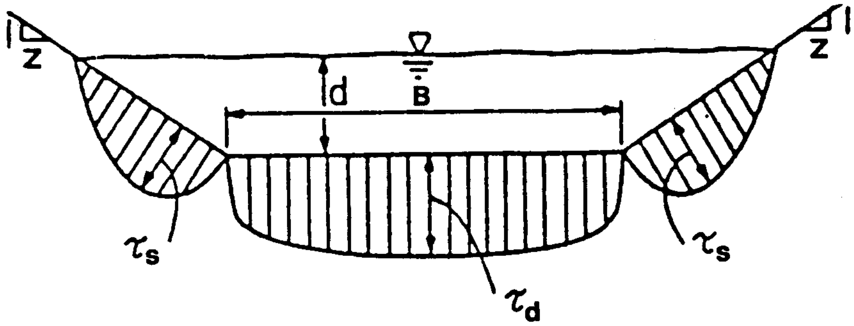


Figure F.7: Typical Shear Stress Distribution on Trapezoidal Channels

Note: τ_s = 0.75 δ ds = 0.75 τ_{max}

τ_d = 0.97 δ ds = τ_{max}

δ_w = Unit weight of water

d = Depth of water

s = Channel gradient

Source: Chow 1959

F.11.2 Bends

The changing flow paths along a bend in a channel induce additional shear stress at the shaded locations shown in Figure F.3. Upstream of a bend, the additional shear occurs along the inside, while downstream, the greater shear moves toward the outside. Downstream, the additional shear persists for some distance beyond the bend. Protection of the channel may be required for some distance, L_p, beyond the bend as given by the equation below.

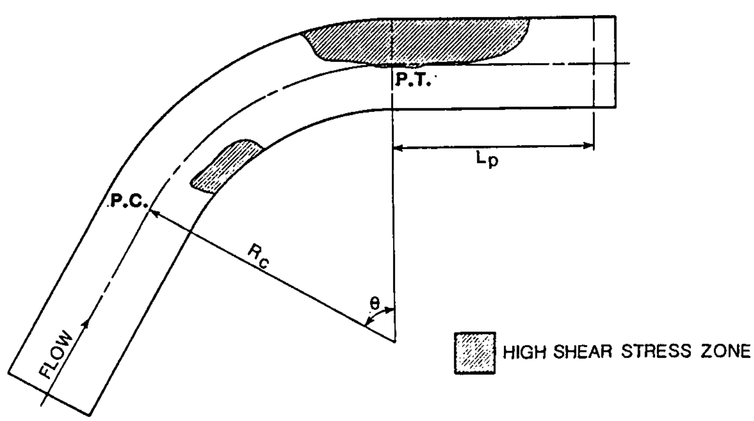


Figure F.8: High Shear Stress Zones in Bends

Source: Nouh & Townsend, 1979

$$L_p / R = (0.694 \times R^{1/6}) / n_b \qquad \text{(Equation F.6)}$$

Where: L_p = Length requiring protection

R = Hydraulic radius

n_b = Manning's roughness coefficient in bends

F.12 Resistance of Bare Soil to Erosion from Concentrated Flows

The behaviour of a soil is largely influenced by its composition. Such composition can range from completely granular material such as cobbles, gravel and sands to completely flat, plate-shaped, microscopic clayey particles. Most soils comprise a mixture of granular and clayey particles and the overall behaviour of such a soil will be dependent on the influence of each fraction comprising the soil.

Experience has found it convenient to separate naturally occurring soils into cohesive and cohesionless materials based on particle size distribution and plasticity. The convenience arises from the fact that many characteristics of a soil can be inferred from the plastic behaviour of cohesive soils and the grain size distribution of cohesionless soils.

F.12.1 Permissible Shear Stress

Any soil subjected to the flow of water over it experiences a shear stress along its surface which acts to dislodge soil particles. Initially, with low shear stress, the soil may be capable of resisting the flow. Thus the bed and sideslopes remain stable. With increasing flow depth, there comes a time when the shear stress imposed by the flow on the channel bed is capable of dislodging soil particles into suspension. The shear stress at which this soil loss first occurs is referred to as the Critical Shear Stress and represents the maximum hydraulic shear stress to which the soil can be subjected. For design purposes, the critical shear stress is regarded as the Maximum Permissible Shear Stress.

As an extension of the concept, critical shear also occurs on manufactured channel linings. In this case, the critical shear is interpreted as either the hydraulic shear causing lining failure or rapid soil loss. Permissible shear is similarly taken as the maximum stress to which a lining can be subjected before the onset of failure.

F.12.2 Cohesive Soils

Numerous investigators have looked at the problem of cohesive soil erodibility in attempts to obtain correlations between the critical shear stress and the properties of a soil. Some of the properties identified as influencing soil erodibility are:

- Mineralogical composition
- Chemical composition of the fluid surrounding soil particles
- Sodium Absorption Ratio (SAR)

- Degree of compaction
- Plasticity

At present, no procedure exists for evaluating the critical shear stress that takes into consideration all the identified variables. Even if such a procedure existed, it would not be very valuable for design purposes as the many factors that affect soil erosion are difficult to determine. Cost would be the influencing factor.

An acceptable method using two parameters is available to evaluate the permissible shear stress of a cohesive soil. One of these parameters, the plasticity index, is routinely determined by the designer in their routine soil investigation and testing. The other parameter, compaction, as measured by the blow count, N, on the Standard Penetration Test is not as routinely evaluated. However, an estimate of the N value can be made by the feel of the sample when worked between the fingers. Alternatively, a simple hand-held soil investigation tool called a Pocket Penetrometer can be used as a more accurate determination. In theory, the penetrometer measures undrained shear strength which can be related to the blow count, N, as shown in Table F.6.

In the absence of any data on soil compactness, a subjective evaluation of the N parameter will be required. As a guide, the consistency of the soil can be determined in the field using simple test as given below. Then using Table F.6, an appropriate N value can be selected for use in Figure F.4 to determine the permissible tractive shear stress of the soil.

Table F.5: Field Soil Consistency Determination

Very soft	Easily penetrated several centimetres by the fist
Soft	Easily penetrated several centimetres by the thumb
Medium	Moderate effort to penetrate several centimetres by the thumb
Stiff	Readily indented by the thumb, but penetrated only with great effort
Very stiff	Readily indented by the thumb nail
Hard	Indented with difficulty by the thumb nail

Table F.6: Consistency of Cohesive Soils Related to Standard Penetration Test Value, N

Consistency	Standard Penetration Value, N
Very soft	0 - 2
Soft	2 - 4
Medium	4 - 8
Stiff	8 - 16
Very stiff	16 - 32
Hard	> 32

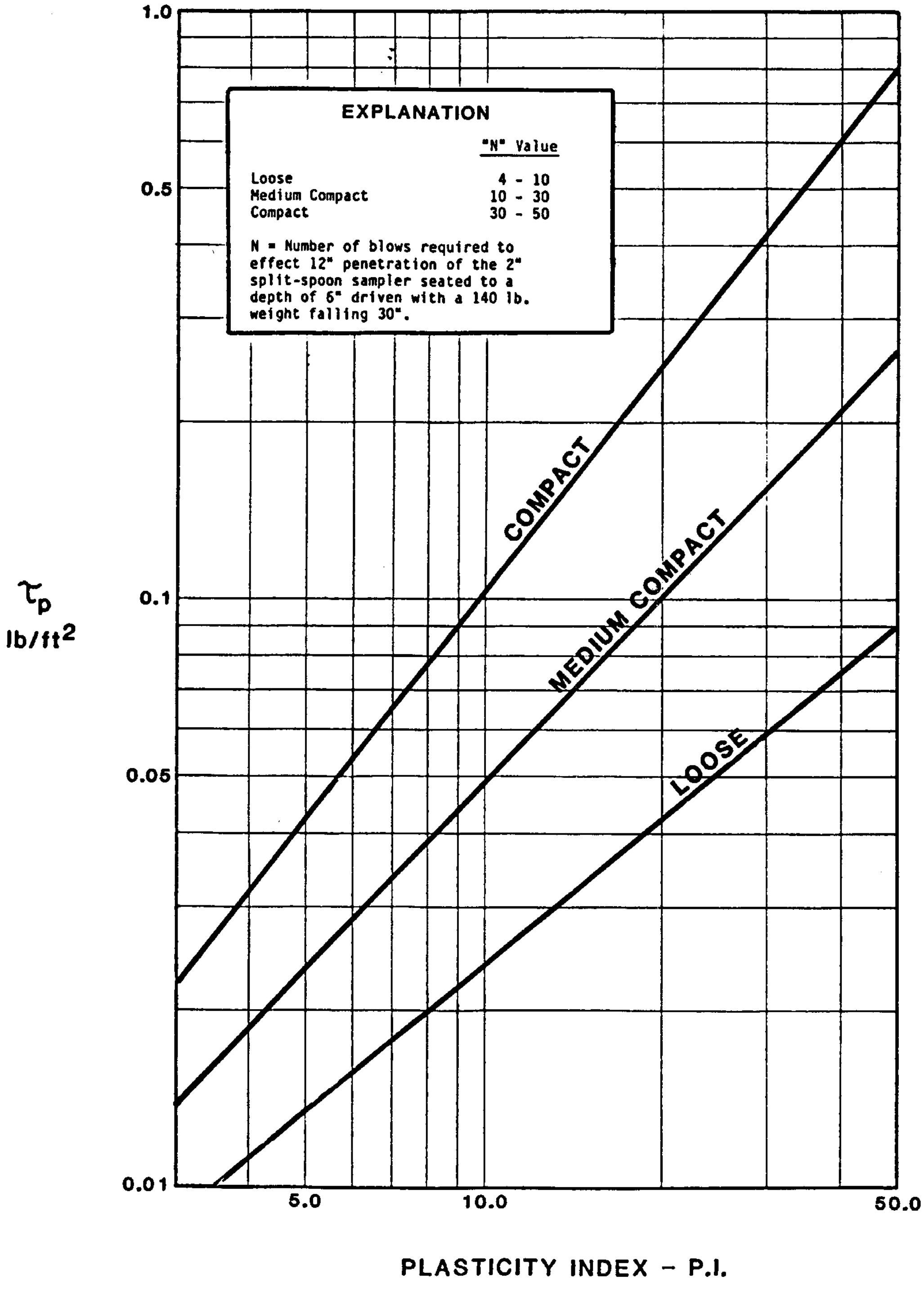


Figure F.9: Permissible Shear Stress for Cohesive Soils

Source: Smerdon & Beaseley, 1959

Note: 1 lb/ft² = 48 N/m²

F.12.3 Cohesionless Soils

With cohesionless soils, the particles are relatively inert and erodibility is dependent mainly on the grain size distribution. Tests carried out on various cohesionless soil samples have shown that the permissible shear stress can be related to the mean particle size of the sample as shown in Figure F.5. Thus it is a simple matter of assessing the mean particle size from a grain size distribution curve to determine the permissible shear stress.

For particles larger than 100 mm, $\tau_{p,}$ can simply be evaluated by the equation:

$$\tau_p = 6.25 \times 10^{-4} D_{50} \qquad \text{(Equation F.7)}$$

Where: τ_p = permissible shear stress (kPa)

D_{50}= mean particle diameter (mm)

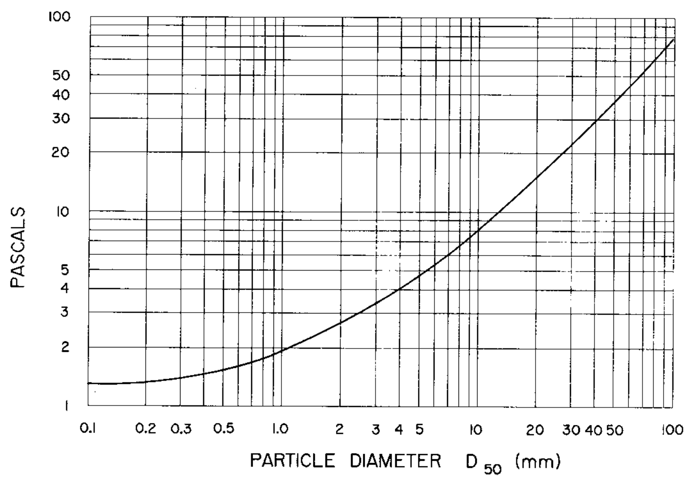


Figure F.10: Permissible Shear Stress for Cohesionless Soils

Source: Thibodeaux 1982-1985

F.13 Resistance of Vegetation to Concentrated Flow

The most widely used method for permanently controlling soil erosion, both on slopes and along ditches is the establishment of vegetation. Because of the relatively low cost, vegetation is the first and sometimes erroneously the only choice among soil erosion control practitioners.

There is a limitation to the extent to which vegetation will be successful in controlling soil erosion along ditches. Unless the limitation is defined, many instances will occur in which vegetation will prove to be inadequate for the function intended.

The determination of the appropriateness of vegetation for soil erosion control along ditches is rather simple. It entails comparing the tractive resistance of the proposed vegetation with the shear stress exerted by the design flow. Vegetation will be adequate if the shear stress of the flow is less than the resistance of the vegetation.

There is one additional complexity in the calculation process introduced by a vegetative lining. The degree of flexibility and variations in growth height of various grasses and legumes normally used for the control of erosion vary with the different species. Further, the mowed height of the vegetation also affects roughness. As such, the roughness coefficient, n, an input into Manning's Equation is not a constant.

F.14 Resistance of Non-Vegetative Linings to Soil Erosion

Non-vegetative ditch linings used for soil erosion control are of two types:

- Temporary; and
- Permanent.

Temporary linings are to be considered for use only at those locations in which vegetation growth is expected to take over the erosion control function in the future. Conversely, in sterile areas or those locations expected to experience larger hydraulic shear stresses than can be handled by vegetation, permanent erosion controls are required.

The approach to designing erosion control in either case is to compare the shear resistance of the lining with the tractive stress of the design flow. The lining selected should have a shear resistance greater than the flow shear stresses. However, when the channel gradient becomes steep (say greater than 10%) and the lining selected is a weighty material (such as gravels and rock riprap), special design procedures are required as the lining on the channel bed and more so on the sideslopes provides an additional de-stabilizing force component down slope. Procedures for such design are given in Section F.18.

Other permanent linings, such as articulating blocks that rely not only on their weight but also on their inter-connection with each other for their stability, must have their design based on the recommendations of the manufacturers. These recommendations will usually be deduced from the results of hydraulic tests carried out on the linings for performance evaluation.

Many manufactured materials are currently available for soil erosion control. Most of them are bio-degradable although some permanent ones are available.

F.15 Flexible Lining Design

Flexible linings, while not always applicable, are capable of handling most of the soil erosion problems along provincial roadways. Additionally, flexible linings are more versatile than rigid linings because of their ability to accommodate minor distortions in the subgrade without leading to failure. This property, in particular, makes them the preferred choice among ditch linings.

A word of caution in the use of lining materials be they rigid or flexible. Linings ought not to be placed onto unstable slopes as the lining material will soon separate at one or more of the crack locations which normally appear when instability occurs on a slope. The gap so created will render the lining ineffective. In fact, the lining may aggravate the instability by conducting water into the unstable mass.

The design procedure is a three step evaluation from which a decision is made at the end of each step regarding the need for the succeeding step. The three steps are given in the following paragraphs.

Step 1: Assess the capability of the in-situ soil to withstand the erosive forces of flowing water. If adequate, use seed, fertilizer, harrow or mulch as required to establish vegetation. Sediment retention structures may be required to control sediment loss to areas beyond right-of-ways.

Proceed to Step 2 if in-situ soil cannot withstand erosion.

Step 2: Assess the capability of vegetation to control soil erosion. If adequate, provide temporary lining to control erosion while vegetation is being established.

Proceed to step 3 if vegetation cannot control the erosion.

Step 3: Design permanent erosion control measure (flexible or rigid), depending on local factors such as economy, ease of installation, availability of materials, maintenance costs, etc. The advantages and limitations of each lining types should be considered for situations of flow, slope, vegetation growth density, and soil type of specific soil conditions.

F.16 Rigid Lining Design

Rigid channel linings, because of cost, are only considered for erosion control when special conditions prevail that would preclude the use of other linings. Examples of such conditions are:

- Steep grade;
- Limited right-of-way;
- Appropriate flexible lining unavailable; and
- Good probability of tampering by the public (i.e., removal of riprap or other measures).

As such, the first step in the design of a rigid lining is to determine the existence of any condition that may adversely affect the performance of the lining. Conditions to look for are:

- Unstable ground;
- Ground water seepage;
- Frost susceptible soil;
- Expansive clays; and
- Hydraulic uplift conditions.

The presence of any of the above will lead to distortions in the channel lining and eventual failure if the problem is not adequately addressed at the design stage. Such conditions may require the services of a hydrotechnical or geotechnical engineer during the design and construction phase.

When non-problematic ground conditions are present, the design is completed by estimating the design discharge and providing an adequate hydraulic section using the principals of open channel hydraulics presented earlier in this section.

The design discharge for permanent installations should correspond to the estimated runoff from an event with a return period of 1:10 years. A larger design event with a return period of 1:25 years or greater may be used in situations where it is judged that a safety hazard exists and that significant disruption of traffic will be caused by a structural failure of the installation.

F.16.1 Other Requirements

Rigid lining design requires considerations of upstream and downstream scour, hydrostatic uplift of the lining, anchorage to the slope and structural cracking. For small drainage areas less than 25 ha, the above requirements can be addressed by the following "rule-of-thumb" provisions:

- Utilize virgin ground or well-compacted fill for subgrade;
- Place a 150 mm thick drainage layer under the region of the downstream outlet;
- Provide a riprap apron with 150 mm diameter rock to a thickness of 225 mm for a length of 2 m;
- Provide cut-off walls at both the upstream and downstream end of the structure. Depth of cut-off should be 0.5 m across the entire width of the transition;
- Ensure structural thickness of the lining is a minimum of 75 mm; and
- Provide adequate freeboard.

F.17 Steep Gradient Channels

Steep gradient channels, defined herein as channels having gradients in excess of 10%, are sometimes required of the conveyance of water from an elevation to another at a significantly lower level. In cases of low flow conditions, a temporary lining will suffice to control any soil erosion until vegetation gets established. However, in situations of moderate flow, there will be the need for a permanent erosion control measure such as random riprap linings.

Permanent flexible linings (i.e., riprap lining) will be capable of handling most of the cases that cannot be resolved by vegetation. Rarely will a piped conduit (downdrain) or a rigid lining be required.

Materials commonly used for permanent flexible linings along steep gradients are riprap and gabions. Gabions include drop structures and mattresses. Hollow precast concrete blocks which interlock may sometimes be used if economy can be achieved. Generally, precast blocks tend to be more costly than riprap options.

For steep channels, drop structures are commonly used for flow control and energy dissipation.

F.17.1 Design Procedure

On steep channel bed slopes, temporary linings, which are usually of the blanket type, can be designed as outlined in Section F.15. Permanent rigid linings are to be designed according to Section F.16. In either case, there is a need to distinguish between a steep gradient and a gentle one.

With permanent flexible linings like riprap, gabion or concrete blocks, there are additional factors that must be taken into consideration when comparing the tractive stress of the design flow with the resistance of the lining. In none of the three types can a single permissible shear stress value be defined for steep gradient channels.

Physical factors to be considered are size and shape of the material comprising of the bed and sideslopes and channel geometry. Other factors are material buoyancy and the weight component down slope.

With proprietary concrete block systems (in which size, shape and surface roughness vary with each type of block), a generalized channel design procedure cannot be presented. Designs incorporating these materials must be completed according to the recommendations of the manufacturer.

However, with riprap and gabions, extensive hydraulic testing and theoretical evaluations have been carried out on material gradation normally used for such purposes and design procedures were evolved which are presented below. A comparison of the relative thickness of riprap versus gabion mattress was once investigated to indicate that a smaller (2 to 3 times) thickness of gabion mattress can be utilized under identical severe hydraulic conditions.

F.17.2 Riprap Design

Investigations into the use of riprap on steep slopes have led to rather complex equations which may not be of practical value in design. By making simplified assumptions regarding the typical gradation of riprap and by conducting hydraulic tests, charts given in Figures F.11 to F.14 have been produced from the complex formulation to simplify the design process. The charts can be used for bed slopes varying between 10% and 25% and bed width increasing from 0 to 1.5 m. Linear interpolation will be required for bed slope and bed width intermediate between the limits given on the charts. These procedures are illustrated in design examples presented in Appendix H as design examples H.10 and H.11.

Riprap used as a ditch lining on either gentle or steep grades needs to be sufficiently thick to ensure minimal loss of the underlying material. Additionally, a filter consisting of a suitably graded granular material or geosynthetic of appropriate weight is required under the riprap to prevent piping failure of the underlying material.

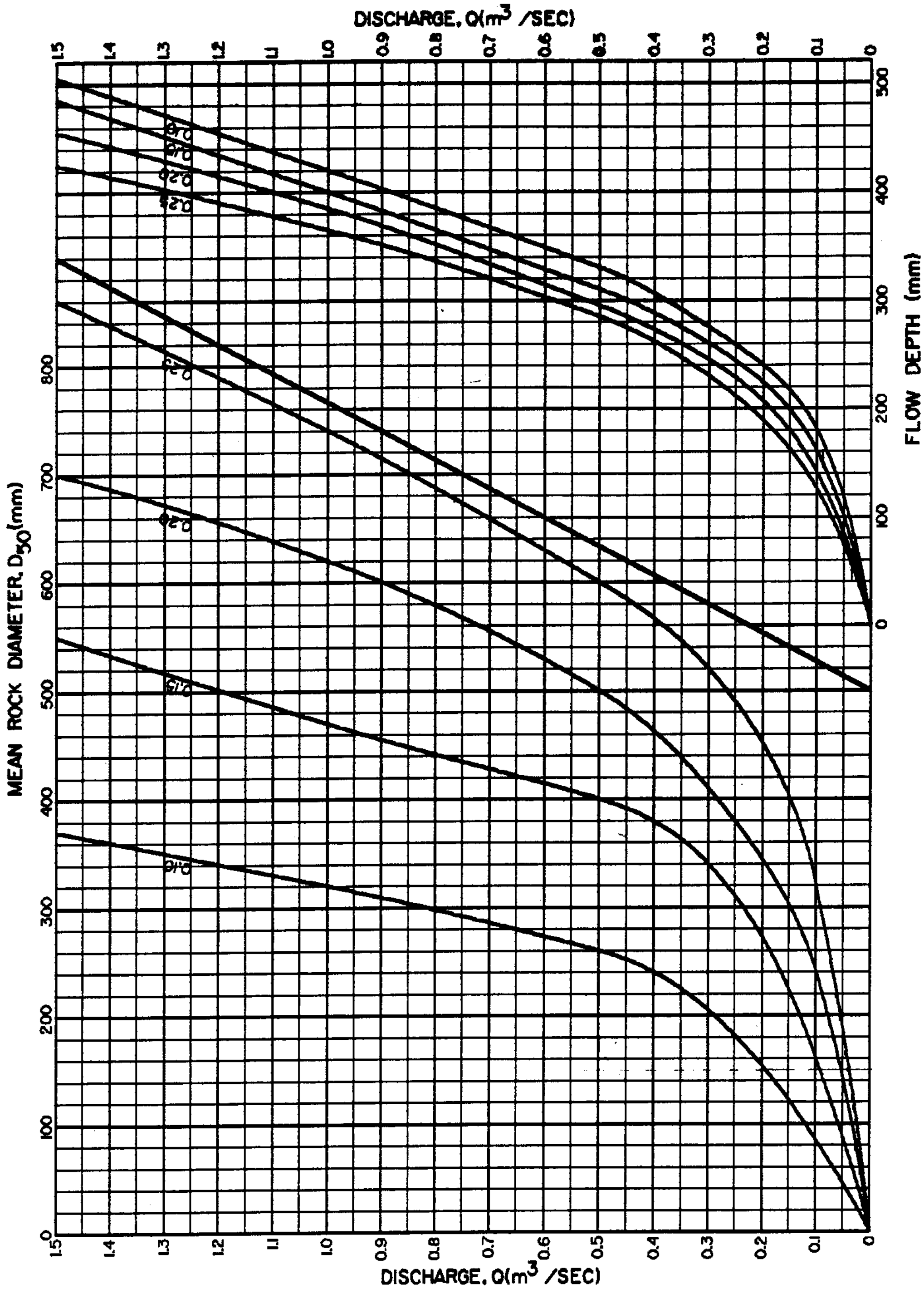


Figure F.11: Steep Slope Riprap Design
(Bed Width = 0 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

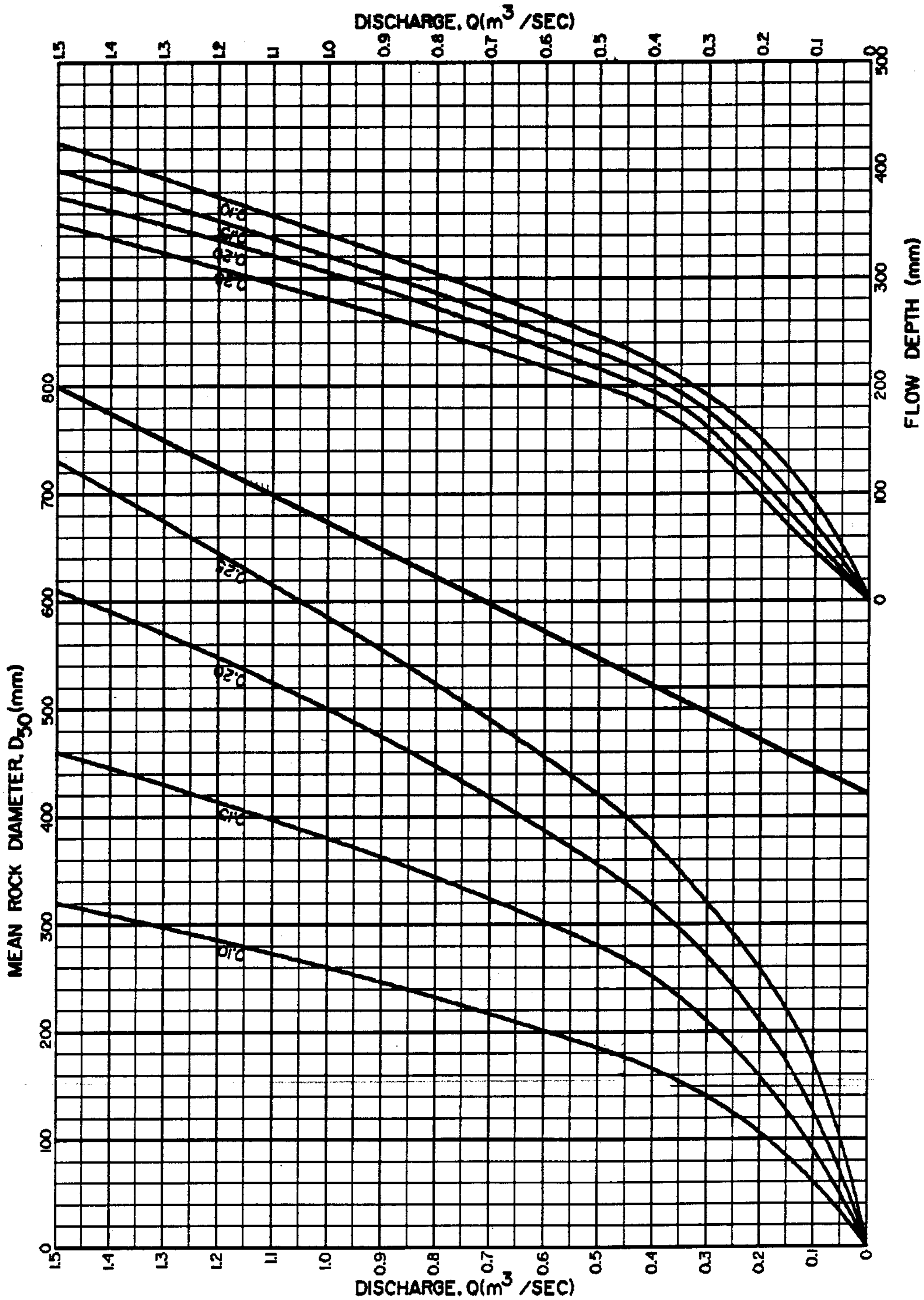


Figure F.12: Steep Slope Riprap Design
(Bed Width = 0.5 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

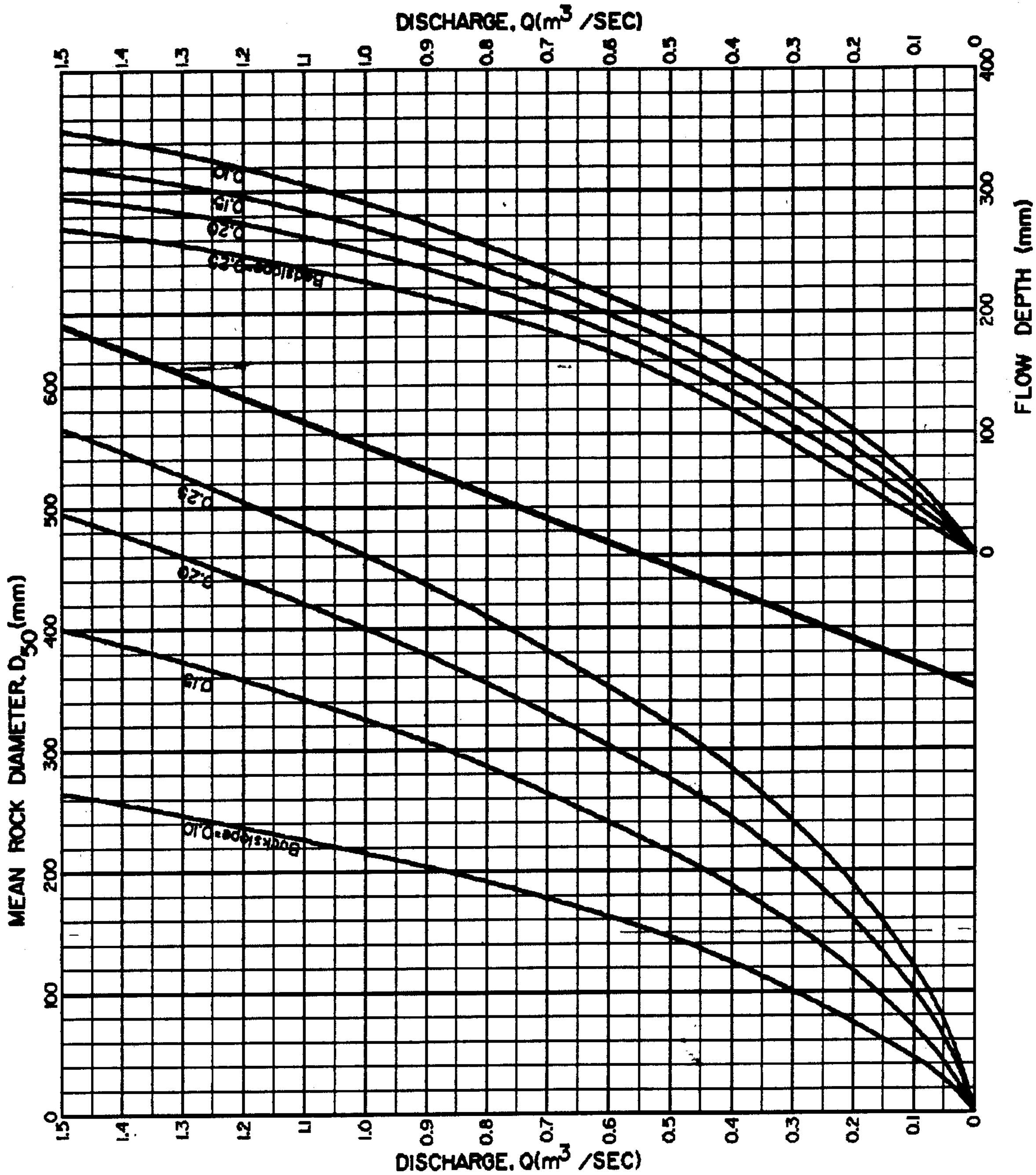


Figure F.13: Steep Slope Riprap Design
(Bed Width = 1.0 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

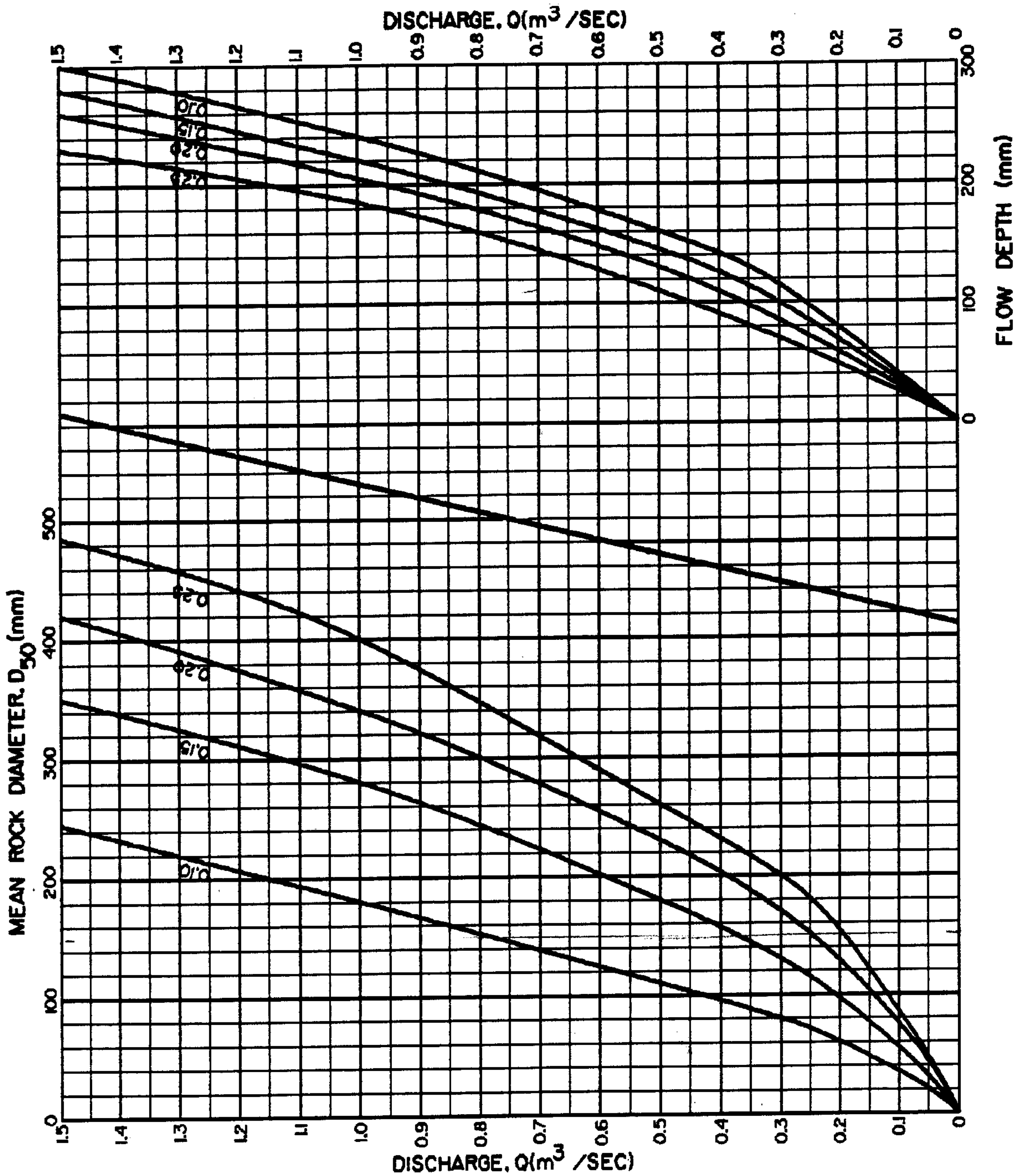


Figure F.14: Steep Slope Riprap Design
(Bed Width = 1.5 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

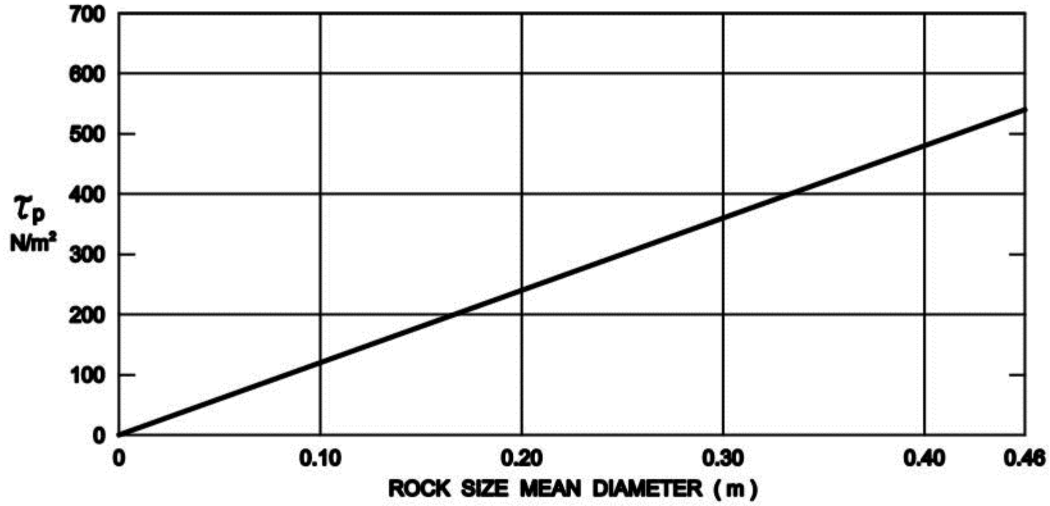


Figure F.15: Permissible Shear of Gabion Mattress vs. Rock Fill Size

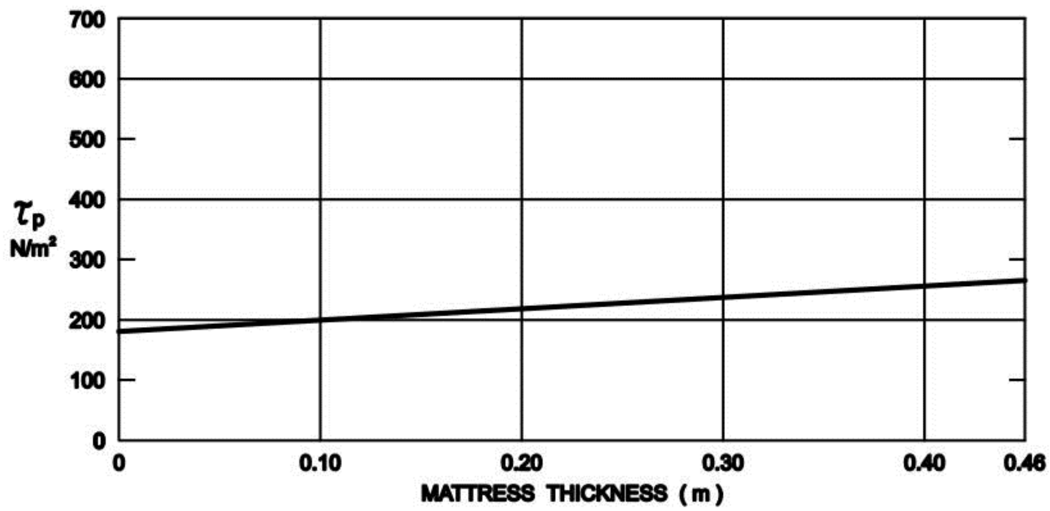


Figure F.16: Permissible Shear of Gabions vs. Mattress Thickness

Source: Chen & Cotton, 1988

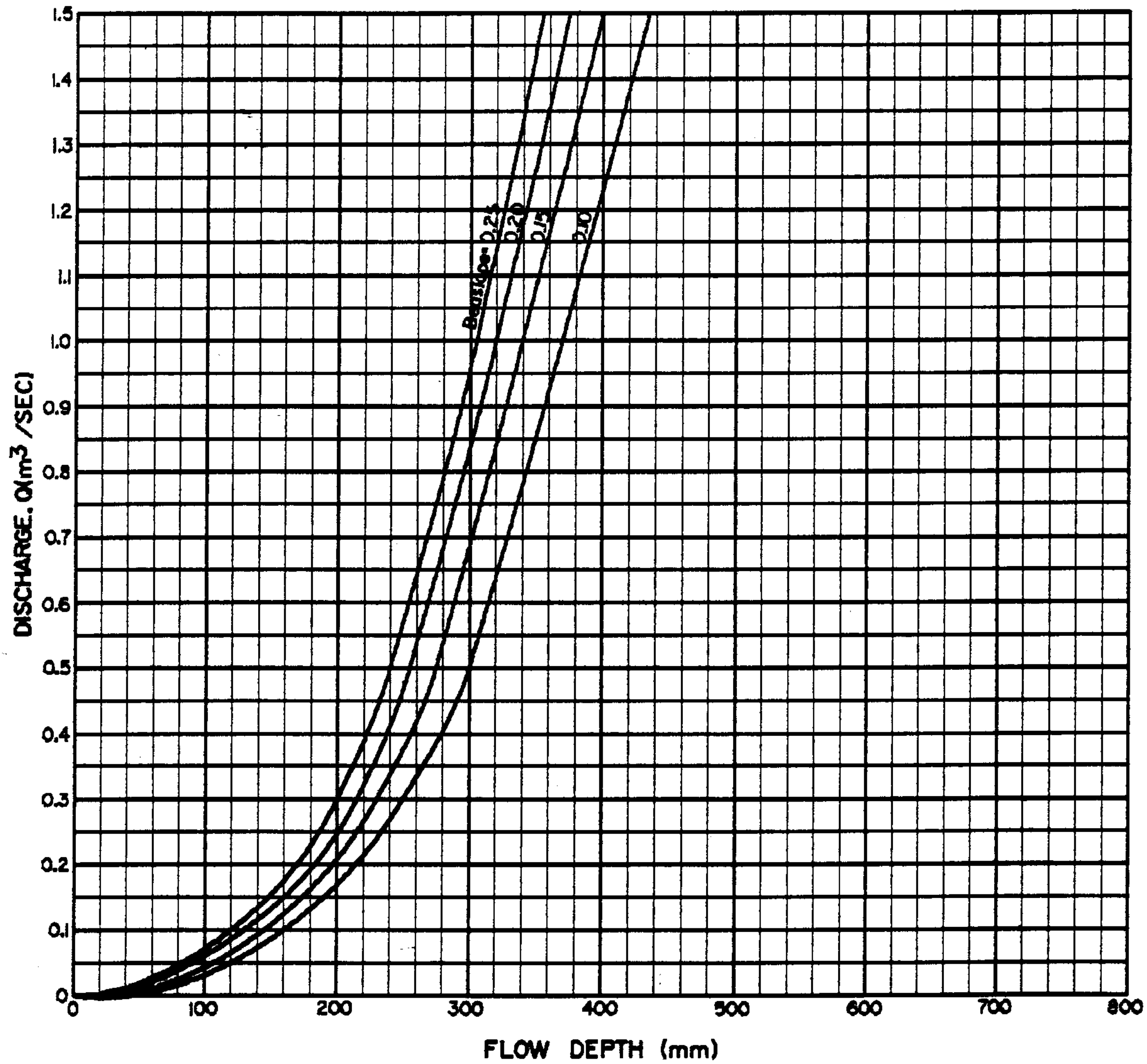


Figure F.17: Steep Slope Gabion Design
(Bed Width = 0 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

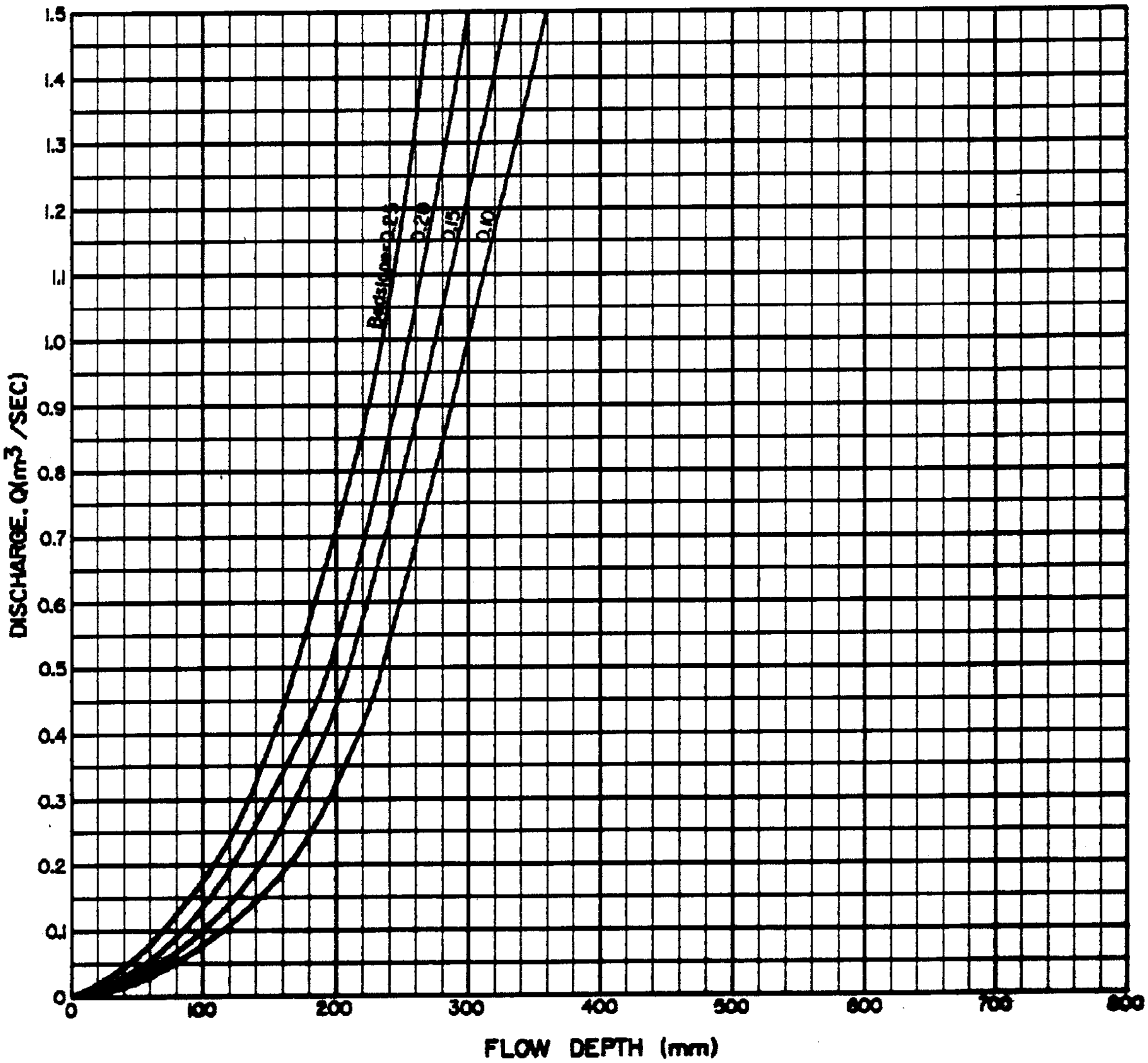


Figure F.18: Steep Slope Gabion Design
(Bed Width = 0.5 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

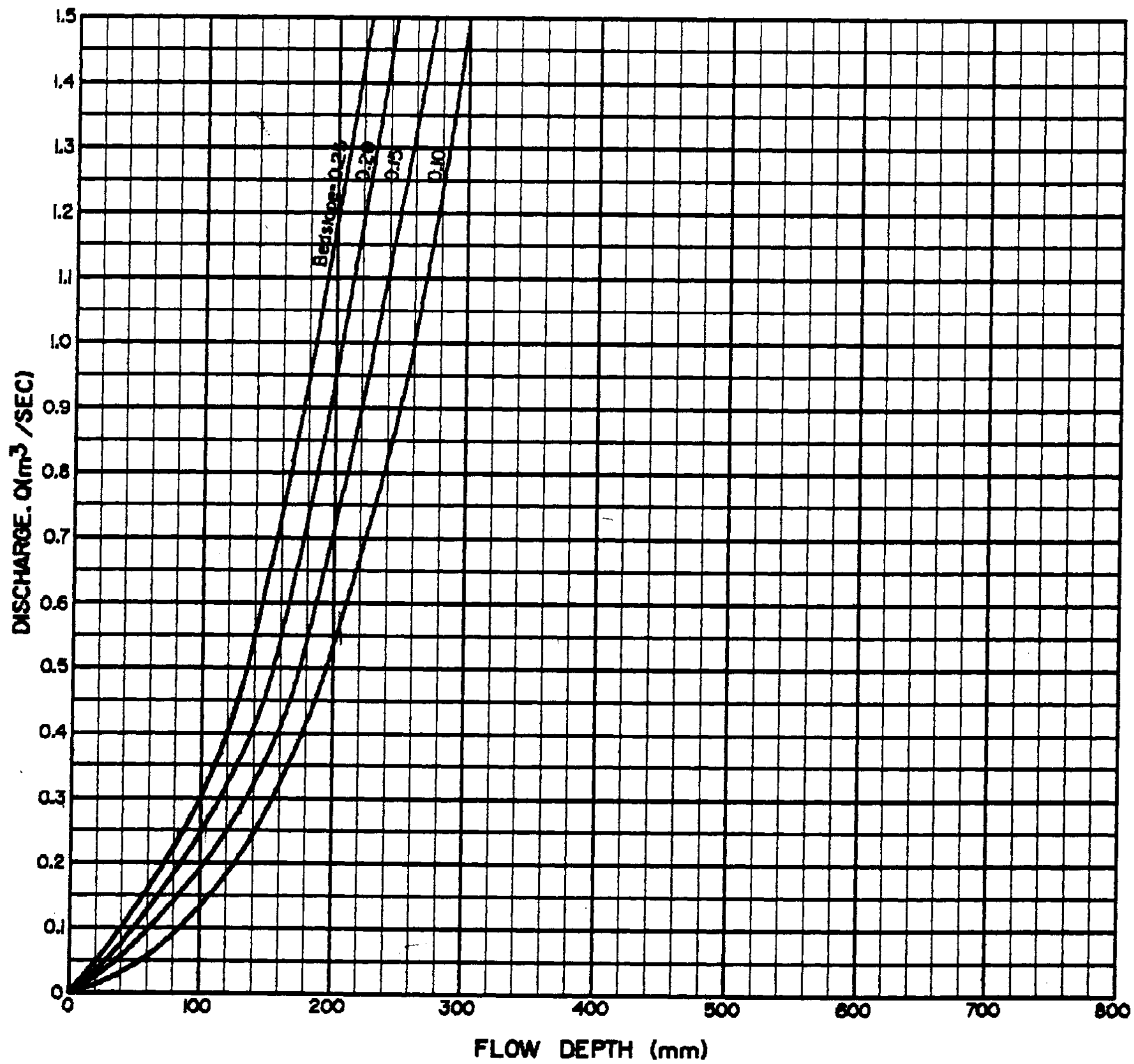


Figure F.19: Steep Slope Gabion Design
(Bed Width = 1.0 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

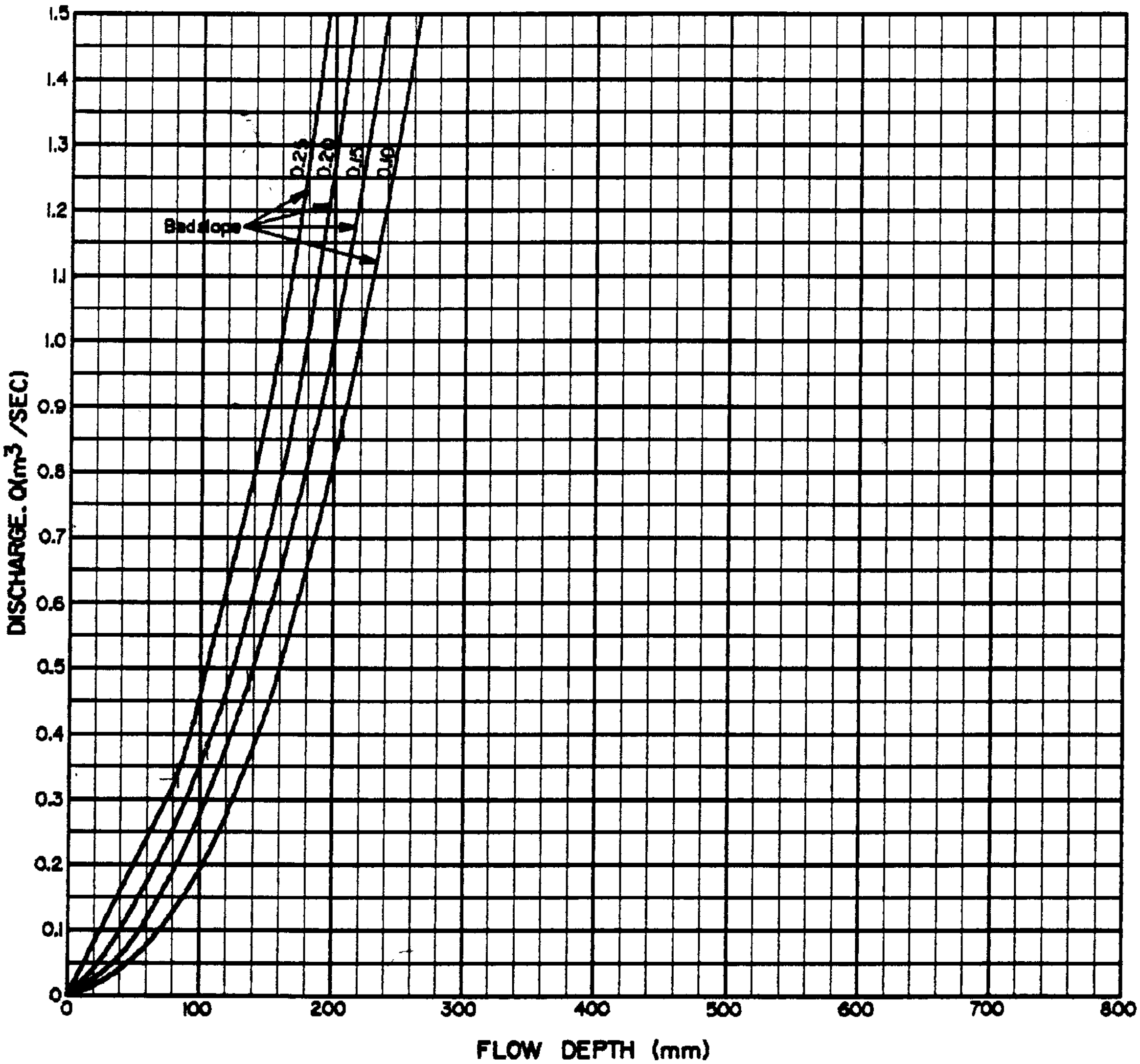


Figure F.20: Steep Slope Gabion Design
(Bed Width = 1.5 m, Sideslope = 3:1*)

Source: Chen & Cotton, 1988

* Typical slopes for a highway construction site in Alberta range from 3:1 to 6:1.

F.17.3 Gabion Design

Gabions are somewhat different from riprap in that the rocks are bound together by a wire mesh. Thus rocks rolling down slope are not considered to be a mode of failure. The gabion structures can accommodate higher discharges than an equivalent-sized riprap channel.

Gabions are commonly used as drop structures for flow control and energy dissipation. Changing the channel slope from steep to mild, by placing drop structures at intervals along the channel reach, changes a continuous steep slope into a series of gentle slopes and vertical drops. Instead of slowing down and transferring high erosion producing velocities into low non-erosive velocities, drop structures control the slope of the channel in such a way that the high, erosive velocities never develop. The kinetic energy or velocity gained by the water as it drops over the crest of each structure is dissipated by a specially designed apron or stilling basin which may be constructed of gabion mattress (FHWA HEC #14).

One probable failure mode though is the rearrangement of the rocks within the gabion structure through the shear action of flowing water. Another mode is the scouring of the material underneath and behind the gabions. Both failure modes must be addressed in design to ensure a functional structure. In this regard, charts given in Figures F.17 and F.18 have been prepared to guide both rock size selection and structure thickness evaluation.

The hydraulics of gabion structures has also been investigated (Chen & Cotton 1988). To assist in design, charts shown in Figures F.17 to F.20 have been prepared which relate discharge with depth of flow and bed slope. Bed widths considered are 0 to 1.5 m and bed slopes varying between 10 and 25% with sideslopes fixed at 3:1.

The charts can be extended to other channels with stable sideslopes by firstly designing an equivalent bed width channel with 3:1 sideslopes. The flow depth in the channel to be designed is then adjusted by equating flow areas. This procedure is presented in the design example presented in Appendix H as Example H.13.

Gabions used as ditch lining on either gentle or steep grades, need to be sufficiently thick to ensure minimal loss of the underlying material. Additionally, a filter consisting of suitably graded granular material or geosynthetic of appropriate weight is required under them to prevent piping failure of the underlying material.

F.17.4 Filter Material

Traditionally, a filter layer comprised of well-graded granular material is placed between the base soil and the riprap or gabion system. The intent is to ensure sufficient permeability to allow seepage to take place out of the underlying soil while at the same time minimizing the size of the voids in the filter to prevent the underlying material from migrating into the armour layer.

In current engineering practice, the granular filter blanket is largely replaced by a geotextile filter which performs essentially the same functions. Specific requirements for each type of filter area are:

Granular Filter:

$$(1) \quad \frac{D_{15}(filter)}{D_{85}(soil)} < 5 < \frac{D_{15}(filter)}{D_{15}(soil)} < 40 \qquad \text{(Equation F.8)}$$

$$(2) \quad \frac{D_{50}(filter)}{D_{50}(soil)} < 40 \; (U.S.\ Army\ Corps.\ of\ Engineers, 1955)$$

(3) Filter thickness $\geq 1xD_{100}$ (filter) or 150 mm minimum thickness, whichever is greater.

Where:

D_{50} = particle size diameter (m/mm) corresponding to 50% passing by mass

Geotextile Filter:

In selecting an engineering filter fabric, the fabric should be able to transmit water from the soil and also have a pore structure that will hold back soil. The following properties of an engineering filter fabric are required to assure that their performance is adequate as a filter under riprap and gabion rock.

1. The fabric must be able to transmit water faster than the soil.
2. The following criteria for the apparent opening size (AOS) must be met:
   a) For soil with less than 50 percent of the particles by weight passing a 0.075 mm opening (U.S. No. 200) sieve AOS < 0.6 mm (greater than U.S. No. 30 sieve).
   b) For soil with more than 50 percent of the particles by weight passing a 0.075 mm opening (U.S. No. 200) sieve AOS <0.297 mm (greater than U.S. No. 50 sieve).

The above criteria only apply to non-severe or non-critical installations. Severe or critical installations should be designed based on permeability and gradient ratio testing.

F.17.5 Lining Thickness

The minimum thickness of gabion or riprap structures should be the size of the largest stone to be used. Obviously, an isolated large stone which is not representative of the overall material should be discarded and not taken as a measure of the structure thickness. For most rocks used for ditch lining purposes, the criterion will translate into the following:

$$\text{Lining thickness} = (2 \text{ to } 3) \times D_{50} \qquad \text{(Equation F.9)}$$

F.17.6 Gradation

Both riprap and gabion stone should be uniformly graded meeting the requirements below:

$$3 > D_{100} / D_{50} > 1.5; \text{ and}$$
$$3 > D_{50} / D_{20} > 1.5 \qquad \text{(Equation F.10)}$$

The criteria will allow some smaller rock sizes in the armouring which will fill the voids between the larger rocks to form a compact layer.

A further requirement, applicable only to gabion structures, is that the largest rock should not be less than 2/3 of gabion thickness nor should the smallest rock be smaller than the mesh opening size.

F.18 Design Examples

Simple design examples using the tractive stress theory and permissible velocity theory have been worked out and are illustrated in design examples presented in Appendix H as H.8 to H.14.

APPENDIX G

SEDIMENT CONTAINMENT SYSTEM DESIGN RATIONALE

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FIGURES

TABLES

G.I Sediment Containment System Design Rationale

The following design rationale is considered reasonable to evaluate the effectiveness of containment system (Type I and II) for use at high to medium risk areas.

- An inflow quantity (Q_i) is assessed based on runoff volume (Q) from a 24-hour intensity rainfall, a 1:2 year storm. (Runoff from a 1:10 year storm will be approximately 2.5 times that for a 1:2 year storm. Thus, it is impractical to provide such large storage volume, especially if revegetation of disturbed area is to be achieved in 1-2 years and deactivation of the basin/trap considered for rural highways.)
- A sediment delivery ratio (SDR ranges from 0 to 1) is a subjective parameter
- SDR = 1; when a high risk area is at immediate connectivity downslope of an erosion source

Runoff (Q) and Inflow (Q_i) Estimation *(1:2 yr. storm, 24hr intensity rainfall, soil type, area of disturbance)*

$$Q_i = SDR \times Q \qquad \text{(Equation G.1)}$$

Where: Q_i = Inflow to sedimentation pond (m^3/s)

SDR = Sediment delivery ratio (dimensionless)

Q = Natural runoff (m^3/sec)

Runoff is estimated using:

- Precipitation of a 24 hour rainfall intensity from a 1:2 year storm;
- Effect of ground absorbency of different soil types affecting runoff. For various soil types, a general relationship between precipitation and runoff per hectare can be assessed. (see Figure G.1);
- Some jurisdictions (such as EPA) assume 25 mm runoff as minimum parameter;
- 150-250 m^3/ha of disturbed land;
- Amount of fine sediment laden runoff close to high risks: SDR=1

The quantity of runoff from precipitation is affected by the absorbance, permeability and texture of the surficial soils (Figure G.1).

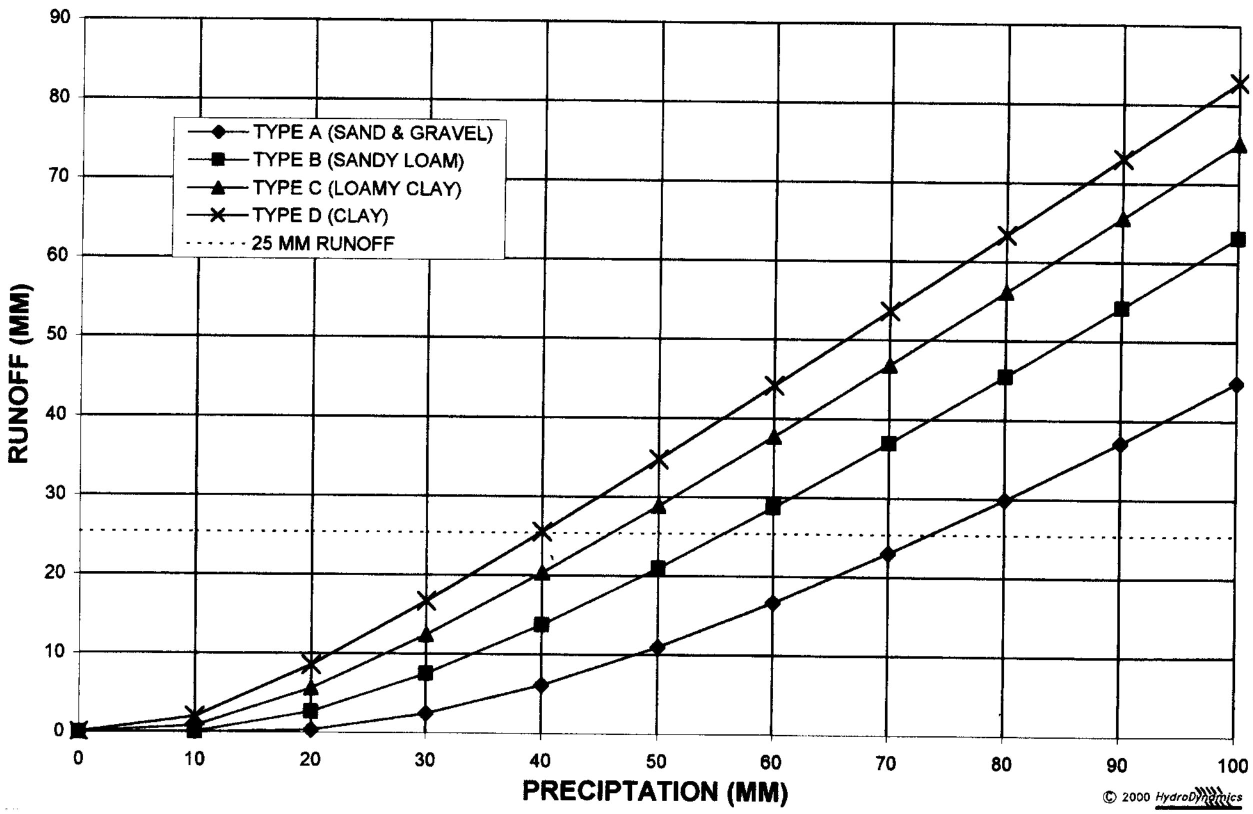


Figure G.1: Estimated Runoff from Precipitation over Different Soils

Source: Fifield, 2001

Settling Velocity (Vs) for Soil Particles

A particular soil particle size (D_S) can be targeted within the sediment laden runoff and its percentage by weight is determined from a hydrometer gradation curve of local soil materials. Different size particles exhibit different settling velocities with smaller particles requiring a longer time to settle. The different settling velocities for sand to silt to clay size particles are presented in Table G.1. The times required for the clay to sand size particles to settle in vertical distances in water are presented in Figure G.2 and it shows that clay size particles require a very long settling time.

The introduction and use of approved coagulants, such as polyacrylamide (PAM), causes the coagulation of small clay particles into larger particles thereby increasing their settling velocity and effectively reducing the settling time for small particle-sized soil.

The settling velocity (V_S) is assessed for a target soil particle size

$$V_S \; \alpha \; D_S \quad \textbf{(Stokes' Law)}$$

Where:

D_S = Diameter of a target particles size (cm)

Stokes' Law

$$V_s = g \times (S - 1) \times d^2 / (18 \times \mu) \qquad \text{(Equation G.2)}$$

Where: V_s = Settling velocity (cm/sec)

g = Acceleration of gravity (981 cm/s^2)

μ = Kinematic viscosity of a fluid (cm^2/s^2)

S = Specific gravity of a particle

d = Diameter of a particle (cm) (assuming a sphere)

Table G.1: Settling Velocities (V_s) for Suspended Particles (Specific Gravity = 2.65) in Water at Different Temperatures, as Calculated by Stokes' Law

Diameter (mm)	Settling Velocity in Centimetres per Second					Particle
	0°C	5°C	10°C	15°C	20°C	
0.01	0.005	0.006	0.007	0.008	0.009	Fine Silt
0.02	0.020	0.023	0.027	0.031	0.035	Medium Silt
0.03	0.044	0.052	0.060	0.069	0.078	
0.04	0.078	0.092	0.107	0.122	0.139	Coarse Silt
0.05	0.122	0.143	0.167	0.191	0.217	
0.06	0.176	0.207	0.240	0.275	0.313	
0.07	0.239	0.281	0.327	0.375	0.426	Very Fine Sand
0.08	0.312	0.367	0.427	0.490	0.556	
0.09	0.395	0.465	0.540	0.620	0.704	
0.11	0.488	0.574	0.667	0.765	0.869	
0.11	0.590	0.694	0.807	0.926	1.051	
0.12	0.703	0.826	0.960	1.101	1.251	
0.13	0.825	0.970	1.127	1.293	1.468	Fine Sand
0.14	0.956	1.125	1.307	1.499	1.703	
0.15	1.098	1.291	1.501	1.721	1.955	
0.16	1.249	1.469	1.707	1.958	2.224	
0.17	1.410	1.658	1.928	2.211	2.511	
0.18	1.581	1.859	2.161	2.478	2.815	
0.19	1.761	2.072	2.408	2.761	3.136	
0.20	1.952	2.295	2.668	3.060	3.475	
	32°F	41°F	50°F	59°F	68°F	

Source: Fifield, 2001

Commonly Used Conversion Factors

- 1.0 cm/sec. = 0.0328 ft/s or 0.3937 in/s
- 1.0 m = 3.281 ft or 39.37 in
- 1.0 in. = 2.54 cm = 254 mm
- 1.0 ha = 2.471 ac = 107,637 ft^2 = 10,000 m^2
- 1.0 m^3 = 35.3 ft^3
- °C = 5/9(°F - 32°)

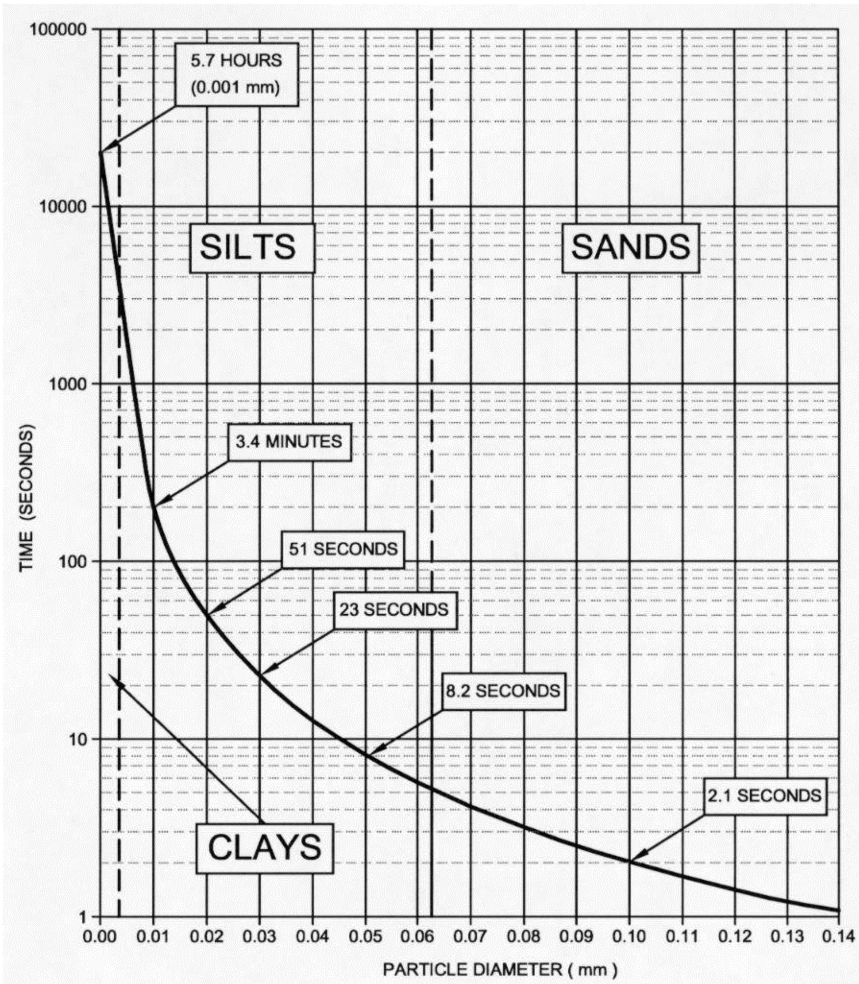


Figure G.2: Time for Suspended Particles to Fall 1 cm in Water at 0°C (Stokes Law)

Source: Fifield, 2001

From Figure G.2, the smaller diameter (D_s) soil particle (such as fine silt and clay) yields a very slow settling velocity (V_s), thus rendering a low efficiency system to settle very fine size clay particles.

The efficiency of a containment system is proportional to the settling velocity (V_s) and the particle size (D_s).

Outflow capacity (Q_o) of the containment system can be designed, based on free-draining properties of an outflow system which normally functions through a seepage or filter drainage outlet of the containment system. The outflow capacity is designed equal to or smaller than the inflow volume. It functions in a pond size configuration to provide sufficient flow path and containment time to effect sedimentation of a target size particle. During the time of containment, the target size particle will have sufficient detention time to settle to the bottom of the pond system. Generally, the outflow design of these systems is a free drainage granular berm, or a combination of perforated pipes, or a riser system functioning as filter/seepage structures and the size/configuration of the system will allow sufficient settling time for sediments to collect within the containment system. An example of the containment systems (Type I and II) is presented in Figures G.3d, G.3e and G.3f , as discussed below.

The general criteria for the selection and functioning of a containment pond system are presented in Section 12.2. The selection is dependent on the size of disturbed land, amount of runoff into the pond (Q_i) and target particle size (D_s) for settlement in order that an assessment of pond size/surface area (SA) can be estimated. The outflow capacity (Q_o) of the pond outlet is a function of structural and permeability design.

Generally, the runoff inflow (Q_i) is determined by a hydraulic or hydrotechnical professional or engineer. For the efficient settling operation of a pond, the inflow (Q_i) is equal to or less than the outflow (Q_o) to allow for sufficient settlement time for a low lateral flow passage within the pond chambers. Therefore, the rationale of settlement pond design assumes inflow (Q_i) equals outflow (Q_o).

$$Q_o=Q_i \qquad \text{(Equation G.3)}$$

Where:

Q_o = Outflow capacity of containment system

Q_i = Inflow

Outflow System

Two options of an outflow system: (1) Riser Outlet Option; (2) Permeable Rock Berm Outlet Option. They are discussed below:

Riser Outlet Option

A riser outlet is a circular overflow spillway that is connected to a culvert that passes through the containment berm. The riser pipe is fabricated from corrugated steel pipe conforming to CSA Standard CAN 5-G401-M81. The outlet pipe passing through the containment berm consists of a horizontal pipe welded to a 45° elbow (mitre joint) connecting to the riser pipe. The riser outlet system is equipped with a trash rack to minimize debris blockage.

100 mm diameter drainage holes are cut in the base of the riser pipe to form a perforated section near the elbow. A steel mesh is tack welded over it to form a screen. The portion of the riser pipe and elbow with the 100 mm diameter drainage holes and

mesh is to be backfilled with gravel. The size of the mesh covering the 100 mm diameter holes should be fine enough to filter granular material but coarse enough not to impede flow. Similar 100 mm diameter drainage holes can be provided along the riser pipe immediately above the elevation of the projected maximum sediment level.

The design of a riser pipe outlet can be completed by a hydrotechnical engineer to ensure the system has adequate capacity to discharge design flows without the risk of overtopping. Furthermore, a geotechnical engineer should design the culvert passing through the containment berm if the risk consequences of berm failure are significant.

Overflow Section System

An overflow section in the sediment containment system is not recommended as the primary means of discharging water due to concern of erosion of the containment berms. However, an overflow section is considered appropriate as an auxiliary outflow system for use in the event that the primary permeable rock outlet system (described in the following paragraph) should become blocked. Erosion protection at the outlet and on the berm slope is to be designed by an engineer. The overflow section is to be dimensioned at a minimum width of 1.5 m per 250 m^2 of pond area.

Permeable Rock Berm Outlet Option

One type of granular berm system is considered appropriate for use to allow seepage flow to exit from a sediment containment system. The following relationship (Jiang et al., 1998) can be used. The seepage outflow through drainage rock (25 mm to 100 mm diameters) in a gabion basket is modeled and can be applied to a granular berm outlet of a sedimentation pond/trap as illustrated in Figure G.3a and G.3b. The parameters and porosity of drainage rocks are shown in Figure G.3c.

$$Q_o = 0.327\, e^{1.5S} (g\, D_{50} / T)^{0.5}\, \rho W\, H^{1.5} \qquad \text{(Equation G.4)}$$

(Jiang et al, 1998)

Where:
- Q_o = Outflow capacity of containment system (m^3/s)
- g = Acceleration due to gravity = $9.8 m/s^2$
- D_{50} = Mean diameter of the rock (m)
- W = Total width of the barrier (m)
- ρ = Porosity of the rock barrier
- T = Thickness of the barrier (m)
- H = Hydraulic head (m)
- s = Slope of channel (%) (generally varies from 0% to 7% for highway gradeline profiles)

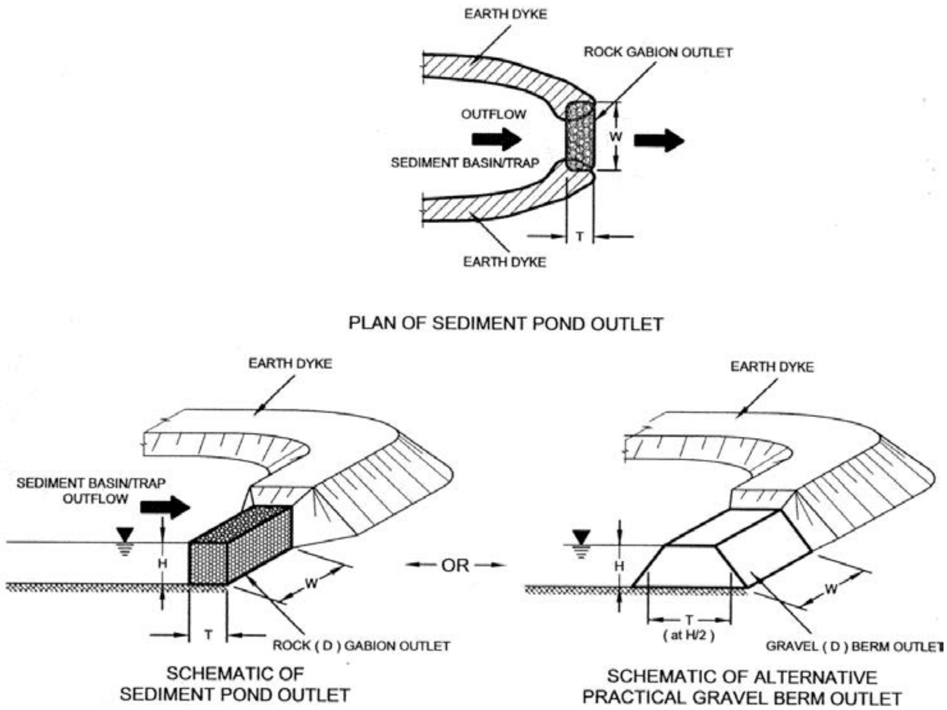


Figure G.3a: Model of Drainage Outlet of Sediment Pond

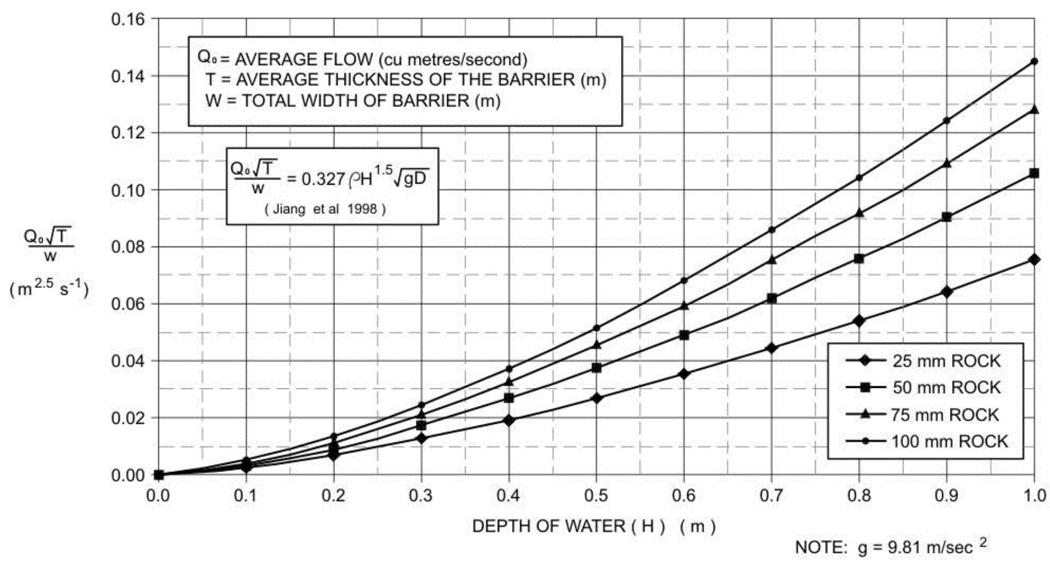


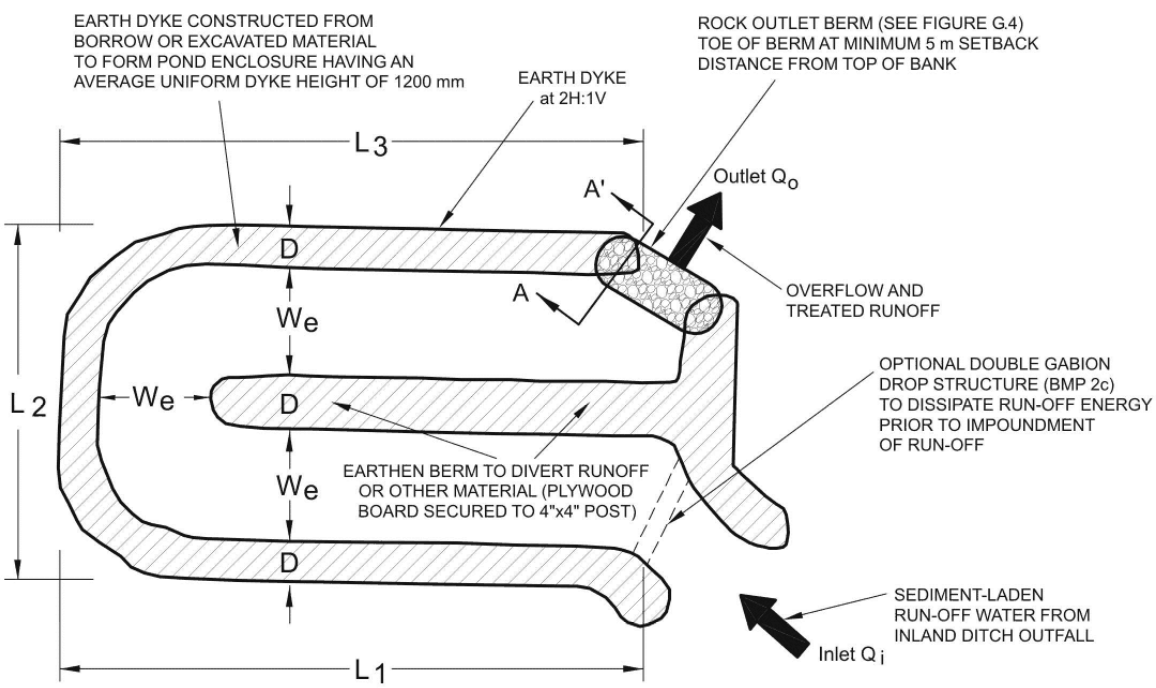
Figure G.3b: Flow (Q) Through an Outlet Barrier of Various Diameter (D) Rocks in Gabion Basket

Source: Fifield, 2001

Mean Diameter (D) (mm)	Rock Density (kg/m^3)	Bulk Density (kg/m^2)	Porosity of Rock Fill (ρ)
25	2648	1593	0.398
43 - 50	2675	1446	0.459
75 - 88	2657	1461	0.450
100	N/A	N/A	N/A

(Source: Jiang et al 1998)

Figure G.3c: Parameters and Porosity (ρ) of Rocks



NOTES:

1. CONTRIBUTING RUNOFF AREA CAN BE LARGER THAN 2.0 ha BUT LESS THAN 40.0 ha.
2. EFFECTIVENESS APPROPRIATE FOR REMOVING MEDIUM TO COARSE SILT PARTICLES SUSPENDED IN RUNOFF.
3. FLOW PATH L = L1+ L2+ L3; FLOW WIDTH We = 6 m MINIMUM
4. PROVIDE 1 TO 2 m (1 TO 2% GRADE) ELEVATION DROP BETWEEN INLET AND OUTLET GRADES.
5. SHAPE OF POND TO CONFORM TO LAND WITH OUTLET AT MINIMUM 5 m SETBACK FROM TOP OF BANK.
6. CONSTRUCTION TO ENSURE SWALES AND BAFFLES ARE TO CHANNEL WATER INTO THE PROPOSED SEDIMENT PONDS.

Figure G.3d: Type I Sedimentation Pond Containment Structure (Sediment Basin Plan)

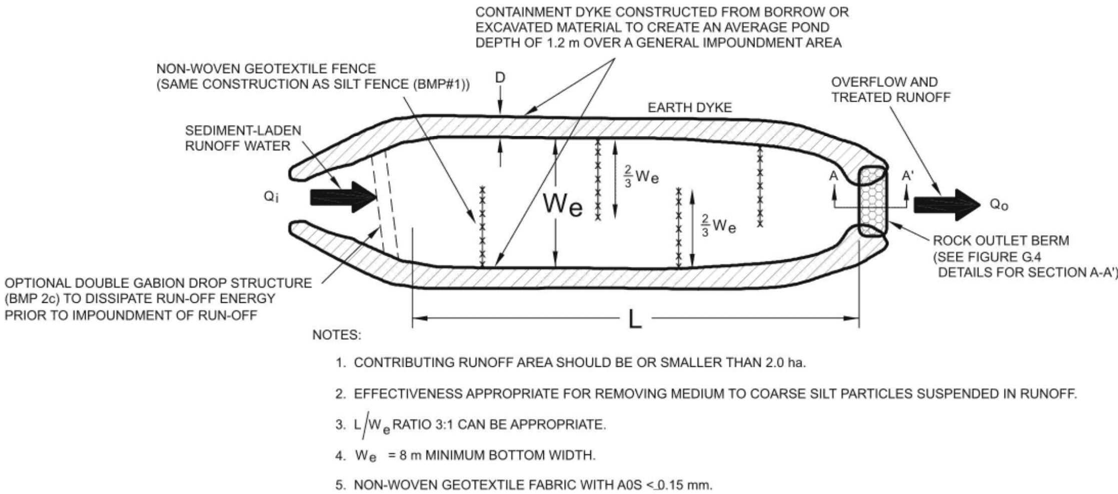


Figure G3.e: Type II Containment Structure (Sediment Trap Plan)

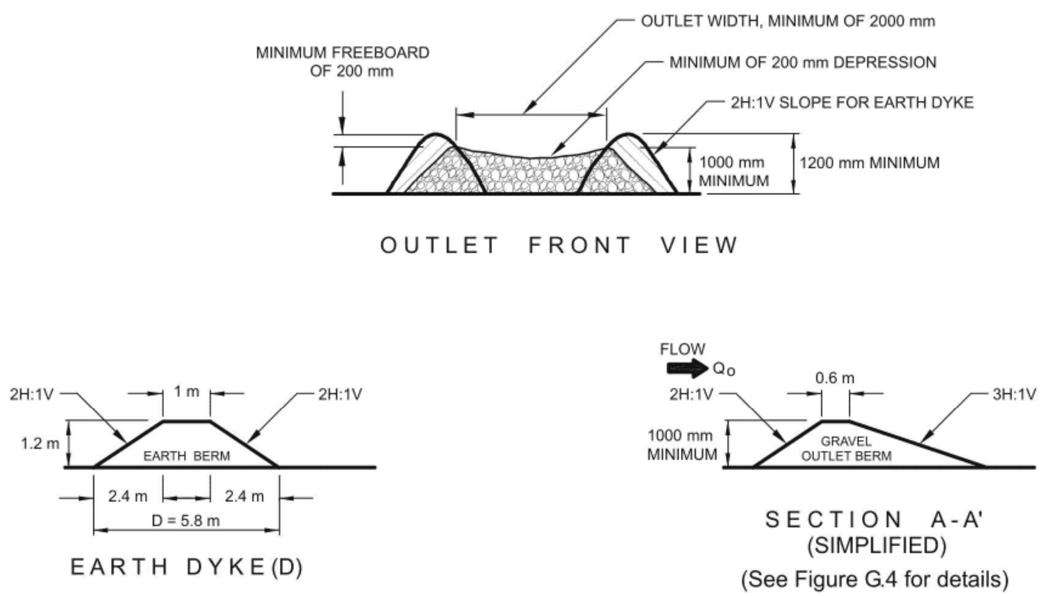


Figure G.3f: Simplified Sections of Dyke/Outlet

Source: Fifield, 2001

The outflow filter capacity of a rock barrier appears not sensitive to channel slopes varying from 0 to 6% (Jiang et al., 1998). The equation (Jiang et al., 1998) can be used for rock checks along channel with properly sized rocks for appropriate flow velocity (a nominal gradation can be: top size 250 mm, average size 150 mm, and bottom size 25 mm diameter) to provide stability to flow impact. A typical permeable outlet structure (with rock filter and perforated pipe) for sediment basin/trap is presented in Figure G.4 for practical highway constructions.

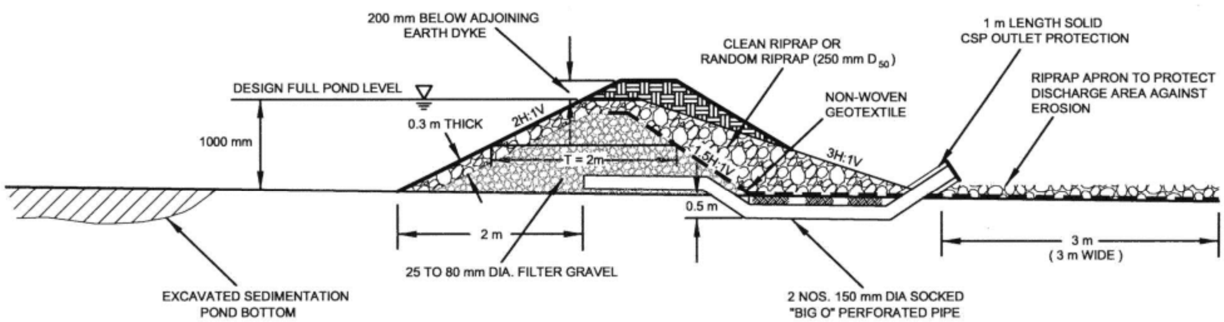


Figure G.4: Typical Sedimentation Basin/Trap Outlet Permeable Structure with Rock Filter Barrier and Perforated Pipe

Pond Area

The pond area (SA) size is based on the outflow capacity (Q_o) of the outlet structure (Figure G.3d and G.3e) and the settling velocity (V_S) of a target size particle. The outflow capacity (Q_o) is designed based on the runoff inflow quantity (Q_i) (Equation G.3).

$$SA = 1.2\, Q_o / V_s \qquad \text{(Equation G.5)}$$

Where:

- SA = Pond area (m^2)
- Q_o = Outflow capacity for an outflow structure (m^3/s)
- V_s = Settling velocity of a target particle size (m/s)
- 1.2 = 20% extra capacity allowed for pond size

Pond Configuration

The size and configuration of a containment system is designed to provide sufficient volume and flow path to allow the target soil particles within the sediment laden runoff to settle during the time of impoundment.

Pond configuration entails length (L) and width (We) can be evaluated from pond area (SA).

$$L = SA / We \qquad \text{(Equation G.6)}$$

Multiply both sides by L, $L^2 = (SA \times (L / We))$

$$L = (SA \times (L / We))^{0.5} \qquad \text{(Equation G.7)}$$

Where:

We = Width of Pond Chamber (m)

L = Length of Pond Chamber (m)

SA = Surface Area of Settling Pond (m^2)

L/We = 10 is recommended for 100% apparent efficiency (A_{eff}) to minimize short-circuiting and maximize settling area (Goldman 1986). However, the exact behaviour of L/We in determining 100% A_{eff} can be subjective. The limitation of space does not normally allow a large size pond to be constructed to an L/We ratio of 10. The following pragmatic L/We ratios can be considered appropriate for the following structures:

Containment Structure	**L/We**
Sediment Basin (Type I)	8
Sediment Trap (Type II)	3

Pond Efficiency

The net efficiency (N_{eff}) of the containment system can be assessed based on model suggested by Fifield (Fifield 2001) utilizing the following concepts.

A_{eff} (%): Apparent Efficiency

PEG (%): Particle Size Equal to and Greater than a target size soil particle of a substrate soil (Reverse presentation of hydrometer gradation curve)

A_{eff} is modeled on pond dimensions (Fifield 2001) and the L/We ratios are postulated (Goldman, 1986). The dimensions of a pond to be designed are compared to dimensions of a model pond where 100% A_{eff} can be achieved for a target soil particle size.

PEG is a form of presentation of the gradation curve (hydrometer results of the fines portion) of an erodible substrate soil showing the percentage of coarser particles (Figure G.5) in the runoff that can be settled out in comparison to a target size soil particle (e.g., medium silt of 0.04 mm diameter). The soil tested for sedimentation PEG is usually taken from erodible soil sources of cutslope or borrow material used as fills on highway projects.

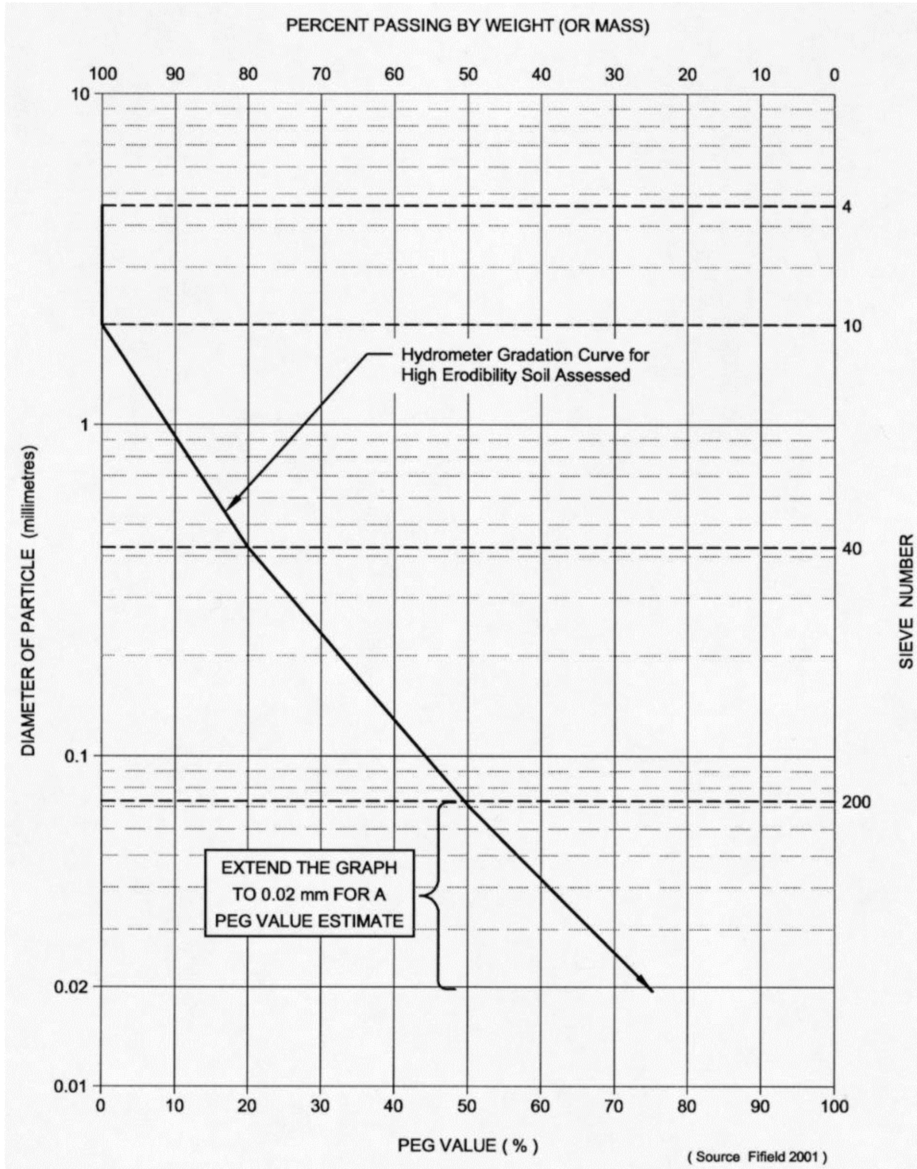


Figure G.5: Hydrometer (Particle Size) Gradation Curve to Determine PEG

Source: Fifield, 2001

Apparent Efficiency (A_{eff}) is modeled from the ratio of a 2-dimensional (length and height of flow area) design pond (A_c) to a model pond (A_{tc}) with an idealized design outfall capacity. A proportionality factor (K) of 0 to 1 is proposed for the ratio of realistic pond area of sediment capture to the model pond area (A_{tc}) of sediment capture. Within the containment pond, the flow path (L) is sized utilizing a lateral flow velocity (V_a) and a vertical settling velocity (V_s) of a target size soil particle allowing sufficient time for the particle to settle within the containment system (Fifield 2001). An illustration of the Apparent Efficiency (A_{eff}) model is presented in Figure G.6. The vertical distance of settlement is suggested by some investigators at 0.67 m for minimum height for a pond dyke. However, for design purposes with a factor of safety of 1.8, it is prudent to use 1.2 m for pond dyke to provide an extra freeboard of 0.2 m above the outlet permeable berm.

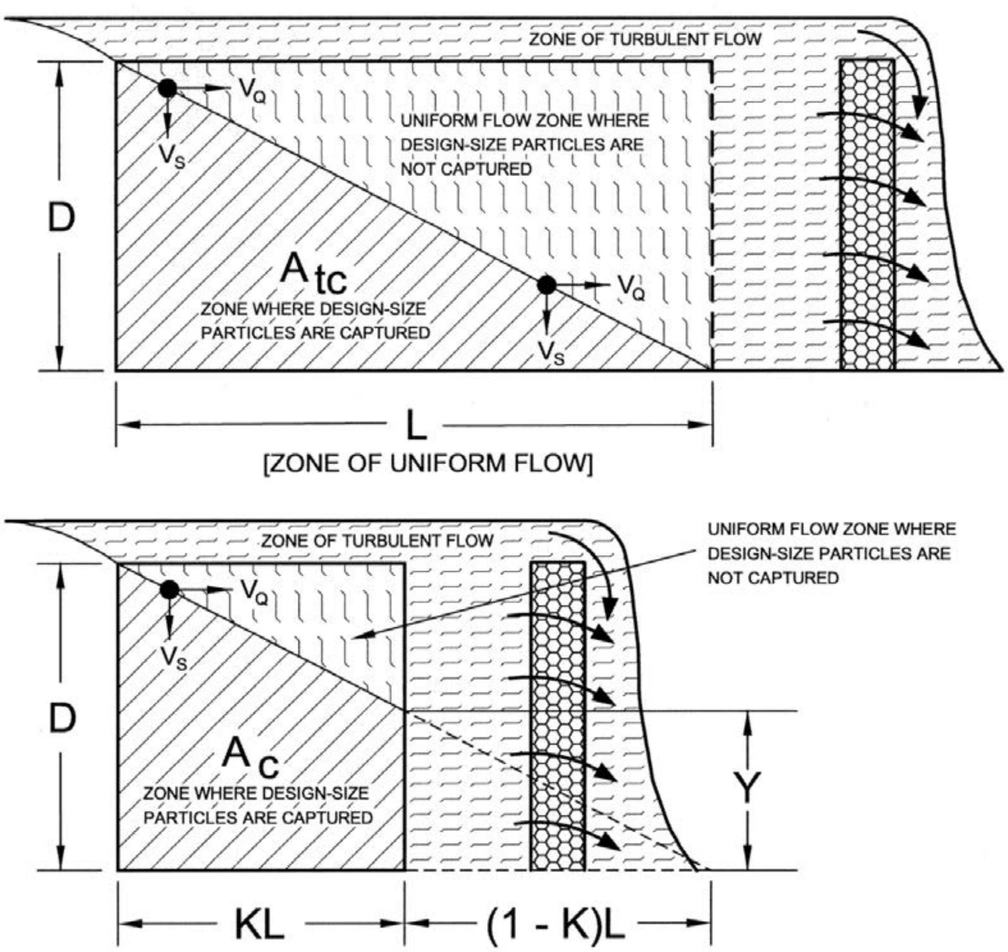


Figure G.6: Concept of Sedimentation Apparent Efficiency (A_{eff}) for Suspended Particles in Zones of Uniform and Turbulent Flows at Permeable Berm of a Containment System Outlet

Source: Fifield, 2001

$$A_{eff} = (A_c / A_{tc}) \times 100 \quad \text{(Equation G.8)}$$

$$A_{eff} = (2K - K^2) \quad \text{(Equation G.9)}$$

$$K = 0.1 (L / We) \quad \text{(Equation G.10)}$$

$$N_{eff} = A_{eff} \times PEG \quad \text{(Equation G.11)}$$

Where: D = particle fall distance

A_{eff} = Apparent Efficiency (%)

K = A factor of 0.1 to 1, based on L/We ratio of 0 to 10 (10 is 100% A_{eff})

N_{eff} = Net Efficiency (%)

PEG = % of Particles Equal to and Greater than a target size particle determined from hydrometer gradation curve (see Figure G.5)

L = Length of a containment (chamber) system

We = Width of a containment (chamber) system

= 8 m bottom width is considered appropriate for highway construction application

Incorporating the above relationship, the $\mathbf{A_{eff}}$ can be estimated from the following curve (Figure G.7).

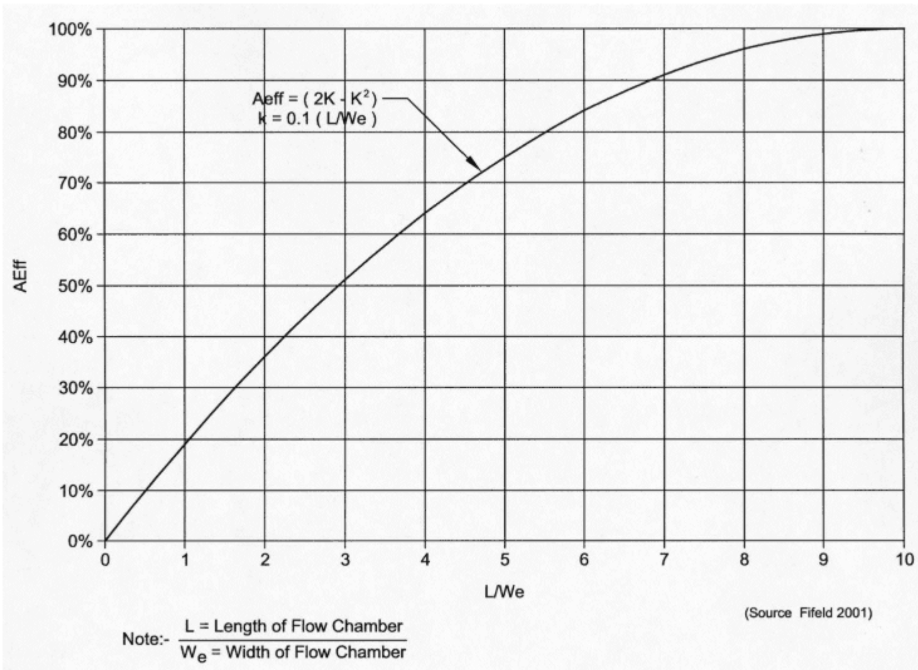


Figure G.7: Apparent Effectiveness ($\mathbf{A_{eff}}$) of a Sediment Containment System

Source: Fifield, 2001

Design Example

A simple design example is presented in Appendix H as H.16.

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APPENDIX H

DESIGN EXAMPLES

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H.I Introduction

In this section, 17 design examples are included to illustrate the successive stages involved in the design of erosion measures required in a grading project.

The different phases of erosion control calculations and design, and the corresponding examples, are shown in the following table.

Description		**Example**
Erosion Potential	Single Slope	H.1, H.6
	Irregular (bench) Slope	H.4, H.5
	Low Embankment Slope	H.7
	Variation with Soil Types	H.3a, H.3b
	For Varying Site Hazards	H.2
Channel Protection	Vegetative Lining	H.8
	RECP Mat (soil covering) Lining	H.9
	Gravel Lining	H.10
	Riprap Lining	H.11
	Concrete Lining	H.12
	Gabion Mat Lining	H.13
Flow Depth Estimation		H.14
Sediment Barriers – Storage Capacity		H.15
Sediment Basin/Trap		H.16

Example H.1 (Erosion – Single Slope)

A highway construction site just north of the city of Edmonton requires the excavation of a large uniform cut-slope approximately 30m in length at a 3H:1V slope (roughly 33%). Excavation and grading of the slope is to occur through the spring and summer (May through August) and the site will be highly disturbed during the course of the construction period. Top soil placement and seeding is scheduled to take place at the end of August.

The exposed soils are expected to be normally consolidated and consist of silty clay. Supporting field investigation information for the soil indicates the following:

Agriculture Soil Data	Geotechnical Soil Data
Classification: CL	Classification CL-ML
50% Silt and Very Fine Sand	Plasticity Index (PI) = 15
10% Sand >0.1 mm	Plastic Limit (PL) = 27
0% Organic Matter Content	Moisture Content = 26%

Using the RUSLE, determine the Site Erosion Potential for this particular construction site.

1. Determine the appropriate Rainfall Factor (R_t) for the Construction Area.

   From the Isoerodent Map (Figure B-1) the R-factor for the Edmonton area is 350 (MJ mm ha^{-1} year^{-1}) and the corresponding winter adjustment value (Figure B-3) R_s is 20 (MJ mm ha^{-1} year^{-1}). The total rainfall factor R_t is therefore 370 (MJ mm ha^{-1} year^{-1}).

2. Determine the Monthly Distribution of the Rainfall Factor (R_t).

   The monthly distributions are summed for the period of anticipated construction that the soil is expected to be exposed (e.g., without top soil/vegetation). In this example, top soiling and seeding is scheduled to occur at the end of August.

   The summed monthly distributions are expressed as a percentage of the total annual value.

   From the supporting information (Table B-1 and Figure B-4) shown in Appendix B. The monthly distribution (Figure B-4) of the Rainfall factor for the Edmonton area over the construction months is as follows: May (10%), June (20%), July (25%) and August (15%). Therefore, R_t for this particular site over the period of construction noted is equal to 240 (MJ mm ha^{-1} year^{-1}), which is about 70% of the total annual value.

3. Determine the Slope Factor (LS).

   The slope factor table, which supports the equation for a uniform slope is shown on Table B-3.

   For an average slope length of 30 m with a slope gradient of 33% a corresponding slope factor of approximately 5.4 is interpolated.

   Applying the suggested Topographic Adjustment factor ($Ø_{LS}$) of 0.8 (see Section 6.2.3.2) results in an adjusted LS of 4.3.

4. Determine the Soil Erodibility Factor (K) for the Soil to be exposed during Construction.

   From Figures B-6 and Figure B-7, Clay Loam has a corresponding Structure Code of 4 and a Permeability Code of 4.

   Using the Soil Erodibility Nomograph in Figure B-5 for the given soil structure, permeability and composition, the exposed soil is estimated to have an Erodibility Factor (K) of 0.047.

   Applying the suggested Soil Erodibility Adjustment factor ($Ø_K$) of 0.8 (see Section 6.2.2.2) results in an adjusted K of 0.038.

5. Determine Management (C) and Support Practice (P) Factors.

   This slope is expected to produce a highly disturbed surface that is relatively compacted and smooth from the excavation and grading process. Furthermore no treatments are being applied to the slope, therefore the C Factor (Table B-6) and P Factor (Table B-7), for this site follow that for a bare soil (packed and smooth) and are both equal to 1.0.

   It should be noted that some immediate reduction (from 1.0 to 0.9) can be made to the Support Practice (P) Factor if the slope is roughened during the excavation grading process. Roughening of the slopes is considered a Minimum Measure for all slopes.

6. Calculate the Soil Erosion Potential (Soil Loss) for this Construction Site.

   A summary of the RUSLE parameters is as follows:

   Rt = 240 (MJ mm ha^{-1} $year^{-1}$) (adjusted for construction season 0.70 of annual)

   K = 0.038 (adjusted by $Ø_K$ = 0.8) (MJ mm ha^{-1} $hour^{-1}$)

   LS = 4.3 (adjusted by $Ø_{LS}$ = 0.8)

   C = 1.0

   P = 0.9 (with slopes roughened)

   Using RUSLE: **Estimated Soil Loss (A) = R x K x LS x C x P**

   Soil Loss (A) = 35.3 (tonnes ha-1 year -1)

   This value represents the estimated soil loss from this site over the period of construction prior to placement of top soil and seeding.

Example H.2 (Erosion Potential and Site Hazard)

1. Determine the Site Erosion Hazard Classification for the soil loss evaluated in Example H.1 where Soil Loss (A) = 29.7 tonne ha^{-1} $year^{-1}$.

Based on the estimated site erosion potential for the period of construction noted, and the general hazard classes shown in Table 6.1, a HIGH site hazard class is indicated for this particular slope.

RUSLE Erosion Hazard Classification		Site Hazard Evaluation	
Soil Erosion Potential (A) (tonnes/ha/yr)	**Site Hazard Class (RUSLE)**	**Soil Loss (tonne/ha/yr)**	**Hazard Class**
<6	Very Low		
6-11	Low		
11-22	Moderate		
22-33	High		
>33	Very High	35.3	Very High

Example H.3a (Variations of Erosion Potential for Soil Types using RUSLE (Section 6.2)

Various Soil Types:

Using the average K values (from Table B-2, Appendix B) for various soil textures and multiply by $Ø_R$, similar evaluation are assessed for varying soils for the similar site condition in Example H.1. The following table provides a summary of various soils types for the same construction site to show the sensitivity of site erosion potential classification to various types of soil.

Table Comparing Various Soils and Erosion Potential (Edmonton Area)

Soil Type	Average Erodibility Factor (K) x $Ø_K$	Soil Loss Potential (A)	Site Erosion Potential
Very Fine Sand	0.057 x 1.0 = 0.057	52.9	Very High
Silt Loam	0.050 x 0.8 = 0.040	37.1	Very High
Clay Loam	0.040 x 0.8 = 0.032	29.7	High
Clay	0.03 x 0.8 = 0.024	22.3	Moderate to High
Sandy Loam	0.017 x 0.8 = 0.014	13.0	Moderate
Heavy Clay	0.02 x 0.8 = 0.016	14.9	Moderate
Coarse Sandy Loam	0.009 x 0.8 = 0.007	6.5	Low to Very Low
Sand	0.001 x 1.0 = 0.001	0.9	Very Low

Note: Soil Loss Potential (A) in tonnes/ha/year

Note that for the same soil type (e.g., Clay Loam to Sandy Clay Loam) two different erodibility factors and subsequently site erosion potentials are calculated. This demonstrates the sensitivity of the soil class and the importance of determining the proper soil classification based on all available information such as geotechnical assessments and lab testing. It is noted that for sand material, no modifications to Erodibility is applied (i.e., $Ø_R$=1). The use of typical values for determining the soil erodibility factor (K) is only recommended when specific soil information is unavailable or cannot be obtained.

Example H.3b (Variation of Erosion Potential for Sample Alberta Soils – Preliminary Estimate using USCS Chart (Figure 4.3) and Common Soil Testing Data for Highway Construction)

In this example, typical highway soil testing (grading design only) are presented to show that a preliminary measurement of soil erodibility potential can be assessed from plasticity and gradation data. Only a portion of Alberta areas is presented for illustration.

Soil type variations across Alberta are a function of a geological deposition process and geomorphology at the locations of highway construction. Soil investigation surveys for grading construction generally provide the following general and additional soil information for highway designs:

A) General Information	1.	Plasticity Index (PI)
	2.	Soil Classification (USCS)
	3.	Field Moisture (M.C.) (%)
	4.	Estimated Optimum Moisture (OMC) (%)
	5.	Estimated Proctor Density (kg/m^3)
B) Additional Information (if required)	1.	Gradation – coarse granular soil
	2.	Hydrometer gradation – fine grained and/or cohesive soil

The preliminary assessment of soil erodibility (by USCS chart approach) is presented in Appendix A for soil data obtained for some Alberta sites.

Example H.4 (Erosion Potential of Irregular (benched) Slope)

The effect of slope shape with multiple slope segments in reducing erosion potential is demonstrated in the following example:

- A long slope with narrow benches at the top and in the middle of the excavation is to be constructed at the same site as defined in the above example (i.e., similar soil and location). The total length of the slope is roughly 70 m and is divided into 4 segments with the following geometry.

Slope Description Summary

Slope Segment *	Slope Length	Slope Gradient
1 – Top Bench *	5.5 m	2%
2 – Mid-Slope	30 m	33% (3:1)
3 – Mid-Bench	3 m	2%
4 – Base Slope	30 m	33% (3:1)

Note * The effect and inclusion of the top bench (Slope Segment #1) as one slope segment can provide an under-estimate of slope erosion potential; therefore the top slope segment is ignored and only 3 segments of slope are considered (#2, 3 and 4).

For each of the three effective slope segments, the slope factor (LS), slope length exponent (m) and appropriate soil loss factor (SLF) needs to be determined. These values can be easily taken from the supporting tables provided in Appendix B. Once a value for each segment has been derived, the actual slope factor (LS) for the separate segments can be determined as shown in the following summary:

Summary of Slope Factors for Slope with 3 Segments of Benched Slope

Slope Segment #	Slope Factor (LS) Table B-3	Slope Length Exponent (m) Table B-4	Soil Loss Factor (SLF) Table B-5	Segment LS (LS x SLF)
1 – Top Bench (N/A)	0.2	0.24	0.71	0.14 (N/A)
2 – Mid-Slope	4.3	0.66	0.87	3.74
3 – Mid-Bench	0.2	0.24	1.11	0.22
4 – Base Slope	4.3	0.66	1.50	6.45
				∑ Segments (LS) = 10.41
				Benched Slope Average LS = 10.41/3 = 3.5

Once the Slope Factor (LS) has been determined for each of the slope segments, the total LS for the slope is determined by summing the LS Segments (10.41) and dividing it by the number of effective slope segments (3). For this particular benched slope, the averaged LS is about 3.5. In comparison with a base slope of half height (Slope Segment #4, base slope with Segment LS = 6.45), the erosion potential (LS = 3.5) of a benched slope of twice the height is approximately 54% (i.e., LS ratio @ 3.5/6.45). In comparison with the mid-slope (Segment #2) with half height at LS = 3.74, the ratio of erosion potential of the benched slope of twice the height is approximately 93% (i.e., LS ratio @ 3.5/3.74).

This example shows the benefit of irregular slope configurations with intermediate benching can effectively reduce the erosion potential close to the equivalent of a single slope at the top half of the bench slope. It also shows that the lower portion of a benched high slope have higher erosion potential (LS = 6.45) compared with the top portion of the benched high slope (LS = 3.74).

Example H.5 (Erosion Potential of Benched Slope)

It is proposed to reduce the soil erosion on a 15 m high simple 3:1 slope by providing a 3 m wide berm at midslope (Fig. H.5). Estimate the percentage reduction in sediment yield for:

- single slope vs. benched slope
- single slope (15 m height) vs. single slope (7.5 m height)

Is benching of slope more advantageous to reducing slope height?

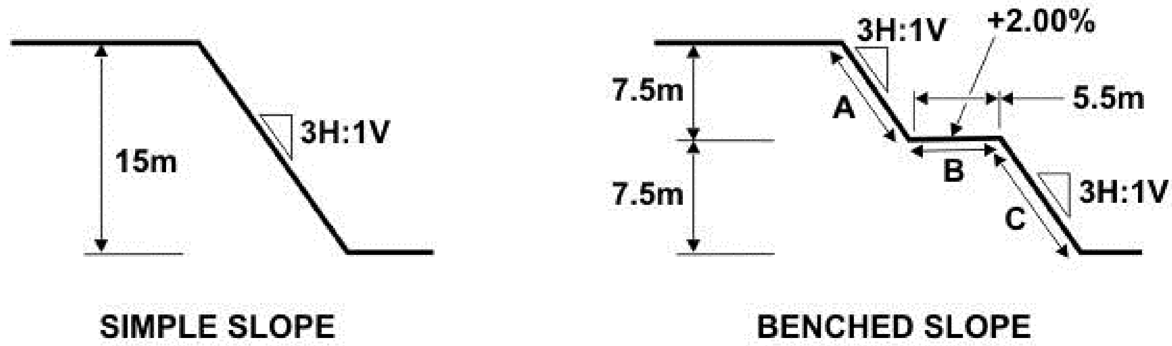


Figure (Example H.5): Cross-section with and without a bench

Step 1: Topographic Soil Loss Factor (LS) from un-benched simple slope

Length along the slope face, L = 15 x 3.2 = 48 m

For L = 48 m and slope = 33.33%, LS = 7 (from Table B-3, Appendix B)

Step 2: Topographic Soil Loss Factor (LS) from benched slope

Slope Segment	Vertical Height (m)	Inclined Length Along Slope (m)	Slope (%)	LS Factor (Table B-3 App. A)	m Factor (Table B-4 App. A) Moderate	SLF (Table B-5 App. A)	LS x SLF
A	7.5	23.7	33.3	4.7	0.66	0.5	2.35
B	0.0	3.0	2	0.18	0.24	1.02	0.18
C	7.5	23.7	33.3	4.7	0.66	1.46	6.86
							∑ = 9.39

$$Bench\ Slope = \frac{9.39}{3} = 3.1$$

Step 3:

Compare two cases:

a) Single slope vs. benched slope

Percentage soil loss from benched slope = LS bench slope/LS single slope = 3.1/7 = 53%

LS percentage reduction = (100% - 53%) = 47% reduction of soil loss (slope design component)

b) Single slope (15 m high) vs. single slope (7.5 m high)

Percentage soil loss from low height single slope = LS lower slope/LS high single slope = 4.7/7 = 67%

LS percentage reduction = (100% - 67%) = 33% of soil loss (slope design component) reduction.

Step 4:

In comparison with a single long slope (3H:1V), the benching of slope (full 15 m height) yields a 47% reduction in sediment yield; whereas the reduction of slope height (to 1/2 height at 7.5 m) only yields a 33% reduction in sediment yield. The benching of slope is more effective in reducing the percent erosion and sediment yield in comparison with reducing slope height.

Example H.6 (Erosion Potential of a Low Cutslope – Seasonal)

A simple 3:1 backslope in Grande Prairie is to be constructed in a medium plastic (CI) clay having the grain size distribution given. If the configuration of the slope is as shown in Figure (Example H.6), estimate the mean annual soil loss. What would the soil loss during the construction season from July to October?

Grain size distribution:

Fraction	Percentage
Sand (2 - 0.1 mm)	7
Very fine sand (0.1 - 0.05 mm)	10
Silt (0.05 - 0.002 mm)	49
Clay (< 0.002 mm)	34

Organic Content = 0%
Sand Structure = Blocky Platy Massive
Permeability = Slow

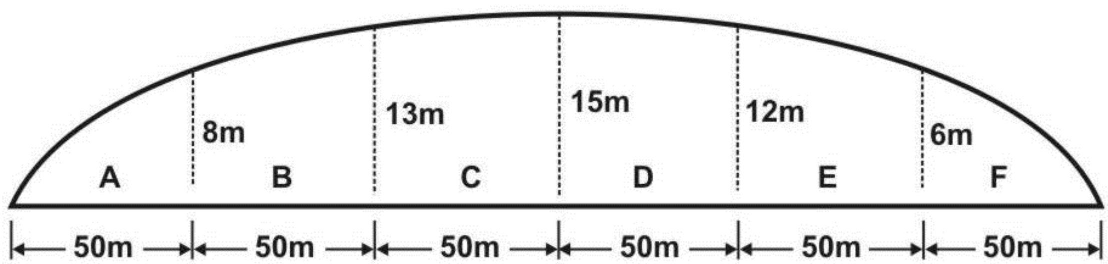


Figure (Example H.6): Elevation of Slope

Solution:

Soil loss = R.K.LS.C.P (from Equation 6.1)
R = 385 (from Figures B-1, Appendix B)
K = 0.032 (clay from Table B-2, Appendix B)
$Ø_K$ = 0.8 (highway modification factor suggested for K)
$K_{highway}$ = 0.8 x 0.032 = 0.026
CP = 1.0 (from Tables B-6a and B-7)
LS = variable with each slope segment = $LS_{average}$ = 4.8
$Ø_{LS}$ = 0.8 (highway modification factor suggested for LS)
$LS_{highway}$ = 0.8 x 4.8 = 3.8
Area = Length x average slope length = 50 m x (4+10.5x14+13.5+9+3)m
= 50 m x 54 m = 2700 m² = 0.27 Ha

Slope Segment	Mean length along the slope face (m)	Slope (%)	LS factor (Fig. 6.4)
A	12.6	33.3	2.6
B	33.2	33.3	6
C	44.3	33.3	6.5
D	42.7	33.3	6.5
E	28.5	33.3	5.0
F	9.5	33.3	2.6
Average:	28.5	33.3	4.8

Note: 1 Ha = 100 m x 100 m = 10,000 m²

Mean annual soil loss = R.K.CP.LS.Area (K = $K_{highway}$; LS = $LS_{highway)}$

= 385 x 0.026 x 1.0 x 3.8 x 0.27 Ha

= 10.3 tonnes/yr

Referring to Figure B-3, Appendix B (monthly rainfall distribution) for Grande Prairie.

Total percentage of soil loss from July to October = 14 + 18 + 10 + 5 = 47%.

Hence, expected soil loss from July to October = 0.47 x 10.5 = 4.8 tonnes.

Example H.7 (Erosion Potential of a Low Fill Embankment)

A soil classified as a low plastic silt (ML) according to the Unified Soil Classification System is used to construct a secondary highway embankment construction (Example H.7). Estimate the mean annual soil loss from typical low fill (1m @ 4H:1V) embankment in the Edmonton area and the grain size distribution is as given below:

Fraction	Percentage
Sand (2.0 – 0.10 mm)	22%
Very fine sand (0.10 – 0.05 mm)	5%
Silt (0.05 – 0.002 mm)	54%
Clay (<0.002 mm)	19%
Organic	0%

- To Find Soil Erodibility k = 0.064

  Use of Erodibility Nomograph (Figure B-5, Appendix B)

  % Sand + % Silt = 59%

  % Sand = 22%

  % Organic = 0%

  Soil Structure = blocky, platy, massive (4)

  Permeability = Slow to Moderate (4)

- To Find Soil Erodibility Rating (use Figure 4.2, Section 4.4.3)

  USCS Soil: ML – Erodibility Rating = High

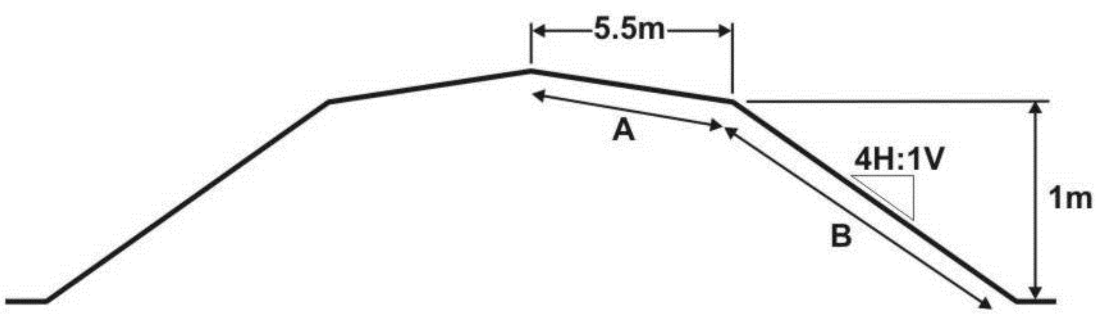


Figure (Example H.7): Secondary Highway Embankment Cross-Section

Solution:

Soil loss/hectare (A) = R K LS CP (from Equation 6.1)

R = 350 (from Figures B-1 and B-2, Appendix B)

K = 0.064 for the given soil information (Figure B-4, Appendix B)

CP = 1.0 (from Tables B-6a and B-7, Appendix B)

Equivalent LS value calculations (for half of the road cross-section):

Slope Segment	Vertical Height (m)	Inclined length Along Slope Face (m)	Slope (%)	LS factor (Table B-3) (Appendix B)	Remarks
A	0.0	5.5	2	0.12 (N/A)	Treated as simple slope, neglect the top segment.
B	1.0	4.12	25	1.77	This LS value is for a simple slope.

Hence, Soil Loss = R.K.LS.CP

= 370 x 0.064 x 1.77 x 1.0 = 41.9 tonnes/ha/yr (agriculture soil loss)

Therefore, Soil Erosion Potential (41.9 tonne/ha/yr) is very high (Table 6.1) in agriculture practice.

Hence, for highway construction, apply suggested highway modification factor ($Ø_K$ and $Ø_{LS}$) for K and LS:

$Ø_k$ = 0.8 to K

$Ø_{LS}$ = 0.8 to LS

Soil Loss (highway) = 41.9 t/ha/yr x 0.8 x 0.8 = 26.9 tonne/ha/yr ↔ High Erosion Hazard

Therefore, Soil Erosion Potential (26.9 tonne/ha/yr) is high (Table 6.1) in the highway construction practice. Erosion control measures such as scheduling can be adopted to effect completion of short sections of roadway in a few months followed by speedy topsoiling and seeding. This will reduce the soil erodibility for the whole year (370 tonne/ha/year) to part of a year (240 tonne/ha/year) as shown in Example H.1. Thus, with speedy construction scheduling, it will reduce the Soil Erosion Potential to Moderate for 17.4 tonne/ha/half year period (i.e., 240/370 of 26.9 tonne/year).

Example H.8 (Channel Protection – Vegetation Lining)

A roadside ditch having the geometric properties listed below is required to discharge 1 in 10 year storm estimated at 0.1 m^3/s (Figure Example H.8). Determine whether unmowed, full grown Kentucky Bluegrass having a height of 250 mm will be adequate as a ditch lining.

Bed width = 3.5 m   Sideslope = 4:1

Backslope = 3.1   Ditch grade = 5% = 0.05

Solution:

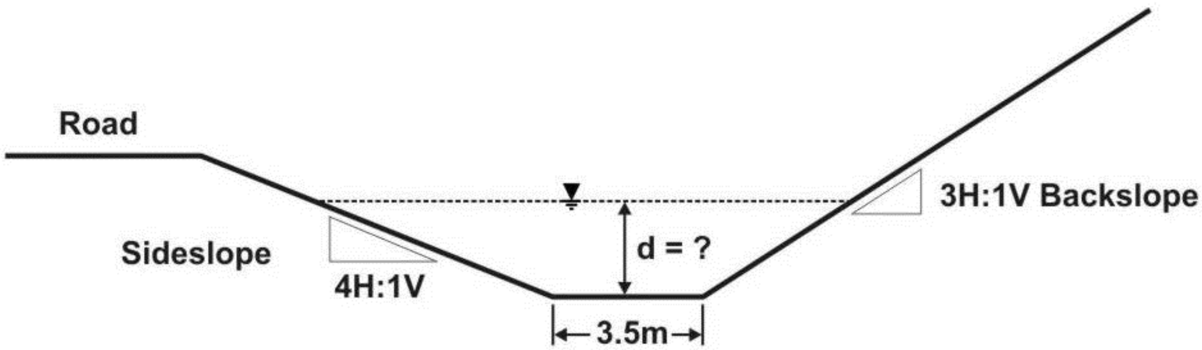


Figure (Example H.8): Typical Cross-Section

Step 1: Find the classification for the grass.

From Table F.3(a), vegetative retardance class could be either upper end of Retardance C or lower end of B; assume Retardance C.

Step 2: Estimate the depth of flow.

Trial 1:

Assume flow depth, d = 0.075 m

Top width of flow = 3.5 + 4 x 0.075 + 3 x 0.075 = 4.025 m

Cross-sectional area, A = 0.5 x 0.075 (3.5 + 4.025) = 0.282 m^2

Wetted perimeter, P = 3.5 + 0.075 (3.162 + 4.123) = 4.046 m

Hydraulic radius, R = A/P = 0.282/4.045 = 0.0697 m

From Figure F.4, for R = 0.228 ft, slope = 0.05, Manning's n = 0.28 (for Vegetation C)

Discharge, Q $= (1/n)\ A\ R^{2/3}\ s^{1/2}$ (from Equation F.3)

$= (1/0.28)\ (0.282)\ (0.0697^{2/3})\ (0.05^{1/2})$

$= 0.038\ m^3/s < 0.100\ m^3/s$, required

Hence, increase assumed flow depth.

Trial 2:

Revised flow depth, d = 0.10 m

Top width flow area = 3.5 + 4 x 0.1 + 3 x 0.1 = 4.2 m

Cross-sectional area, A = 0.5 x 0.1 x (3.5 + 4.2) = 0.385 m^2

Wetted perimeter, P = 3.5 +0.1 (3.162 + 4.123) = 4.228 m

Hydraulic radius, R = A/P = 0.385/4.228 = 0.091 m = 0.298 ft

From Figure F.4, for Vegetation Class C, R = 0.298 ft, slope = 0.05, Manning's n = 0.18

Discharge, Q = (1/n) A $R^{2/3}$ $s^{1/2}$ (from Equation F.3)

= (1/0.18) (0.385) ($0.091^{2/3}$) ($0.05^{1/2}$)

= 0.096 m^3/s < 0.100 m^3/s, required

The estimated discharge and the required discharge are very close and a flow depth of 0.1 m is o.k.

Step 3: Check the shear resistance of the grass lining.

Tractive shear stress of flow, $\tau_p = \rho$ d s (from Equation F.5)

= 9.81 x 0.100 x 0.05

= 0.049 kPa

(since, s = slope of channel = 0.05

d = depth of flow = 0.100m

δ_w = unit weight of water = 9.81 KN/m^3)

Shear resistance of Vegetation Class C = 0.048 kPa (from Table F.3(c))

Hence, the Kentucky Bluegrass lining is considered adequate.

Example H.9 (Channel Protection – Mat (soil covering) Lining)

Design a temporary ditch lining for the channel conditions in Example H.8. Assume the exposed natural ground in the ditch is incapable of resisting soil erosion in the ditch (Figure Example H.9).

Channel geometry: Sideslope = 4:1 Backslope = 3:1

Bed width = 3.5 m Ditch grade = 5% = 0.05

Discharge = 0.100 m^3/s

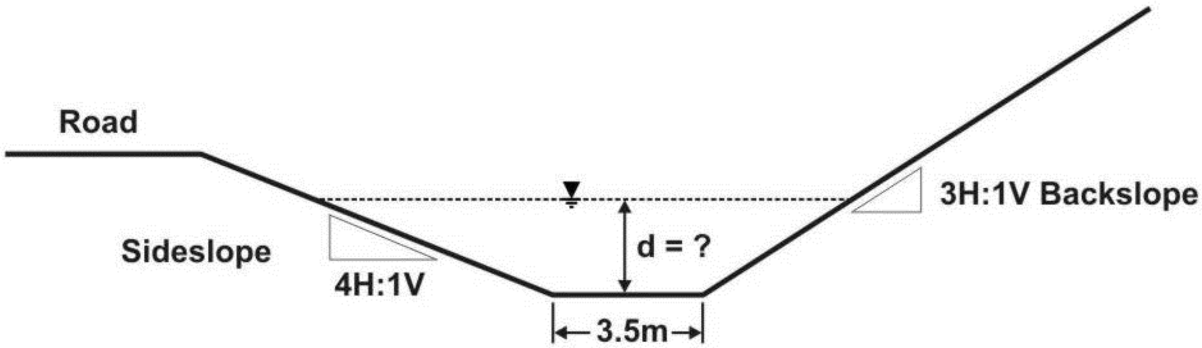


Figure (Example H.9): Typical Cross-Section

Solution:

Assuming use of a straw or wood excelsior mat

Manning's n = 0.065 (from Table F.2)

Step 1: Estimate the depth of flow.

Trial 1:

Assume depth of flow = 0.075 m

Top width of the flow = 3.5 + 4 x 0.075 + 3 x 0.075 = 4.025 m

Cross-sectional area, A = 0.5 x 0.075 x (3.5 + 4.025) = 0.282 m^2

Wetted perimeter, P = 3.5 + 0.075 (3.162 + 4.123) = 4.045 m

Hydraulic radius, R = A/P = 0.282/4.045 = 0.0697 m

Discharge, Q $= (1/n)\ A\ R^{2/3}\ s^{1/2}$ (Equation F.3)

$= (1/0.065)\ (0.282)\ (0.0697^{2/3})\ (0.05^{1/2})$

$= 0.161\ m^3/s > 0.100\ m^3/s$

Hence, revise the depth of flow to a lower value, say, d = 0.060 m

Trial 2:

Top width of the flow = 3.5 + 4 x 0.060 + 3 x 0.060 = 3.92 m

Cross-sectional area, A = 0.5 x 0.060 (3.5 + 3.92) = 0.222 m^2

Wetted perimeter, P = 3.5 + 0.060 (3.162 + 4.123) = 3.93 m

Hydraulic radius, R = A/P = 0.222/3.93 = 0.0564 m

Discharge, Q $= (1/n)\ A\ R^{2/3}\ s^{1/2}$

$= (1/0.066)\ (0.222)\ (0.0564^{2/3})\ (0.05^{1/2})$

= 0.112 m^3/s > 0.100 m^3/s

Hence, the depth of flow is close to 0.060 m, may be like 0.058 m.

Step 2: Check the shear resistance of the erosion control mat.

Tractive shear stress of flow, $\tau_p = \delta\ d\ s$ (Equation F.5)

= 9.81 x 0.060 x 0.05

= 0.029 kPa = 29 Pa

Permissible shear stress of manufactured mat (such as Excelsior mat) = 74 Pa (from Table F.3(c)).

Hence, curled wood mat (Excelsior mat) is more than adequate as a temporary ditch lining.

Example H.10 (Channel Protection – Gravel Lining)

A roadside ditch, similar in cross-section in Example H.9, is required to carry a 1 in 10 year storm discharge of 0.15 m^3/s (Figure H.7). Determine the mean diameter of granular material that is required to permanently control soil erosion.

Ditch cross-section information:

Bed width = 3.5 m   Sideslope = 4:1

Backslope = 3:1   Grade = 5%

Solution:

Assume using rock riprap, D_{50} = 150 mm

Corresponding value of Manning's n = 0.104 (from Table F.2)

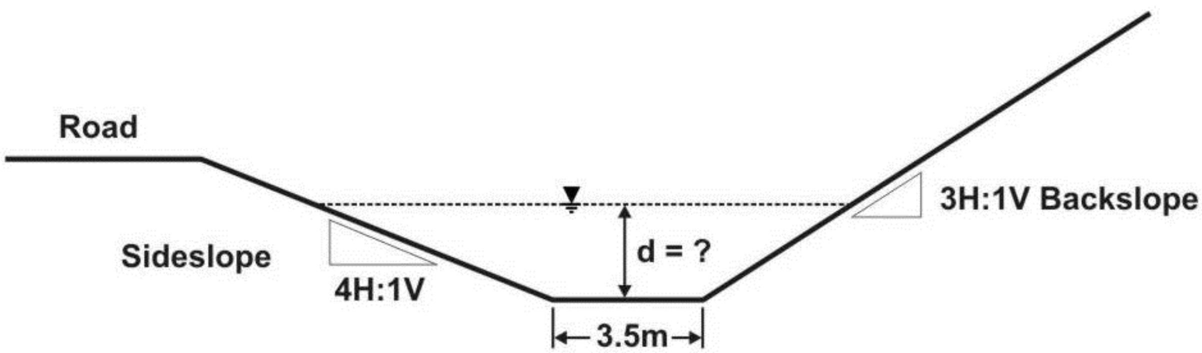


Figure (Example H.10): Typical Cross-Section

Step 1: Estimate the depth of flow.

Trial 1:

Flow depth (say) = 0.10 m

Top width of flow area = 3.5 + 4 x 0.1 + 3 x 0.1 = 4.2 m

Cross-section area, A = 0.5 x 0.1 (3.5 + 4.2) = 0.385 m^2

Wetted perimeter, P = 3.5 + 0.1 (3.162 + 4.123) = 4.228 m

Hydraulic radius, R = A/P = 0.385/4.228 = 0.091 m

Discharge, Q $= (1/n)\, A\, R^{2/3}\, s^{1/2}$ (from Equation F.3)

$= (1/0.104)\,(0.385)\,(0.091^{2/3})\,(0.05^{1/2})$

$= 0.167\ m^3/s > 0.15\ m^3/s$, required

Try another depth slightly smaller than 0.10 m.

Trial 2:

Flow depth (say) = 0.09 m

Top width of flow area = 3.5 + 4 x 0.09 + 3 x 0.09 = 4.13 m

Cross-section area, A = 0.5 x 0.09 (3.5 + 4.13) = 0.343 m^2

Wetted perimeter, P = 3.5 + 0.09 (3.162 + 4.123) = 4.155 m

Hydraulic radius, R = A/P = 0.343/4.155 = 0.082 m

Discharge, Q = $(1/n)\ A\ R^{2/3}\ s^{1/2}$

= $(1/0.104)\ (0.343)\ (0.082^{2/3})\ (0.05^{1/2})$

= 0.139 m^3/s < 0.15 m^3/s, required

Hence, the actual depth of flow would be in between 0.09 m and 0.10 m. Take 0.10 m for simplicity in further calculations.

Step 2: Check the shear resistance of the gravel lining.

Trial 1:

Tractive shear stress of flow, $\tau_p = \delta\ d\ s$

= 9.81 x 0.10 x 0.05

= 0.049 kPa = 49 Pa

Permissible shear stress of 150 mm diameter rock riprap = 0.096 kPa = 96 Pa (from Table F.3(c)).

Hence, D_{50} = 150 mm diameter riprap is more than adequate.

Try using smaller rock size riprap if possible from cost-effective considerations.

Trial 2:

Assume riprap D_{50} = 50 mm = 0.050 m, corresponding Manning's n = 0.066 (from Table F.2)

Assume depth of flow = 0.075 m

Top width of the flow = 3.5 + 4 x 0.075 + 3 x 0.075 = 4.025 m

Cross-sectional area, A = 0.5 x 0.075 x (3.5 + 0.025) = 0.282 m^2

Wetted perimeter, P = 3.5 + 0.075 (3.162 + 4.123) = 4.045 m

Hydraulic radius, R = A/P = 0.282/4.045 = 0.0697 m

Discharge, Q = $(1/n)\ A\ R^{2/3}\ s^{1/2}$

= $(1/0.066) \times 0.282 \times 0.0697^{2/3} \times 0.05^{1/2}$

= 0.166 m^3/s > 0.150 m^3/s, required

Tractive shear stress of flow, $\tau_p = \delta\ d\ s$

$= 9.81 \times 0.075 \times 0.05$

$= 0.036$ kPa = 36 Pa

Permissible shear stress of 50 mm diameter rock riprap = 0.031 kPa = 32 Pa (from Table F.3(c)).

Hence, D_{50} = 50 mm riprap does not satisfy the limiting permissible shear stress values marginally.

Trial 3:

Try using riprap with slightly higher D_{50} = 60 mm.

To find permissible shear stress for D_{50} = 60 mm size rock, interpolate between the permissible shear stress values of 50 mm and 150 mm size rock (from Table F.3(c)).

$$\tau_p = 32 + (96 - 32)(60 - 50) / (150 - 50) = 38.4 \text{ Pa}$$

Hence, riprap with D_{50} = 60 mm is adequate.

Thickness of riprap lining = (1.5 to 2.0) D_{50}

= 90 to 120 mm

Use thickness of 100 mm of riprap with D_{50} = 60 mm

(Note: 100 mm is assumed since it is a simple fraction of a metre)

Example H.11 (Channel Protection – Riprap Lining)

Estimate the mean riprap diameter that will adequately convey a discharge of 0.5 m^3/s down a channel having 15% slope (Figure Example H.11). Assume the channel bed width is 1 m and the sideslope is 3:1. Also estimate the flow depth.

Solution:

Discharge, Q = 0.5 m^3/s Bed slope, s = 0.15 m/m

Bed width, w = 1.0 m Sideslopes = 3:1

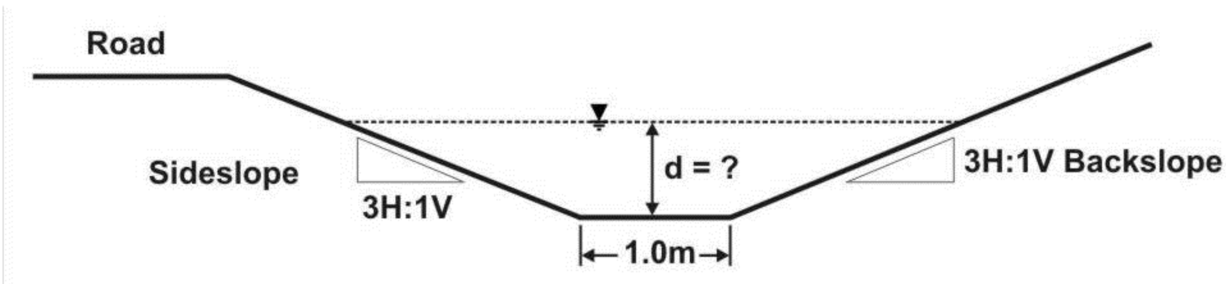


Figure (Example H.11): Typical Cross-Section

Enter Chart of Figure F.13, for, Q = 0.5 m^3/s

Flow depth = 180 mm

Riprap mean diameter D_{50} = 220 mm

Example H.12 (Channel Protection – Concrete Lining)

Design a concrete lining for a channel to carry a discharge of 1.5 m^3/s down a steep stable slope of 3H:1V (Figure Example H.12).

Solution:

Step 1: Find the depth of flow.

Trial 1:

Assume channel dimensions: Bed width = 1.0 m, Sideslope = 2:1, Flow depth = 0.3 m

Manning's n = 0.013 (from Table F.2) for 30 cm flow depth for concrete

Top width of flow area = 2 x 0.3 + 1.0 + 2 x 0.3 = 2.2 m

Flow cross-sectional area, A = (½) (0.3) (1.0 + 2.2) = 0.48 m^2

Wetted perimeter, P = 1.0 + 2 x 0.3 x 2.236 = 2.34 m

Hydraulic radius, R = A/P = 0.48/2.34 = 0.205 m

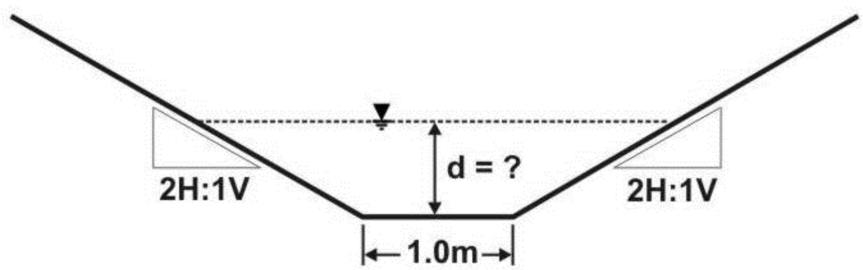


Figure (Example H.12): Typical Cross-Section

Discharge, Q (from Manning's equation)

$$Q = (1/n)\ A\ R^{2/3}\ s^{1/2} \text{ (Equation F.3)}$$

$$= (1/0.013)\ (0.48)\ (0.205^{2/3})\ (0.33^{1/2})$$

$$= 7.38\ m^3/s$$

This section is too large for the desired discharge, hence revise bed width and flow depth.

Trial 2:

Assume, Bed width = 0.5 m Flow depth = 0.2 m

Top width of flow area = 2 x 0.2 + 0.5 + 2 x 0.2 = 1.3 m

Cross-sectional area, A = (½) (0.2) (0.5 + 1.3) = 0.18 m^2

Wetted perimeter, P = 0.5 + 2 x 0.2 x 2.236 = 1.39 m

Hydraulic radius, R = A/P = 0.18/1.39 = 0.129 m

$$\begin{aligned} \text{Discharge, } Q &= (1/n)\ A\ R^{2/3}\ s^{1/2} \\ &= (1/0.013)\ (0.18)\ (0.129^{2/3})\ (0.33^{1/2}) \\ &= 2.04\ m^3/s > 1.5\ m^3/s, \text{ required by a slight margin} \end{aligned}$$

Hence, bed width = 0.5 m and Flow depth = 0.2 m are adequate.

Add freeboard = 0.2 m (equal to depth of flow), hence, required total depth of channel = 0.4 m

Example H.13 (Channel Protection – Gabion Mat Lining)

Estimate the rock size and gabion thickness required to discharge of 0.3 m^3/s down a channel with a 20% gradient (Figure Example H.13). Assume the bed width of the channel = 1.5 m and sideslopes = 3:1.

Solution:

Step 1: Find depth of flow.

Discharge, Q = 0.3 m^3/s Bed slope, s = 0.20 m/m

Bed width, w = 1.5 m Sideslopes = 3:1

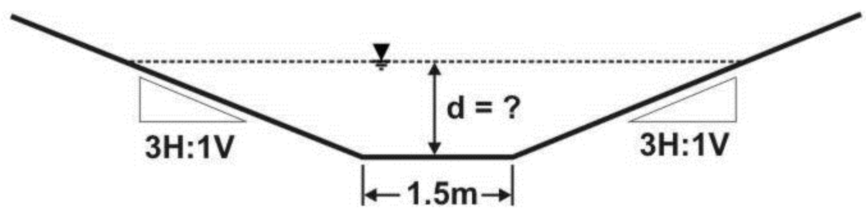


Figure (Example H.13): Typical Cross-Section

Enter Chart of Figure F.20, for Q = 0.3 m^3/s, and Flow depth = 90 mm

Step 2: Determine the size of gabion filling rock.

Tractive shear stress of flow, $\tau_p = \delta$ d s

τ_p = 9.81 x 0.090 m x 0.20

= 0.176 kPa = 3.676 lbs/ft^2 (assume 1 kPa = 20.886 lbs/ft^2)

From Figure F.15, for τ_p = 0.176 kPa, mean rock size diameter = 0.5 ft = 150 mm

Step 3: Find thickness of gabion mattress:

a) From Figure F.16, for τ_p = 0.176 kPa

Minimum thickness = 0.25 ft = 0.076 m

b) From the guidelines mentioned in Section F17.1

Mattress thickness = (2 to 3) times D_{50}

= 300 mm to 450 mm if D_{50} = 150 mm rock used

c) Gabion mattress thickness as manufactured is from 0.25 m to 0.45 m

Hence, adopt 0.30 m thickness, which is close to 2 times D_{50}.

Example H.14 (Flow Depth Estimation)

What would be the flow depth in Example H.11, if the sideslope is 4H:1V (Figure Example H.11)?

Solution:

From Example H.11, flow depth = 180 mm = 0.180 m bed width = 1.0 m

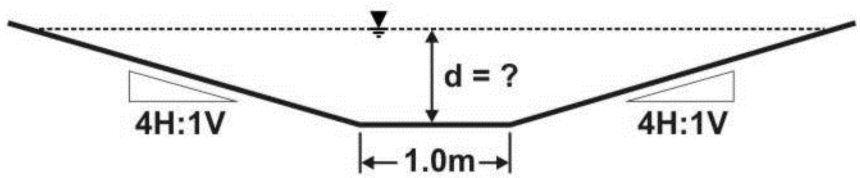


Figure (Example H.14): Typical Cross-Section

Top width of flow area = 1.0 + 3 x 0.180 + 3 x 0.180 = 2.08 m

Area of flow = 0.5 x 0.180 (1.0 + 2.08) = 0.277 m^2

Let d be the depth of flow, then top width of flow = 1.0 + 4d + 4d = 8d + 1

Area of cross-section = 0.5 x d x (8d + 1 + 1) = $4d^2 + d$

Equating the areas of 3:1 and 4:1 sideslope of the ditch configurations, $4 d^2 + d = 0.277$ m^2

Solving the equation for d, d = 0.163 m < 0.180 m, marginally

Example H.15 (Sediment Storage Capacity for Sediment Barriers)

Assume a typical secondary highway roadside ditch section with the geometric properties given below (Figures Example H.15a and H.15b). Determine the appropriate ditch barrier spacing to control the sediment loss from the site. Assume a mean annual sediment yield of 40 m³/ha.

Bed width = 3.5 m	Barrier height = 0.5 m	Backslope = 3:1 (horiz : vert)
Ditch grade = 4%	Ditch depth = 1 m	Sideslope = 4:1 (horiz : vert)

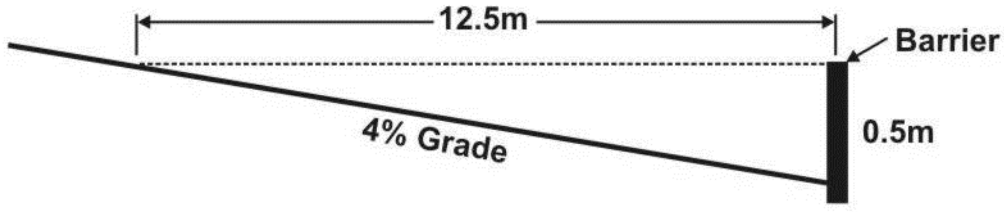


Figure (Example H.15a): Longitudinal Profile

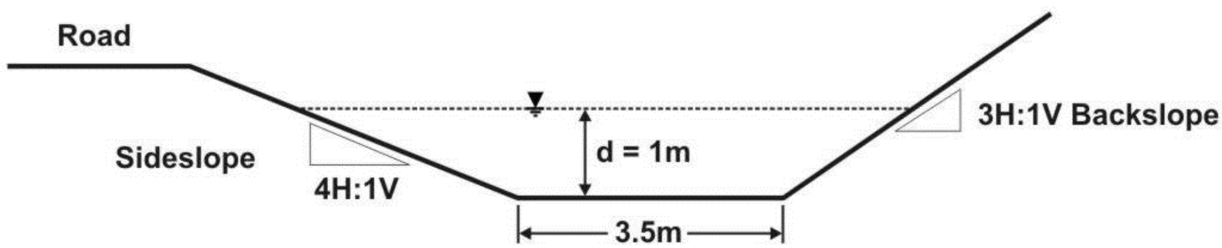


Figure (Example H.15b): Cross-Section

Solution:

Step 1: Calculate the length of sediment spread behind a barrier.

Since the ditch grade is 4% and the height of a barrier is 0.5 m, the sediment will be stored over a ditch length of 12.5 m behind the barrier.

Also, note that, while calculating the likely sediment volume behind a barrier, the cross-section of the deposited sediment changes from one location to another within this 12.5 m distance.

Step 2: Calculate the volume of sediment storage behind a barrier.

From Figure H.15a,

Top width of the storage area at the barrier = 3.5 + 4 x 0.5 + 3 x 0.5 = 7 m

Top width of storage at 12.5 m away from and behind the barrier = 0 m

Area of cross-section at the barrier = 0.5 x 0.5 x (3.5 + 7.0) = 2.625 m^2

Area of cross-section 12.5 m behind the barrier = 0.0 m^2

Hence, volume of storage (assuming a linear variation between the two locations)

= 0.5 x (2.625 + 0) x 12.5 = 16.4 m^3

Assume only half of this volume is allowed to be filled up by sediment. Reason: the remaining will be like a buffer space for erosion during unanticipated very heavy rainfall seasons or, if cleaning is done in alternate years.

Hence, sediment volume likely to be deposited behind a barrier = 8.2 m^3

Area served by one barrier = 8.2/40 = 0.205 ha

Likely width of disturbed area = 6+ 4 x 1 + 3.5 +12.6 = 26.1 m (from Figure H.15c), assuming the ground is disturbed up the backslope by a distance of 12.6 m.

Note: 1 ha = 10,000 m^2

Hence, spacing = 0.205 x 10,000/26.1 = 78.5 m, say, 75 m spacing for convenience of construction. For practical and conservative purposes, a spacing of 60 m (every 3 stations of 20 m) can be considered.

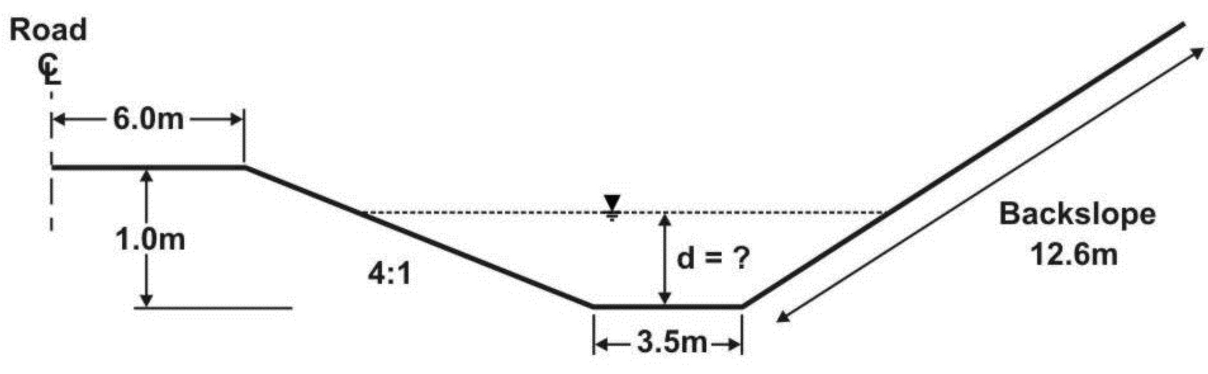


Figure (Example H.15c): Cross-Section Profile up the Backslope

Example H.16 (Design of Sedimentation Pond/Trap)

In the Peace River area, the construction of a highway alignment down a river valley exposed a cutslope of 3 hectare area of bare soil surface. The average cutslope is a single slope at 3H:1V and 25 m length. The cutslope was stipulated for surface texturing with track walking up/down slope. The contactor will schedule to excavate the slope to follow with topsoiling and seeding within the 3 months of July, August and September. The alignment traverses the river course and there is direct connectivity to a fish bearing stream of high environmental sensitivity. The soil types of the area consist of 60% silty low plasticity clay (ML to CL) and 40% high plasticity clay (CH). No rainfall gauge station is available for the immediate area and the hydraulic/hydrotechnical engineer's assessment on inflow runoff quantity into the sedimentation pond is not available. Soil sampling of the ML soil was undertaken at mid height of cutslope and a hydrometer gradation analysis of the ML soil was carried out in preliminary recognition of the erodibility of the ML material.

Hydrometer Gradation (see Figure Example H.16c)

Soil Particles	**Percent**	**Other USCS Properties (Figure 4.1)**	
Clay	14	Plasticity Index	PI = 10%
Silt	43	Liquid Limit	LL = 24%
Sand	41	ML to CL material	
Gravel	2		

Note: This design follows the design approach of Fifield 2001 with engineering modifications.

Questions:

1) **What is preliminary soil erodibility assessment?**

2) **What is the amount of erosion sediment from the cutslope?**

3) **What is the hazard rating of the site; appropriate action if required?**

4) **If sedimentation pond is required, what storage volume of sediment laden runoff can be anticipated?**

5) **How to develop the requirement for the design of a sedimentation pond?**

6) **Design of sedimentation control (as a perimeter control measure adjacent to high risk area).**

Question (1): Evaluate the preliminary soil erodibility:

Determine preliminary Soil Erodibility based on USCS from Figure 4.2.

For CH soil, soil erodibility is considered LOW – no concern

For ML soil, soil erodibility is considered HIGH – concern

Answer: For ML soil, erodibility is considered **HIGH** (Figure 4.2) and of concern

Hydrometer gradation analysis is necessary

Question (2): What is the amount of erosion sediment (SOIL LOSS) from the cutslope?

Construction Conditions:

a) Erodible Soil Distribution Area: 60% of the area is ML soil of high erodibility

b) Construction Schedule 3 months: Soil Erodibility (K) reduction by 35%

(July + Aug + Sept = 41 + 17 + 7 = 65% of annual Erodibility Factor (R))

SOIL LOSS (A): evaluate using RUSLE formula (Equation 6.1) with highway modification factors

$RUSLE_{highway}$

$$A = R \times K_{highway} \times LS_{highway} \times C \times P \qquad \text{(Equation 6.1)}$$

= 325 x 0.07 x 4.1 x 1 x 0.9

= 84 tonne/ha/yr Soil Loss Hazard: very high (Table 6.1)

x 0.6 erodible soil distribution area in (a)

x 0.65 construction schedule time distribution per year in (b)

Therefore,

$A_{construction\ period}$ = 84 x 0.6 x 0.65

= 32 tonne/ha/construction period Soil Loss Hazard = high (Table 6.1)

Where:

$R = 325$ MJ mm ha^{-1} h^{-1} y^{-1} (Figure B-1; Appendix B)

$K_{agriculture} = 0.088$ MJ^{-1} mm^{-1} tonne hr (Figure B-5; Appendix B)

$K_{highway} = 0.070$ ($K_{agriculture}$ x 0.8 (highway modification factor $Ø_K$) see Section 6.2.2.2)

% silt + sand = 84 (use 70%; maximum value in Figure B-5; overestimation of K is possible)

% sand = 41

% OM = 1 (assume 1 for using Figure B-5)

Soil Structure = 4 (blocky, platty, massive)

Permeability = 3 (slow to moderate)

$LS_{agriculture} = 5.2$ (Table B-3; Appendix B)

$LS_{highway} = 4.1$ ($LS_{agriculture}$ x 0.8 (highway LS modificator factor $Ø_{LS}$) see Section 6.2.3.2)

Single slope

33% Slope (3H:1V)

Slope length = 25 m

C = 1 (Table B-6a; bare soil with no mulch)

P = 0.9 (Table B-7; bare soil freshly rough)

Answer: SOIL LOSS (A)

A_{annual} = 84 tonne/ha/yr

$A_{construction\ period}$ = 32 tonne/ha/construction period

Question (3): What is the hazard rating of the site?

Answer:

A_{annual}	= 84 tonne/ha/yr	Soil Loss Hazard: Very High (Table 6.1)
$A_{construction\ period}$	= 84 x 0.6 x 0.65	
	= 32 tonne/ha/construction period	Soil Loss Hazard: High (Table 6.1)

Answer:

The rating of soil loss hazard per year is very high:

- Therefore scheduling of construction to minimize bare soil exposure and speedy topsoiling and seeding are required to lower the annual soil loss hazard rating.
- The rating of soil loss hazard per construction season is still high after scheduling of the construction.
- Therefore the design of sediment pond at perimeter of site is required.

Question (4): If sedimentation pond is required, what storage volume of sediment laden runoff can be anticipated? How to develop the requirements of a sedimentation pond?

If available runoff estimate is not available, it is appropriate to use 250 m^3/ha of disturbed soil areas for estimating storage volume of sedimentation pond. This is based on 25 mm runoff per hectare (EPA requirements; (Fifield 2001)). The 25 mm runoff per hectare is appropriate for 40 to 45 mm precipitation over loamy clay (Type C) to clay (Type D) (see Figure 4.5).

In areas of severe land constraint, a minimum size of sedimentation pond at 150 m^3/ha of disturbed land may be considered in accordance with the risk level of the site. Thus, a pond size of 450 m^2 may be a minimum requirement for 3 ha of land disturbed.

Answer:

A 750 m^3 storage volume as preliminary estimate is appropriate for 3 ha of disturbed area.

Question (5): How to develop the requirement for the design of a sedimentation pond?

The following parameters should be available.

Steps to determine:

1) Target size particle (D_s) for settlement performance
2) Settling velocity (V_s) of target size particle (D_s)
3) Outflow (Q_o) performance and capacity of outflow structure of Sedimentation Pond

4) (i) Inflow (Q_i) Runoff Estimation based on affected area, and (ii) Estimate of Width (W) requirement of outflow structure

5) What is surface area (SA) of sedimentation pond using 1m retention depth?

6) What is gradation (PEG) of the material coarser than the target size particle for sedimentation?

7) What is the efficiency of the sedimentation pond?

Step 1: Target size particle (D_s) for settlement

D_s = 0.03 mm medium size silt is targeted for sedimentation.

Step 2: Settling velocity (V_s) of target size particle

Result:

V_s = 0.06 cm/s for D_s = 0.030 mm size medium silt particles @ 10°C water temperature (Table G.1)

Step 3: Outflow performance and outflow capacity (Q_o) of Sedimentation Pond

The outflow capacity (Q_o) of sedimentation seepage flow from outflow structure of a sedimentation pond can be more accurately assessed with the use the following properties of construction material and design geometry (Refer to Figure G.3a for pictorial of the following dimensional properties).

1) porosity (ρ) and permeability of filter system

2) average rock diameter (D) of gravel berm

3) width (W) of permeable berm

4) flow length (T) through filter system

5) height (H) of water under retention

Equation G.4 (proposed by Jiang et al., 1998) on relationship on outflow performance provides reasonable results for a permeable berm outlet system was considered appropriate for use in sedimentation retention (Fifield, 2001). See Section 12 for details.

$$Q_o = 0.327\, e^{1.5S} (g\, D_{50} / T)^{0.5} \rho W H^{1.5} \qquad \text{(Equation G.4)}$$

(Jiang et al., 1998)

Where:

Q_o = Outflow capacity of containment system (m^3/s)

g = Acceleration due to gravity = 9.8 m/s^2

D_{50} = Mean diameter of the rock (m); for this equation

W = Total width of the barrier (m)

ρ = Porosity of the rock barrier

T = Thickness of the barrier (m)

H = Hydraulic head (m)

S = Slope of channel (%) (generally varies from 0% to 7% for highway gradeline profiles)

The concept of Equation G.4 is presented in Figure G.3 and a typical detail of permeable gravel outlet berm option is presented in Figure G.4.

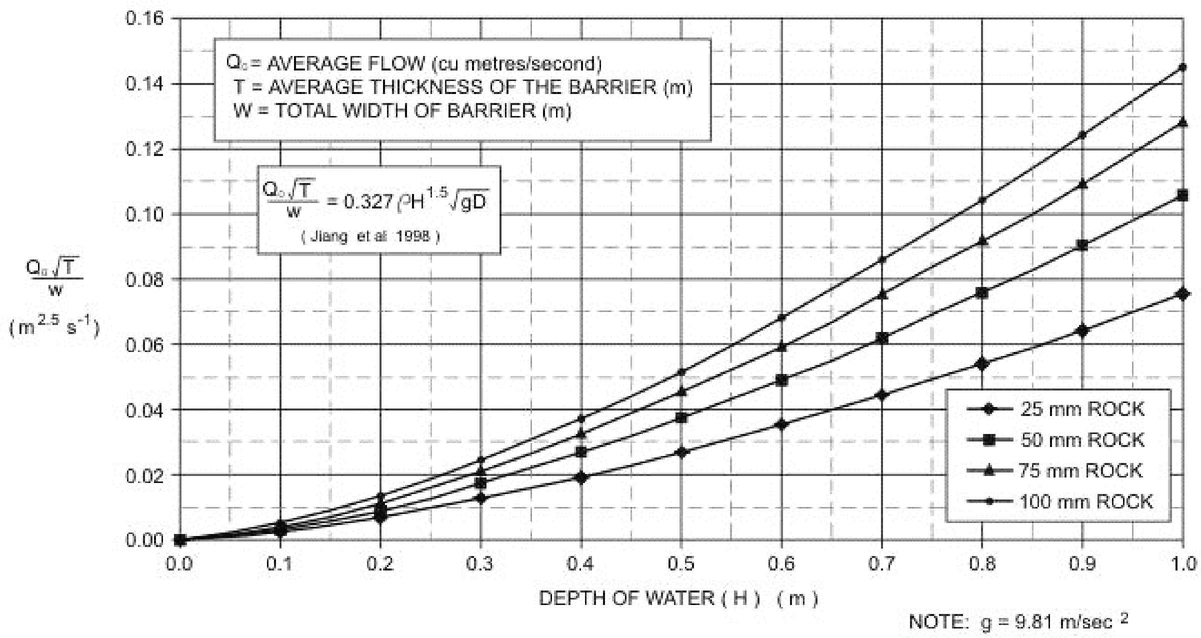


Figure (Example H.16a)

Figure G.3b: Flow (Q) through an Outlet Barrier (g) of various Diameter (D) Rocks in Gabion Basket

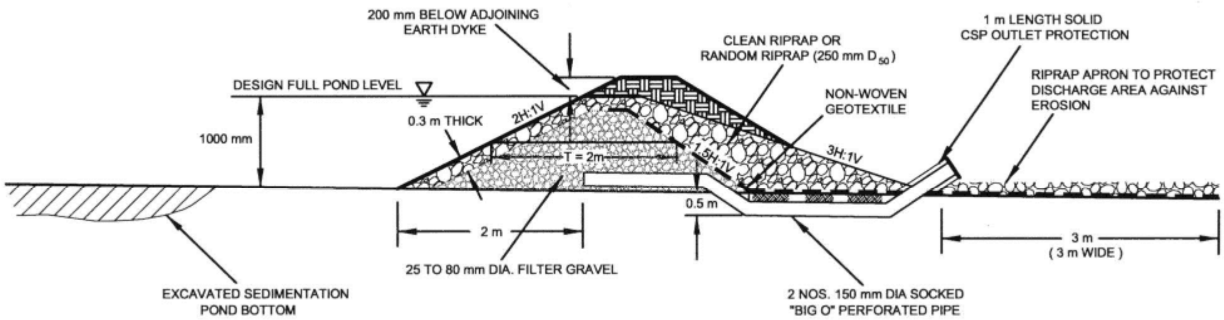


Figure (Example H.16b)

Figure G.4: Typical Sedimentation Basin/Trap Outlet Permeable Structure with Rock Filter Barrier and Perforated Pipe

From Figure Example H.16a (Figure G.3b), a derived version outflow capacity ($Q_o\ T^{0.5} \div W$) result of sedimentation pond outlet construction of permeable gravel berm can be read off. The outflow (Q_o) can be calculated from construction parameters as follows:

Assumed typical parameters and properties of permeable rock berm:

Porosity (ρ) = 0.45

Gravel berm average clean rock size (D) = 80 mm = 0.08 m

Average width of berm (W) - W to be determined

Average thickness of berm (T) = 2 m (see Figure Example H.16b) (i.e., Figure G.4)

Maximum height of runoff retention = 1 m

Thus, from Figure Example H.16a (Figure G.3b):

for H = 1m

$Q_o\ T^{0.5} \div W = 0.11\ (m^{2.5}\ s^{-1})$

Where:for T = 2 m

$$Q_o = \frac{0.11W}{1.41} = 0.08W$$

Results:

Outflow capacity (Q_o) of permeable gravel berm $Q_o = 0.08W\ m^3\ s^{-1}$

Step 4: i) Inflow runoff estimation based on affected area

ii) Estimate of width requirement of outflow structure

The hydrologist or hydrotechnical engineer should assess the terrain drainage and the affected area of construction to assess the amount of sediment laden inflow runoff (Q_i) into the sedimentation pond area. The inflow is compared with the estimate outflow capacity (Q_o) of the permeable outlet to design the width (W) of the permeable outlet.

use: $Q_i = 0.5\ m^3\ s^{-1}$ (assumed)

at full storage: $Q_o = Q_i = 0.5\ m^3\ s^{-1}$

then for: $Q_o = 0.08W$

$W = 6.3\ m$

Results:

For pragmatic design consideration for permeable outlet, a practical outlet width (W = 6.3 m) can be considered to provide an outflow capacity ($Q_o = 0.5\ m^3/s$).

Step 5: What is surface area of sedimentation pond

It is appropriate to consider:

1) inflow (Q_i) equal to outflow (Q_o) (in Step 4)

$$Q_i = Q_o \qquad \text{(Equation G.3)}$$

2) and/or minimum storage volume of 250 m^3 /ha disturbed land for design of sedimentation pond

Thus, Inflow Runoff Volume (Q_o) = $0.5\ m^3\ s^{-1}$ (from step 4), then find surface area of pond (SA)

Pond Surface Area:

$$SA = 1.2\ Q_o \div Vs \qquad \text{(Equation G.5)}$$

$$= 1.2\ (0.5\ m^3\ s^{-1}) \div 0.0006\ cm/s$$

$$= 1000\ m^2$$

Where: $V_s = 0.06\ cm/s = 0.0006\ m/s$ (see step 1)

Step 6: What is Percentage Material Equal to or Greater (PEG) (i.e., gradation of the material coarser than the target size particle for sedimentation)

From hydrometer gradation curve results (see Figure Example H.16c) for:

Where:

D_s = 0.03 mm medium to fine size silt as target size particle

PEG = 55% (or 45% smaller in hydrometer gradation curve)

Step 7: What is the efficiency and design of the sedimentation pond?

Apparent efficiency (A_{eff}) can be determined by configuration of sedimentation using L/We ratio concepts.

Net efficiency (N_{eff}) is the combined effect of pond configuration settling velocity of target size particle as assessed in PEG.

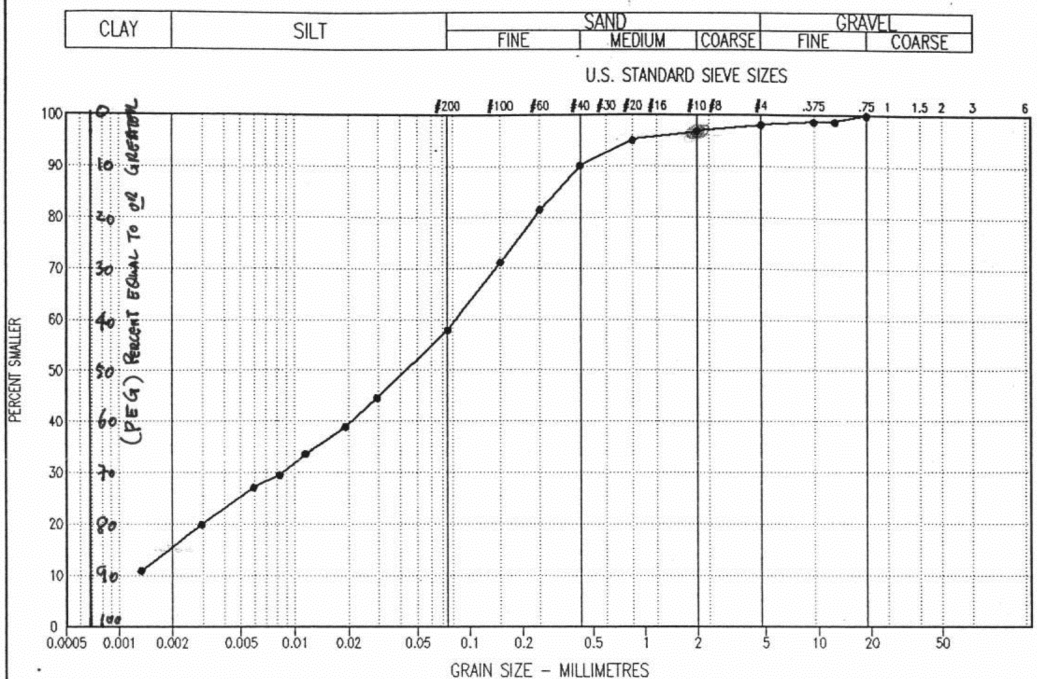
$$\begin{aligned} N_{eff} &= A_{eff} \times PEG \\ &= 0.92 \times 0.55 \\ &= 50\% \end{aligned} \qquad \text{(Equation G.11)}$$

Where : A_{eff} = 92% using L/We = 7 (Figure G.7)

PEG = 55% for D_S = 0.03 mm (medium to fine silt) (Step 6)

EBA Engineering *Figure EX 14.16 PEG (Gradation) Assessment*

PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
•——•	4	32.50 – 33.50	14.0	43	41	2	–	–	

Project: 0104–7100023 Date Tested: 02/03/14 BY: SK

Tested in accordance with ASTM D422 unless otherwise noted.

Figure (Example H.16c): PEG (Gradation) Assessment

Results:

Design of Sedimentation Pond (Figures 12.1, G.3a and G.4)

1) Medium size silt (D = 0.03 mm) as design particle for settlement efficiency goal

2) L/We ratio = 7 (Figure 12.1)

3) Pond area = 1000 m^2; flow chamber width (We) = 12 m; chamber length (L) – 84 m (Figure 12.1)

4) Earth dyke height = 1.2 m (Figure G.3a and G.4)

(5a) Outlet berm height = 1.0 m (Figure G.3a and G.4)

(5b) Outlet berm width (W) = 6.3 m

6) Outlet berm average thickness = 2 m (Figure G.4)

7) Outlet berm average rock size (D) 100 mm diameter

8) Apparent Efficiency (A_{eff}) = 92%

9) Net Efficiency (N_{eff}) = 50%

7. AEPEA Guide to Release Recording

To report a spill or
environmental emergency
call **1-800-222-6514**

Alberta Environment Regional Offices

NORTHERN REGION
Edmonton
#111, Twin Atria Building
4999-98 Avenue
Edmonton, Alberta T6B 2X3
Tel: 780.427.7617
Fax: 780.427.7824

CENTRAL REGION
Red Deer
#304, Provincial Building
4920-51 Street
Red Deer, Alberta, T4N 6K8
Tel: 403.340.7052
Fax: 403.340.5022

SOUTHERN REGION
Calgary
#303, Deerfoot Square Building
2938-11 Street NE
Calgary, Alberta, T2E 7L7
Tel: 403.297.7880
Fax: 403.297.6069

To contact your local Alberta Environment office,
call the regional office nearest you or dial 310-0000.

Alberta

A GUIDE TO RELEASE REPORTING

Alberta Environmental Protection and Enhancement Act

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REFERENCES

Environmental Protection and Enhancement Act, R.S.A. 2000,c. E-12 (as amended)

Release Reporting Regulation, A. R. 117/93 (as amended)

Transportation of Dangerous Goods Regulations (SOR 2001 - 286) under the *Transportation of Dangerous Goods Act*, 1992, S.C. 1992, c. 34

Dangerous Goods and Handling Act, R.S.A. 2000. D-4 (as amended)

Oil and Gas Conservation Act, R.S.A. 2000, c. 0-6 (as amended)

TABLE OF CONTENTS

This guide is not a substitute for the law. Please consult the *Environmental Protection and Enhancement Act* and the *Release Reporting Regulation* for all purposes of interpreting and applying the law.

In the event of a difference between this guide and the Act or Regulation, the Act or Regulation prevails.

Substance

(i) Any matter that
  (a) Is capable of becoming dispersed into the environment, or
  (b) Is capable of becoming transformed in the environment into matter referred to in paragraph (a)

(ii) Any sound, vibration, heat, or radiation or other form of energy, and

(iii) Any combination of things referred to in subclauses (i) and (ii)

Additional definitions can be found in the *Environmental Protection and Enhancement Act* and the *Release Reporting Regulation.* These sources should be consulted to assist in the interpretation of the reporting obligations.

DEFINITIONS

Adverse effect
Impairment of or damage to the environment, human health or safety, or property.

Environment
The components of the earth including:
(i) Air, land and water
(ii) All layers of the atmosphere
(iii) All organic and inorganic matter and living organisms
(iv) The interacting natural systems that include components referred to in clauses (i) to (iii)

Owner of a substance
The owner of the substance immediately before or during the release of the substance.

Person having control of a substance
The person having charge, management or control of the substance.

Release
Includes to spill, discharge, dispose of, spray, inject, inoculate, abandon, deposit, leak, seep, pour, emit, empty, throw, dump, place and exhaust.

INTRODUCTION

This guide is designed to clarify the reporting requirements contained in the *Environmental Protection and Enhancement Act* and the *Release Reporting Regulation*.

The *Environmental Protection and Enhancement Act* requires that any release of a substance into the environment that could cause an adverse effect be reported to Alberta Environment.

The *Release Reporting Regulation* sets out what must be reported, when, how and to who reports must be made.

Individual approvals and codes of practice may also have requirements for reporting contraventions of the terms and conditions of an approval or code of practice, monitoring results and sampling programs. Please consult your approval or registration, or contact Alberta Environment, if you have questions about these reporting requirements.

WHEN TO REPORT A RELEASE

Any spill, release or emergency that **may** cause, **is** causing or **has** caused an adverse effect to the environment must be immediately reported to Alberta Environment.

Prompt reporting assists in ensuring adverse impacts are addressed properly and minimized if possible, and directly affected parties are notified.

As an adverse effect may be difficult to determine, depending on the chemical and physical characteristics of the substance released and where it was released, if you are uncertain about the potential for adverse effects it is recommended that you report the release.

Releases can occur quickly, or over a long period of time. Numerous small releases can result in a potential adverse effect even if the individual release itself may not.

To be reportable, the release must be into the environment. For example, a spill that is fully contained within a building, including odours, is not considered a release into the environment. However, if there is any possibility of odours venting from the building into the environment, Alberta Environment should be notified.

(a) the release is at or in excess of the quantities or emission levels set out for the substance in the Table in section 8.1(1) of Part 8 of the *Transportation of Dangerous Goods Regulations* (SOR 2001-286), or

(b) the substance is released into a watercourse or into groundwater or surface water.

3(2) Subsection (1)(b) applies regardless of whether the quantity or emission level of the release is at or in excess of the levels set out for the substance in the Table in section 8.1(1) of Part 8 of the *Transportation of Dangerous Goods Regulations* (SOR 2001-286).

The Release Reporting Regulation

Notice should be taken of sections 2 and 3 of the Regulation which state:

2 Sections 110 to 112 of the Act and this Regulation do not apply

(a) to releases of substances that are regulated by the *Oil and Gas Conservation Act* or any regulation made under that Act, the *Dangerous Goods Transportation and Handling Act* or any regulation made under that Act, or an approval, licence or permit granted under any of those Acts or regulations, or

(b) to releases of substances classified as Class 1 dangerous goods (explosives) or Class 7 dangerous goods (radioactive materials) as set out in the Schedule to the *Transportation of Dangerous Goods Act, 1992* (Canada).

3(1) Subject to section 2(a), where a release of a substance falling within the Class set out in the first column of the Table in section 8.1(1) of Part 8 of the *Transportation of Dangerous Goods Regulation* (SOR 2001-286) under the *Transportation of Dangerous Goods Act, 1992* (Canada) occurs and the release has caused, is causing, or may cause an adverse effect, sections 110 to 112 of the Act and this Regulation apply in respect of the release only if

WHO SHOULD REPORT

You must report a release if you are:

- The person who releases, causes or permits the release of the substance
- The person having control of the substance that is released (unless they have reasonable grounds to believe that the release has already been reported)
- A police officer or employee of a local or public authority who is informed of, or who investigates, a release of a substance (unless they have reasonable grounds to believe it has already been reported)
- Anyone becoming aware of the release

Local authorities should establish appropriate training and response systems and immediately notify Alberta Environment of releases.

HOW TO REPORT

Report Immediately
Releases must be reported to Alberta Environment at the **first available opportunity,** as soon as the person responsible knows, or should know, about the release. Reports can be made:

- By phoning **1-800-222-6514** (toll-free, 24 hours-a-day) or (780) 422-4505
  or
- In person at any Alberta Environment office

Electronic reporting may also be available in some areas. For further information please contact Alberta Environment.

What to Report
When reporting, please provide:

- The location and time of the release
- A description of the circumstances leading to the release
- The type and quantity of substance released
- The details of any action proposed or taken at the release site
- A description of the immediate surrounding area

A reference number will be issued to confirm that the report was made.

(3) A police office or employee of a local authority or other public authority who is informed of or who investigates a release of a substance into the environment that may cause, is causing or has caused an adverse effect shall immediately notify the Director of the release unless the police officer or employee has reasonable grounds to believe that it has been reported by another person.

Section 111 contains the directions for the manner of reporting where a person is required to report under section 110 and may include reports in person, in writing, and by electronic means. Section 112 states that it is the duty of the person responsible for the substance to take remedial measures to remedy the release and restore the environment.

Section 107(2) of EPEA states that "Sections 110 to 112 apply only to releases of substances that are not authorized by an approval or the regulations." For example, if there was a release of a substance specifically authorized by an approval, registration or the regulations the duty to report will not apply.

LEGISLATION

Environmental Protection and Enhancement Act
Section 110 of EPEA states:

110(1) A person who releases, causes or permits the release of a substance into the environment that may cause, is causing or has caused an adverse effect shall, as soon as that person knows or ought to know of the release, report it to

- (a) the Director
- (b) the owner of the substance, where the person reporting knows or is readily 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.

(2) The person having control of a substance that is released into the environment that may cause, is causing or has caused an adverse effect shall, immediately upon becoming aware of the release, report it to the person referred to in subsection (1)(a), (b), (c) and (e) unless the person having control has reasonable grounds to believe that those persons already know of the release.

Other Required Reporting

You must also report to the following people unless you know that they are already aware of the release:

- The owner or person with control of the substance (if you know or can find out who it is)
- Your employer, supervisor or manager
- Any other person who you know, or should know, may be directly affected by the release

Written Reports

The person responsible must submit a written report to the Alberta Environment Director within **seven days** of the initial immediate report.

The Director may waive the requirement for a written report if the immediate report was sufficient and no adverse effects are likely from the release. You may request a waiver at the time that the initial report is being made. **Unless and until the Director has granted a waiver, you must submit a written report.**

Written reports can be faxed to **(780) 427-3178** or mailed to:

Alberta Environment
Environmental Response Centre
111 Twin Atria Building
4999 - 98 Avenue
Edmonton, AB T6B 2X3

What Should be Included in a Written Report
Written reports should include:

- The date and time of the release
- The location of the release
- The duration of the release and the release rate
- The composition of the release for each substance, including:
  - concentration
  - total weight, quantity or amount released
- A detailed description of the circumstances leading up to the release
- The steps or procedures which were taken to minimize, control or stop the release
- The steps or procedures which will be taken to prevent similar releases
- Any other information required by the Director

What are the reportable limits for a release of polychlorinated biphenyl (PCBs)?
Any release containing concentrations greater than 50 parts per million, or any release that has had, or may have, an adverse affect should be reported. In addition to Alberta Environment reporting requirements, the federal government also has reporting requirements for PCBs.

My vehicle was involved in an accident and as a result fuel was spilled on the ground. Do I need to report this to Alberta Environment?
Typically motor vehicle accidents are reported to a local authority. However, if the quantity of the spill exceeds 200 L, or the fuel has had, or may have an adverse effect, it must immediately be reported to Alberta Environment either by the local authority, or the person(s) involved with the spill.

We spilled a product on the plant site and it has been fully contained. However, the product odours may drift off the site. Do I need to report this to Alberta Environment?
Yes. The odours have a potential to cause an adverse effect and must immediately be reported to Alberta Environment.

My company stores 205 L drums of used oil (a hazardous recyclable) in our yard. One of the drums was accidentally knocked over and the contents were spilled on the ground and soaked into the gravel. Should I report this to Alberta Environment?
Yes. The spill has the potential to have an adverse effect on the groundwater or leave the site. This spill must immediately be reported to Alberta Environment.

I own a service station in an industrial area that borders a residential neighborhood. While removing underground gasoline and diesel storage tanks, I discovered there was free product in the excavation. Is this reportable?
Yes. There is a potential that groundwater aquifers and adjoining residential properties could be affected. In addition, if there are public safety concerns, the local fire department must be notified.

WHAT DOES NOT HAVE TO BE REPORTED

Releases of the following substances do not have to be reported to Alberta Environment, but reporting to other agencies may be required:

- Substances released according to conditions in an approval, registration or regulation
- Substances regulated by the *Oil and Gas Conservation Act*, the *Dangerous Goods Transportation and Handling Act* or any regulations under those Acts
- Substances regulated by an approval, licence or permit granted under the *Oil and Gas Conservation Act*, the *Dangerous Goods Transportation and Handling Act* or any regulations under those Acts
- Substances classified as Class 1 (explosives) or Class 7 (radioactive materials) dangerous goods as set out in the *Transportation of Dangerous Goods Act, 1992* (Canada)

The class and division of substances regulated under the *Transportation of Dangerous Goods Act* and Regulation, and reportable quantities or levels, is available from Alberta Transportation by calling 1-800-272-9600 or (780) 422-9600.

The release of these substances is reportable when:

- The release has caused, is causing or may cause an adverse effect
- The amount exceeds the quantities or emission levels set out for the substance
- The release is into a watercourse or into the groundwater or surface water in any quantity
- The release falls under the *Transportation of Dangerous Goods Regulation* Table 1 under the *Transportation of Dangerous Goods Act, 1992* (Canada)

If you cannot tell if the quantities or levels listed in the *Transportation of Dangerous Goods Regulation* Table 1 are exceeded, the release should be reported.

I was loading a truck with crude oil at a lease site and overfilled the tank, which resulted in approximately 500 L of crude oil being spilled on the ground. The product was contained and will be vacuumed up and no crude oil went off-site or into any waterway. Do I need to report this to Alberta Environment?

No. However, this may be reportable to the Alberta Energy and Utilities Board. *Alberta Energy and Utilities Board IL 98-1 Oil and Gas Notification Requirements* are:

- Any release greater than 2 m^3 on-lease
- Any release off-lease as per the *Oil and Gas Conservation Regulations*
- Any release that has entered or has potential to enter surface water

Any spill or release that goes off-lease that has caused, is causing, or may cause an adverse effect, must immediately be reported to Alberta Environment.

My company repaired an air conditioning system and discovered a broken line that allowed the release of HCFC-22 (R-22). We repaired the line and recharged the system. Do we need to report this release to Alberta Environment?

Alberta Environment only requires immediate reporting of releases 10 kg or greater of Ozone-Depleting Substances, as listed in the *Ozone-Depleting Substances and Halocarbons Regulation, Alberta Regulation 181/2000.*

Our facility is going into a shutdown and as a result we will be required to do some additional flaring. Do we need to report this to Alberta Environment?

If the flaring causes dense black smoke of an opacity greater than 40 per cent for six minutes or more, or if the flaring exceeds an approval limit or has had, or may have, an adverse effect, it must immediately be reported to Alberta Environment. In the event none of these criteria have been exceeded but public complaints could result, please notify Alberta Environment in advance, if possible.

Table Identified in Section 8.1(1) of Part 8 of the Transportation of Dangerous Goods Regulation

Class	Quantity	Emission Limit
1.	Any quantity that could pose a danger to public safety or 50 kg	
2.	Any quantity that could pose a danger to public safety or any sustained release of 10 minutes or more	
3.	200 L	
4.	25 kg	
5.1	50 kg or 50 L	
5.2	1 kg or 1 L	
6.1	5 kg or 5 L	
6.2	Any quantity that could pose a danger to public safety or 1 kg or 1 L	
7	Any quantity that could pose a danger to public safety	An emission level greater than the emission level established in section 20 of the *Packaging and Transport of Nuclear Substances Regulations*
8	5 kg or 5 L	
9	25 kg or 25 L	

WHAT HAPPENS AFTER A REPORT

Alberta Environment responds to all reports. The first priority is always to ensure that any possible adverse effects of a release are being properly dealt with, prevented if possible, or mitigated.

Alberta Environment also ensures all other appropriate authorities are notified and works with other agencies to ensure proper response efforts are underway.

After the situation is being appropriately managed and is under control, Alberta Environment gathers more information about the release incident to determine the cause of the release and how to prevent future releases.

Once the follow-up investigation is complete, a decision is made on whether enforcement action is necessary, and what that enforcement action should be.

Failure to report may result in enforcement action.

FREQUENTLY ASKED QUESTIONS

Do I have to report a spill of 30 L of varsol that occurred inside our warehouse but was contained and cleaned up?
No. If all the varsol was recovered and nothing entered the sanitary or storm drainage system the spill does not need to be reported. A spill inside a building that is fully contained within the building, including odours, is not considered a release into the environment. However, if there is any possibility of odours venting from the building, Alberta Environment should be notified.

I was digging a trench and struck a natural gas line and as a result there was a release of natural gas for a short period of time before the line could be shut-in. Do I need to report this to Alberta Environment?
If the natural gas release poses a danger to public safety or lasted for 10 minutes or more, or the release has had, or may have, an adverse effect, it must immediately be reported to Alberta Environment.

8. EPEA Guide to Spill Recording

Reporting Spills and Releases

The *Environmental Protection and Enhancement Act* (EPEA) requires any release of substances that could cause an adverse effect to the environment be reported to Alberta Environment and Parks.

The *Release Reporting Regulation* sets out what must be reported, when, how and to whom reports must be made. Individual approvals and codes of practice may also have requirements for reporting contraventions of the terms and conditions of the approval or code of practice, monitoring results and sampling programs.

When to Report

Releases of a substance into the environment that **may** cause, **is** causing or **has** caused an adverse effect must be reported to Alberta Environment and Parks. An adverse effect is impairment of, or damage to, the environment, human health or safety, or property.

Who Must Report

The person who releases, causes or permits the release, or has control of the substance released, is responsible for reporting.

Prompt reporting helps to ensure adverse impacts are addressed properly and minimized if possible, and directly affected parties are notified.

How to Report

Releases must be reported to Alberta Environment and Parks at the **first available opportunity** as soon as the person responsible knows or should know about the release.

- Reports must be made by calling 1-800-222-6514

Electronic reporting *may* also be available. For further information please contact your regional Alberta Environment and Parks office.

When reporting, please provide:

- The location and time of the release;
- A description of the circumstances leading to the release;
- The type and quantity of substance released;
- The details of any action proposed or taken at the release site; and
- A description of the immediate surrounding area.

A reference number will be issued to confirm that the report was made.

Written Report

A written report must be submitted to the appropriate Alberta Environment and Parks Director within seven days after the immediate report.

Written reports must include:

- The date and time of the release;
- The location of the release;
- The duration of the release and the release rate;
- The concentration, total weight, quantity or amount released;
- A detailed description of the circumstances leading to the release;
- The steps or procedures which were taken to minimize, control or stop the release;
- The steps or procedures which will be taken to prevent similar releases in the future; and
- Any other information required by the Director.

Written reports can be sent by:

Fax: (780) 427-3178
Email: ERC.Environment@gov.ab.ca

or mailed to:

Alberta Environment and Parks
Environmental Response Centre
#111, Twin Atria Building
4999 — 98 Avenue
Edmonton, AB T6B 2X3

What Doesn't Have to be Reported

Generally, releases of the following substances do not have to be reported to the department:

- Substances released according to an approval or code of practice;
- Substances regulated by the *Oil and Gas Conservation Act* or the *Dangerous Goods Transportation and Handling Act* (these types of releases may need to be reported to other regulators).

The release of these substances are reportable if:

- It has caused, is causing or may cause an adverse effect;
- The amount exceeds the quantities or emission levels set out in the legislation, guideline, approval or code of practice; and/or
- The release is into a groundwater or surface water body.

If unsure whether the quantities or levels are exceeded, the release should be reported.

What Happens After You Report

Alberta Environment and Parks responds to all reports. The first priority is always to ensure that any spill or release is contained and appropriately cleaned up.

The department also ensures all appropriate authorities are notified to ensure proper response efforts are underway.

After the situation is being appropriately managed and is under control, the department will work to gather more information about the release incident to determine the cause of the release and how to prevent future releases.
Once this is complete, a decision is made on whether enforcement action is necessary, and what that enforcement action should be.

Penalties for Not Reporting

Failure to report a release of a substance causing an adverse effect on the environment can result in a fine of up to $100,000 and a year in jail for an individual, and a $500,000 fine for an organization or company.

For More Information

For more information about release reporting requirements, contact the Alberta Environment and Parks regional office nearest you.

- aep.alberta

Alberta Government

9. AT Civil Works Master Spec 02242 Turbidity

1.0 GENERAL

1.1 GENERAL

.1 The Contractors operations will be subject to the maximum allowable increase in total suspended solids (Max-TSS) within the watercourse.

1.2 DEFINITIONS

.1 “Instream Construction Activity” means any planned instream construction activity below the high water mark that has the potential to result in additional turbidity in the watercourse. This would include the installation and removal of isolation measures (i.e., cofferdams, berms, silt curtains, etc.), placing of riprap in the water, bank excavation, etc.

.2 “Max-TSS” means the maximum allowable increase of total suspended solids in the watercourse from the levels at the compliance point downstream of the turbidity control structure from those immediately upstream of the worksite containment.

.3 “Isolated Construction Activity” means any planned construction activity that occurs when working in-stream within a stable site isolation measure (i.e., coffer dams, berms, silt curtains, etc.).

.4 “Site Isolation” means the placement, erecting or installation of a system whose function is to assure sediment produced from construction activities is contained to the isolated work site.

.5 “Visually Conspicuous Plume” means a plume of suspended solids that can be visually observed in the watercourse.

.6 “Normal Construction Activity” means any construction activity that will not cause elevated turbidity levels, and no visual indications of elevated turbidity levels.

.7 “Scheduled Construction Activity” means any planned activity that can be expected to result in additional turbidity in the watercourse, including the installation and removal of cofferdams, silt curtains, placing of riprap in the water, grading, etc.

.8 “Accidental Occurrence” means any situation, beyond the Contractor’s control, that results in elevated turbidity levels in excess of the specified compliance limits, including situations like the unexpected breaching of a cofferdam due to flood conditions exceeding the design levels.

1.3 SAMPLING AND TESTING (QUALITY CONTROL AND QUALITY ASSURANCE)

.1 Perform all sampling and testing of Total Suspended Solids (TSS) as specified herein.

.2 Provide copies of the results of all sampling and testing in a daily summary format. Upon completion of Construction Activities, submit a final report containing all sampling and testing data.

.3 The Minister will carry out random quality assurance inspection as a means to monitor the Contractor’s quality control program. Assist and cooperate with the Minister during the collection of water quality samples.

.4 Prior to the start of construction, carry out sufficient testing to determine the normally occurring linear relationship between Total Suspended Solids (TSS) and turbidity in the watercourse as per the “Conversion Relationship between Nephelometric Turbidity Units (NTU) into mg/L for Alberta Transportations’ Turbidity Specification”. Pay services of a qualified laboratory to determine the relationship.

.5 Submit laboratory results and the linear relationship to the Minister’s representative for review prior to initiating the program.

.6 During construction, perform the following:

.1 Measure the suspended solids in NTU accurate to within 2% of the calibration solution of the equipment.

.2 Convert NTU into mg/L to establish the relationship specific to the site.

.3 Measure upstream and downstream NTU levels within a maximum period of 30 minutes of each other, or as directed by the Minister, unless there is a sediment release (see monitoring frequency below).

1.4 SAMPLING FREQUENCY

.1 Perform sampling 30 minutes prior to daily construction activities until 30 minutes after construction activities have been completed. Compile all sampling information in a daily report.

.2 Perform total suspended solid sampling at the following frequency:

Site Condition	Monitoring Frequency
Instream Construction Activities and Accidental Occurences	• During construction hours, sample at a minimum of once every hour at all compliance transects. • If an exceedance or plume is observed, sampling shall be done within the plume until TSS levels have returned to acceptable background levels for two consecutive sampling events. • No sampling events shall occur during Accidental Occurances until it is safe to do so.
Isolated Construction Activities	• When the Contractor is working within site isolation samples will be taken at all transects at three hour intervals, during construction hours. • If sample results have not exceeded 5 mg/L above background levels for five consecutive active construction days, the sample frequency may be reduced to a minimum of twice per day, as

Site Condition	Monitoring Frequency
	directed by the Minister.

1.5 COMPLIANCE MONITORING

.1 Compliance monitoring is dependent on the type of the watercourse. There are five types of watercourses;

.1 System such as lakes, reservoirs and wetlands where velocities are less than 0.5m/s;

.2 Watercourses where the wetted width is less than 3 m;

.3 Watercourses where the wetted width is between 3 m and 10 m;

.4 Watercourses where the wetted width is between 10 m and 50 m, and

.5 Watercourses where the wetted width is greater than 50 m.

.2 For watercourses less than one meter in depth, take one measurement at 50% of the depth for each sample point along the transect. For watercourses greater than one meter in depth, take two measurements, one at 20% depth and one at 80% depth at each sample point along the transect, and average the results.

.3 The following table summarizes the compliance monitoring locations for each watercourses.

Compliance Monitoring Locations

Type of Watercourse	Number of Transects	Sample Points Along Transect
Systems such as lakes, reservoirs and wetlands where velocities are less than 0.5 m/s.	Transect 1: the lesser of 5 m, or the maximum surface dimension of the waterbody.	5 m intervals around the circumference of the turbidity barrier.
	Transect 2: 20 m from Transect 1 (dependent on the size of the waterbody.)	
	Transect 3: 20 m from Transect 1 (dependent on the size of the waterbody.)	
Wetted width less than or equal to 3 meters.	Background: upstream of the work area	50% of wetted width at each transect
	Transect 1: 1 stream width from work area	
	Transect 2: 2 stream widths from work area	
	Transect 3: 3 stream widths from work area	

Type of Watercourse	**Number of Transects**	**Sample Points Along Transect**
Wetted width between 3 meter and 10 meters.	Background: upstream of the work area	33% and 67% of wetted width at each transect
	Transect 1: 1 stream width from work area	
	Transect 2: 2 stream widths from work area	
	Transect 3: 3 stream widths from work area	
Wetted width between 10 m and 50 m.	Background: upstream of the work area	25%, 50%, and 75% of wetted width at each transect
	Transect 1: 30 m downstream from work area	
	Transect 2: 60 m downstream from work area	
	Transect 3: 90 m downstream from work area	
Wetted width greater than 50 m.	Background: upstream of the work area	25%, 50%, and 75% of wetted width transect
	Transect 1: 50 m downstream from work area	
	Transect 2: 125 m downstream from work area	
	Transect 3: 225 m downstream from work area	

1.6 VISUAL PLUME MONITORING

.1 In the event that Visually Conspicuous Plume is observed, immediately cease all activities, undertake mitigation measures, contact the Minister, and promptly initiate a plume TSS monitoring program in accordance with the following;

.1 Cease all activities that may have a direct or indirect effect on water quality during all plume ocurrences.

.2 Take a sample from the middle of the plume and as close to the source of the plume as possible (within safety limits)

.3 Monitor at all transects and the plume sampling point as often as feasible (a minimum of an hourly basis), and continue until two consecutive monitoring events show no compliance exceedances.

1.7 COMPLIANCE CRITERIA

.1 Criteria are set by the current versions of the Environmental Quality Guidelines for Alberta Surface Waters, which are based on the Canadian Council of Ministers of the Environment.

.2 Following completion of each TSS monitoring event, the Contractor will know if the construction activities are within compliance limits as defined in the table below. This will be accomplished as follows;

.1 Average the results for each of the upstream sample points to determine a background TSS (mg/L) for each event.

.2 Calculate the average TSS concentration (mg/L) for each of the downstream transects (cross sections) and compare the average value for each transect to the background TSS concentration (mg/L). If the result for any transect exceeds the limits in the table below, the project is not in compliance. The average value for any transect is calculated as the arithmetic average of the sample points in that transect.

.3 Compare any differences with the TSS Compliance Criteria to determine if the construction works (i.e. isolated or instream construction activities) are within compliance.

.3 Utilize equipment, labour, and procedures in a manner that ensures the maximum allowable levels of suspended solids are maintained below the following levels;

Site Conditions (Background TSS)	**Exceedance Levels (TSS in Excess of Normal Background Levels)**
TSS < 25 mg/L	• A maximum instantaneous increase of 25 mg/L over background levels at any time. An average increase of >5 mg/L over background levels for more than 24

Site Conditions (Background TSS)	Exceedance Levels (TSS in Excess of Normal Background Levels)
	hours.
TSS 25 mg/L – 250 mg/L	• A maximum instantaneous increase of 25 mg/L from background levels at any time.
TSS > 250 mg/L	A maximum instantaneous increase of 10% of background levels at any time.

.4 Notify the Minister at least 48 hours (2 calendar days) prior to the start of any Instream Construction Activity.

.5 In the event of a measurement is over the Exceedance Levels listed in the table above, or an Accidental Occurrence that results in a Visually Conspicuous Plume of sediment, cease all activities that may have a direct or indirect impact on water quality, and immediately initiate mitigation actions. Notify the Minister immediately and call the Alberta Energy and Environment Response line at 1-800-222-6514.

.6 If an exceedance occurs during Isolated Construction Activity and a reduced sampling program is in effect, the sampling frequency must be reset to the requirements, as listed in the sampling frequency table of clause 1.4.2, where the sampling frequency is to return to three hour intervals during construction hours.

1.8 RECORD KEEPING

.1 Keep a detailed record of the sampling completed for the TSS monitoring program during Instream Construction Activity and Isolated Construction Activity and report to the Minister in a weekly summary format.

.2 Ensure daily sampling records are up-to-date and keep onsite at all times during the period in which the monitoring program is in effect.

.3 Upon completion of the Construction Activities, submit a final report containing all sampling and testing data to the Minister.

.4 Include the followings in the weekly summary report;

  .1 Brief description of the works and types of construction activities completed during the sampling.

  .2 Date and time of each sample.

  .3 Weather conditions at the time of each sample.

  .4 Changes of depth of flow at the upstream transect.

  .5 Documentation of daily NTU instrument calibrations.

  .6 Both turbidity (NTU) and TSS (mg/L) for each sample taken.

  .7 The daily average value (mg/L TSS) of the upstream background samples.

  .8 The daily average value (mg/L TSS) of each downstream transect (all three sites per transect combined).

  .9 Documentation of all non-compliance instances, including the level of exceedance, the duration of exceedance, the mitigation measures taken, verification of the reporting of the exceedance and any related communications with regulators regarding the exceedance event, and future measures to be taken to avoid or control further exceedances.

.10 Description of events or circumferences that may have prevented or hindered completion of the TSS monitoring program.

1.9 SUBMITTALS

.1 Provide the following submittals:

.2 Shop Drawings of the turbidity barriers detailing the components and the material specifications of the components, 15 days prior to commencement of the Work. Provide a turbidity barriers system that has been designed and stamped by a professional Engineer registered with the Association of Professional Engineers, Geologists and Geophysicists of Alberta or a specialist in such Work authorized by the Minister.

.3 Turbidity Control Execution Plan outlining the location of the turbidity barriers, the method of installation, anchorage details, maintenance and inspection procedures, the removal and storage procedures and contingency plans in case of a breach in the turbidity curtain, 15 days prior to commencement of the Work.

.4 Final report referred to in 1.3.2.

2.0 PRODUCTS – NOT USED

3.0 EXECUTION

3.1 INSTALLATION

.1 Install provisions for turbidity control at the Travers Inlet site during all periods of construction that may impact the quality of water in Travers Reservoir including at least the following:

.1 Initial construction of the cofferdam.

.2 Placement of riprap and bedding material.

.2 Install the temporary turbidity barrier system in accordance with the turbidity control execution plan.

.3 Remove the turbidity barriers during the periods they are not required.

END OF SECTION

10. AT Civil Works Master Spec 01390 ECO Plan

1.0 GENERAL

1.1 RELATED SPECIFICATIONS

.1 Section 01391 Environmental Protection.

1.2 ENVIRONMENTAL LEGISLATION

.1 The Minister will obtain the environmental approvals, permits, licences, and authorizations required for the Project.

.2 The Contractor shall familiarize itself with all applicable federal and provincial legislation and regulations concerning environmental protection and shall conduct its activities in accordance with such legislation and regulations, including, but not necessarily limited to, the provincial Environmental Protection and Enhancement Act and Water Act and the federal Fisheries Act and Navigable Waters Protection Act.

.3 Comply with the conditions of all environmental approvals, permits, licences and authorizations issued for the Contract. Obtain any further environmental approvals, permits, licences and authorizations for temporary work as may be required for the Contract.

.4 Provide the Minister with written confirmation of Contractor's full compliance with all approvals, permits, licences and authorizations before the full amount of holdback will be released.

.5 The Contractor shall also familiarize itself with all applicable Codes of Practice issued by Alberta Environment and shall conduct its activities in accordance with such Codes of Practice, including, but not necessarily limited to, the Code of Practice for Asphalt Paving Plants and the Code of Practice for Pits, both under the Environmental Protection and Enhancement Act and the Code of Practice for Watercourse Crossings under the Water Act.

.6 In the event of conflicting statements between the various Acts, Authorizations, Permits, and Codes of Practice, the more stringent requirement shall apply.

.7 Keep on Site, copies of approvals, permits, licences and authorizations. Make these documents readily available to authorized persons at the Site. Keep documents on Site until the date of Warranty Performance of the Work or at such earlier dates accepted by the Minister.

1.3 ECO PLAN

.1 Prepare and implement an Environmental Construction Operations Plan for each phase of the Contract in accordance with the Alberta Transportation manual entitled "Environmental Construction Operations Plan (ECO Plan) Framework," May 2005 version. Completed ECO Plans consist of written procedures and drawings that address the environmental protection issues relevant to the site specific activity being performed and shall detail temporary environmental control measures that the Contractor undertakes to comply with all applicable legislation, regulations and approvals during the course of construction and during "winter shut down," and other similar "shut down".

.2 Prepare the ECO Plan specific to the Work and the Site. Ensure effective implementation of the ECO Plan by assigning responsibility for the implementation, and maintenance of the work prescribed by the ECO Plan, including temporary erosion control measures, to one individual, herein called the work zone representative. The work zone representative shall be identified at the pre-construction meeting.

.3 The ECO Plan shall not cover any permanent or long term environmental or erosion control devices or work specified in the Contract.

.4 Submit the ECO Plan to the Minister at least 14 calendar days prior to the pre-construction meeting. The Minister will review the ECO Plan and communicate any concerns to the Contractor at least 7 calendar days prior to the pre-construction meeting. Address any issues or concerns regarding the proposed ECO Plan the satisfaction of the Minister prior to the commencement of the Work.

.5 Finalized ECO Plans shall be agreed to by all parties and shall be signed by the Contractor's 'Principal-In-Charge' and the Contractor's work zone representative before the commencement of Work. When the Contractors work zone representative changes, the new work zone representative shall provide a letter of acknowledgment to the Minister indicating that the new work zone representative has reviewed the ECO Plan and will comply with its requirements.

.6 The finalization of the ECO Plan to the mutual satisfaction of the Minister and the Contractor does not constitute an approval or assurance from the Minister of Alberta Transportation that the "temporary environmental control measures" detailed in the ECO Plan are sufficient to ensure compliance with all applicable legislation, regulations or conditions of approval. The Contractor is ultimately responsible to ensure all measures, used on the Work, are sufficient to ensure compliance with all applicable authorities. This may mean increasing the number of installations, providing alternate devices or modifying procedures.

.7 If at any time during the performance of the Work of the Contract, it is determined that the devices or procedures detailed in the ECO Plan (any specific measures, locations or quantities proposed) are inappropriate or insufficient, the Minister will notify the Contractor in writing and the Contractor shall modify the ECO Plan accordingly.

.8 The Minister may suspend work in cases where in the Minister's opinion the Contractor fails to comply with procedures stated in the ECO Plan. If the Contractor fails to adhere to finalized ECO Plans, the Minister may make other arrangements to have the Work done, and deduct the cost thereof from any money owing to the Contractor.

.9 The cost of preparing the ECO Plan and the performance of all Work necessary to ensure compliance with the ECO Plan and applicable legislation, regulations or conditions of approval (with the exception of removing and disposing of material from silt containment ponds and sediment barriers) will be incidental to the Work and will not be paid for separately. For scope measurement and payment refer to Section 1280 Measurement Schedule. Removing and disposing of material from silt containment ponds and sediment barriers will be authorized by Change Order and valued in accordance with Section 00725 General Conditions clause 8.3 Valuation of Changes in the Work.

1.4 GENERAL ENVIRONMENTAL PROTECTION REQUIREMENTS

.1 Advise the Minister as soon as possible of any accidents.

.2 Conduct accident investigations.

1.5 DISPOSAL OF WASTE MATERIALS

.1 Do not release, dump, spill or dispose of any substance into the environment that causes or could cause impairment of or damage to the environment or human health or safety. Mitigate to ensure compliance with all regulatory legislation, any wastes arising from the work and any other substances that causes or could cause impairment of or damage to the environment or human health or safety, and should Contractor fail to do so, the Minister may, without further notice, arrange the clean-up of such wastes and other substance at the expense of the Contractor.

.2 Remove and dispose of any inert solid waste materials resulting from the work in accordance with Alberta Environment's Construction, Renovation and Demolition Waste Reduction Guidelines and as determined by the Minister prior to Total Performance of the Work or other time scheduled in the Contract Documents. The Contractor may temporarily store such material in interim stockpiles on the disturbed land.

1.6 REPORTING PROCEDURES FOR SPILLS OF DELETERIOUS OR HAZARDOUS MATERIALS

.1 During the construction, any release of silt or other deleterious substance into a body of water or watercourse Contractor shall immediately report to the Minister, Alberta Environment and the Federal Department of Fisheries and Oceans (1-800-222-6514).

.2 In the event of the release of silt or other deleterious substance into a body of water or watercourse, the Contractor shall take all reasonable measures to contain the release and repair any damage at its expense.

.3 Spills or releases of hazardous materials and any other substances that cause or could cause impairment of or damage to the environment or human health or safety shall also be immediately reported to the Minister, Alberta Environment and, if a body of water or watercourse is involved, the Minister, Alberta Environment and the Federal Department of Fisheries and Oceans (1-800-222-6514). Take all reasonable measures to contain the spill and cleanup and any such work shall be performed in accordance with the applicable legislation and regulations at the Contractors' expense.

END OF SECTION

11. AT Civil Works Master Spec 01391 Environmental Protection

1.0 GENERAL

1.1 SURFICIAL AQUATIC RESOURCES

.1 Physical:

.1 Unless otherwise provided for in the Contract Documents, do not divert, alter, or disrupt water flows in rivers, streams, and other surface bodies of water.

.2 Conform to the Environmental Management Plan as specified in Section 01390 - Environmental Management.

.3 Prevent bark, slash, wood chips, sawdust, ashes, organic debris, topsoil, fuel and lubricants, or other substances harmful to aquatic life from entering a river, stream, or other surface bodies of water.

.4 Do not perform construction operations within the wetted perimeter of a river, stream, and other surface bodies of water unless such work is part of the Permanent Work or Temporary Work.

.5 Do not deepen by excavation or place fill material on the river or stream bed or other surface bodies of water unless such work is part of the Permanent Work or Temporary Work.

.6 Manage construction operations to limit equipment crossings of rivers and streams and prevent turbidity and siltation during crossings. Install temporary culverts or bridge structures where frequent crossings are required.

.7 Use Construction Equipment with bio-friendly hydraulic fluids, free from external oil and grease when operating in, or within the wetted perimeter, of a river, stream, and other surface bodies of water.

.8 Use clean granular fill with less than [5%] [10%] fines passing the 80µm sieve size when exposed to a river or stream for Temporary Work such as cofferdams, causeways, and access ramps. Fine-grained soils may be used, provided only clean granular fill is exposed to the body of water at any time during construction and restoration operations.

.9 Remove Temporary Work, including culverts and bridges, and reclaim river and stream banks and beds, and other disturbed areas, prior to attaining Substantial Performance of the Work unless specified otherwise.

.10 Silt Fence Management:

.1 Be responsible for, and maintain the fabric in silt fences until the date of Warranty Performance of the Work.

.2 Inspect the fabric, posts, and pins, in the silt fencing at intervals appropriate to weather events. Based on inspections, maintain the fencing to perform for the purpose intended.

.3 Remove silt accumulations and dispose of silt on Site, at locations acceptable to the Minister.

.4 Removal and disposal of silt materials collected at silt fabric fencing will be authorized by Change Order and valued in accordance with Section 00725 – General Conditions, clause 8.3 - Valuation of Changes in the Work.

.5 Unless otherwise specified in the Contract Documents, or otherwise requested by the Minister, remove temporary silt fencing within 30 days after the date of Warranty Performance of the Work.

.2 Biological:

.1 Protect fish and fish habitat in rivers, streams, and other surface bodies of water located within the Site in accordance with the Contract Documents and Regulatory Requirements.

.2 Construction operations in the [river] [stream] [lake] is prohibited between the dates of [ ] and [ ] of any year.

1.2 [GROUND WATER RESOURCES]

.1 Physical:

.1 Do not change ground water levels in wells located on adjacent lands.

.2 Biological:

.2 Do not change ground water quality in adjacent landowner wells.

1.3 TERRESTRIAL RESOURCES

.1 Wildlife:

.1 Maintain setback distances between construction operations and the habitat of each of the designated wildlife species and during the critical dates specified below. The Minister may identify additional habitat sites and wildlife species during the Contract Time. Additional work required to protect additional habitat sites and wildlife species will be authorized by Change Order and valued in accordance with Section 00725 – General Conditions, clause 8.3 - Valuation of Changes in the Work.

Species/Period		Critical Dates	Setback Distance
[.1	Mule Deer		
	- winter period	January 1 - February 28	100 m
	- natal period	May 15 - June 30	100 m
.2	Great Blue Heron		
	- nesting period	April 1 - June 30	100 m
.3	Prairie Falcon		
	- nesting period	February 1 - June 30	400 m
.4	Burrowing Owl		
	- nesting period	March 1 - June 30	100 m]

.2 Do not allow pets on the Site.

.3 Do not allow firearms, hunting, or shooting on the Site.

.4 Prevent livestock from entering the Site by:

.1 installing new fences specified in the Contract Documents; and

.2 installing temporary fences as necessary.

.5 Do not harass wildlife.

.2 Vegetation:

.1 Remove or control existing and new adverse vegetation that affects adjacent landowners and their croplands, construction operations, or the function of the Permanent Work.

.2 Do not import any materials to the Site that are contaminated with weed seeds. Clean dirty construction and reclamation equipment to prevent importing weed seeds.

.3 Notify the Minister prior to commencing adverse vegetation control measures.

.4 Be responsible for damage to crops, both on and off the Site, resulting from the Contractor's use of herbicides, or other adverse vegetation control measures.

.5 Maintain records of the types and amounts of herbicides purchased, delivered, stored, mixed, and used, and the means of disposal of all excess. Maintain the records current and accurate, and make them available for review by the Minister.

.6 Comply with standards and practices of the Industrial Vegetation Management Association of Alberta.

.7 [ ]

.3 Vegetation and Weed Control:

.1 Remove or control existing and new adverse vegetation that affects adjacent landowners and their croplands, construction operations, or the function of the Permanent Work.

.2 Do not import any materials to the Site that are contaminated with weed seeds. Clean dirty construction and reclamation equipment to prevent importing weed seeds.

.3 Notify the Minister prior to commencing adverse vegetation control measures.

.4 Be responsible for damage to crops, both on and off the Site, resulting from the Contractor's use of herbicides, or other adverse vegetation control measures.

.5 Maintain records of the types and amounts of herbicides purchased, delivered, stored, mixed, and used, and the means of disposal of all excess. Maintain the records current and accurate, and make them available for review by the Minister.

.6 Monitor the site for early detection of weed growth during the growing season.

.7 Control weeds once by mechanical equipment before they go to seed, but not before [ ].

OR

.4 Vegetation and Weed Control:

.1 Remove or control existing and new adverse vegetation that affects adjacent landowners and their croplands, construction operations, or the function of the Permanent Work.

.2 Do not import any materials to the Site that are contaminated with weed seeds. Clean dirty construction and reclamation equipment to prevent importing weed seeds.

.3 Notify the Minister prior to commencing adverse vegetation control measures.

.4 Be responsible for damage to crops, both on and off the Site, resulting from the Contractor's use of herbicides, or other adverse vegetation control measures.

.5 Maintain records of the types and amounts of herbicides purchased, delivered, stored, mixed, and used, and the means of disposal of all excess. Maintain the records current and accurate, and make them available for review by the Minister.

.6 Comply with the standards and practices of the Industrial Vegetation Management Association of Alberta.

.7 Retain a Professional Agrologist to conduct:

.1 a pre-disturbance weed assessment on the Site, [[of disturbed areas and areas immediately adjacent to the disturbed areas] [including all easement and borrow land]] [ ], and prepare a written report outlining the assessment. Submit the report within 50 days after the commencement date of the Contract.

.2 a post-disturbance weed assessment on the Site, [[of disturbed areas and areas immediately adjacent to the disturbed areas] [including all easement and borrow land]] [ ], at a time mutually determined between the Minister and the Contractor. After assessment, prepare a written report of new weeds, and make recommendations concerning weed control. Submit the Agrologist's report to the Minister within a time required by the Minister.

.8 Employ a herbicide applicator licenced by Alberta Environment to select and apply herbicides in accordance with recommendations made by the Agrologist.

.9 Monitor the Site for early detection of weed growth during the growing season.

.10 The term mechanical equipment in this section means equipment used for mowing, discing, harrowing, rod weeding, or other equipment as determined by the Agrologist, in consultation with the Contractor.

.11 Control weeds by mechanical equipment before they go to seed, and apply herbicides in accordance with recommendations made by the Agrologist.

.12 Meet all the requirements of the Contract Documents for herbicide application, including mixture, method, and application rates.

.13 One application of the herbicide mixture is required by the Contract; to be applied in accordance with recommendations made by the Agrologist.

.14 Prevent importing weed seeds, and remove existing weeds, listed as "Restricted" or "Noxious" under the Weed Control Act. Consult Alberta Agriculture, Food and Rural Development or Municipal Agricultural Field-men for more information on weed regulations and control.

.15 Prevent importing weed seeds, and remove existing weeds, listed as "Nuisance" weeds, where such weeds interfere with the growth of the specified seed. Such weeds to be determined by the Agrologist.

.16 Supply of herbicide mixture combination will be authorized by Change Order and valued in accordance with Section 00725 – General Conditions, clause 8.3 - Valuation of Changes in the Work

.17 During the calendar year following the year of initial herbicide application, reapply herbicide mixture combination over the defective locations as determined by the Agrologist. Defective locations are areas that show more than 20% weed population in any 100 square meters of the Site, including all easement and borrow land and areas adjacent to the Site. Provide accurate records to the Minister of the defective locations treated and the types and amounts of the herbicide mixture combination used.

.18 The Minister will conduct a weed inspection during the month of May of the calendar year following the year of initial seeding. Complete any required re-application of herbicide prior to June 15 of that year. This date will be extended if, in the opinion of the Minister, the weather conditions prior to June 15 are not suitable for reseeding Work.

.19 Correct areas outside the specified areas that show chemical damage.

.20 For re-application of herbicide meet all the requirements of the initial herbicide application, including mixture combination, method, and application rates, as applicable.

.5 Waste Management:

.1 Remove construction waste, including demolition waste, from the Site unless otherwise specified. Dispose of such waste at the waste disposal facility identified in the Environmental Management Plan.

.2 Do not burn, bury, or otherwise discharge construction or demolition waste on the Site unless specified otherwise.

.3 When practical, minimize the amount of waste generated from construction operations and demolitions by salvaging materials for recycling. Salvage and segregate metal, plastic, paper, cardboard, and glass and transfer them to the nearest appropriate collection facility.

.6 Hazardous Materials:

.1 Transport hazardous materials to and from the Site in accordance with Regulatory Requirements.

.2 Use and store hazardous materials in accordance with Regulatory Requirements.

.3 Remove spilled hazardous materials, including hazardous liquid wastes, in accordance with Regulatory Requirements, and reclaim land and other property. Report spills to Alberta Environment and the Minister.

.4 Dispose of hazardous waste materials, including hazardous liquid wastes, in accordance with Regulatory Requirements.

.7 Handling of Construction Equipment Fuels and Lubricants:

.1 Employ persons qualified to handle Construction Equipment fuels and lubricants.

.2 Carry the following protection materials in all fuel and service vehicles:

.1 10 kg of suitable sorbant material.

.2 30 m^2 of 6 mil polyethylene.

.3 A shovel.

.4 An empty fuel barrel with the lid removed.

.3 Prevent handling and fuelling operations from contaminating the ground, surface water, and ground water. Use containment berms and an impermeable base course or other system to contain spilled fuel.

.4 Clearly mark and barricade fuel storage areas and non-portable transfer lines. Use markers that are visible under all weather conditions.

.5 Store waste Construction Equipment lubricants in a tank or closed container, and dispose of off-Site in accordance with the Regulatory Requirements.

1.4 HISTORICAL AND ARCHAEOLOGICAL RESOURCES

.1 Protect known heritage resources specified in the Contract Documents with the specified fencing and marking devices.

.2 Protect new heritage resources found during the Contract Time. Flag an area of [15 m] beyond the edge, and surrounding, a new found heritage resource, and report the finding immediately to the Minister.

.3 Additional work required to protect new found heritage resources will be authorized by Change Order and valued in accordance with Section 00725 – General Conditions, clause 8.3 - Valuation of Changes in the Work.

1.5 SOCIO-ECONOMIC

.1 Air Pollution:

.1 Prevent the discharge of atmospheric contaminants from construction operations in accordance with Regulatory Requirements.

.2 Do not operate equipment, including Construction Equipment, that shows excessive emissions of exhaust gases until corrective repairs or adjustments are made.

.3 Control dust on the Site, and prevent dust from the Site from damaging crops, orchards, cultivated fields, and dwellings, or causing a nuisance to persons. Be responsible for damages from dust caused by construction operations.

.4 [ ]

.2 Noise:

.1 Do not exceed noise levels of [ ] decibels in the daytime and [ ] decibels at night, [on weekdays and weekends]. At the Contractor's option, provide noise barriers to maintain acceptable noise levels outside the barriers.

.2 Perform blasting, drilling, jackhammering, pile driving, and other operations producing high-intensity impact noise between the hours of [ ] pm and [ ] am on [weekdays and weekends except Sundays and Statutory Holidays]. Adhere to other work restrictions specified in the Contract Documents.

.3 Light:

.1 Direct all stationary floodlights to shine downward at an angle less than horizontal. Provide shielding for all floodlights and do not direct at residences.

.4 [Others]:

2.0 PRODUCTS - NOT USED

3.0 EXECUTION - NOT USED

END OF SECTION

12. AT Civil Works Master Spec 02240
Care of Water

1.0 GENERAL

1.1 REGULATORY REQUIREMENTS

.1 Comply with the conditions of the permits for the Project obtained by the Minister under the [Fisheries Act] [and the Water Act] as specified in Section 01410 – Regulatory Requirements.

.2 Make arrangements with the Minister, landowners, or other agencies that may be affected by disposal of water, snow, or ice. Obtain any permits required in addition to those obtained by the Minister.

1.2 SITE CONDITIONS

.1 The Site is located in an area where chinook winds, accompanied by sudden temperature changes, are prevalent. The resulting temperature fluctuations often result in significant snowmelt runoff during relatively short periods of time.

.2 Canal and reservoir operation restrictions that may influence care of water provisions are specified in Section 01110 – Summary of Work.

.3 Water leakage will occur from other works: [ ].

.4 The Site is located where groundwater is present. [Special ground water conditions [ ].]

1.3 DESIGN OF CARE OF WATER PROVISIONS

.1 Design temporary care of water measures including cofferdams, sumps, pumping systems, pipelines, channels, flumes, drains, and other protective and dewatering works to permit construction of the Work in the dry.

.2 Include provisions for handling groundwater, rainstorm runoff, snow, snowmelt, and ice that may enter the Work areas in the design of the care of water measures.

.3 Design dewatering systems that are capable of lowering and maintaining the groundwater level a minimum of 1 m below ground surface on the excavation slopes and base to permit construction of the Work to be conducted in the dry, and on a stable foundation, with no loss of foundation materials or materials from excavated surfaces.

.4 Design care of water provisions so that they do not interfere with [canal] [canal and reservoir] operations.

1.4 SUBMITTALS

.1 Provide the following submittals.

.2 A care of water plan, including Site specific drawings, outlining the care of water provisions designed as specified in clause 1.3 at least [10] [ ] days prior to commencing Work at the Site.

.3 A copy of each permit obtained (in addition to those obtained by the Minister) upon the Minister's request.

.4 Water quality tests upon the Minister's request.

1.5 QUALITY CONTROL

.1 Test the water quality [criteria] at [location] to establish its quality prior to commencement of any work at the [location].

.2 Carry out frequent water quality testing [times per month] during dewatering or other care of water operations to compare to the water quality prior to commencement of the Work.

.3 Submit water quality test results to the Minister upon request.

.4 Take necessary measures to ensure the water quality is made equal to or better than that which occurred prior to commencement of the Work.

1.6 QUALITY ASSURANCE

.1 Sampling by the Minister

.1 [ ]

.2 Testing by the Minister

.2 [ ]

2.0 PRODUCTS – NOT USED

3.0 EXECUTION

3.1 GENERAL

.1 Provide, operate, and maintain all necessary cofferdams, channels, flumes, drains, well points, wells, sumps, pumps, pipelines, and other temporary diversion and protection works.

.2 Provide, operate, and maintain all cold weather protective works including enclosures, insulation, and heating systems.

.3 Have at the Site at all times, at least one standby pump for each category of pump being used for care of water.

.4 Provide standby power sufficient for operation of all required care of water equipment.

.5 Inspect care of water pump and pipeline systems at regular intervals not exceeding 12 hours and verify that the pumps are operating, there is sufficient fuel, and cold weather protection is adequate. If required, decrease the time interval between inspection check to correspond with the type and nature of weather and the work in progress, to the satisfaction of the Minister.

.6 Repair damage to any part of the Work caused by water, snow, or ice due to failure of the care of water measures. Perform additional excavations and fill placement made necessary by water, snow, or ice.

.7 When no longer required, remove cofferdams, sumps, channels, drains, and other protective, dewatering, and temporary diversion works and finish to a leveled and neat condition.

3.2 ENVIRONMENTAL PROTECTION

.1 Do not use care of water measures that cause pollution.

.2 Do not cause damage to property or nuisance on roads, or injury to the public or to wildlife due to discharge of water from the care of water measures.

.3 Provide and maintain sediment ponds or other means to remove sediment from the water prior to allowing it to enter or return into the watercourse. Dispose of sediments in waste disposal areas.

END OF SECTION

13. AT Civil Works Master Spec 02910 Topsoil Subsoil Placement

1.0 GENERAL

1.1 EXTENT OF TOPSOIL AND SUBSOIL PLACEMENT

.1 Topsoil placement is required on exposed finished excavation surfaces, finished fill surfaces, ground areas affected by the Work, and other areas as specified in the Contract Documents or as designated by the Minister.

.2 Subsoil placement is required on prepared surfaces [where Subsoil has been removed as a separate operation] [in borrow areas] as specified in the Contract Documents or as directed by the Minister, prior to placement of Topsoil.

.3 The Minister may adjust the placement thickness of Topsoil and Subsoil to best utilize the available materials.

1.2 REFERENCES

.1 Provide Topsoil and Subsoil placement in accordance with the following standards (latest revision) except where specified otherwise.

.2 American Society for Testing and Materials (ASTM)

.1 ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12400 ft-lbf/ft3 (600 kN-m/m3))

.3 Alberta Transportation

.1 Field Guide for Erosion and Sediment Control available at www.transportation.alberta.ca

.2 Post-Disturbance Reclamation Criteria and Assessment Procedures for Borrow Excavations for Road Construction.

1.3 SUBMITTALS

.1 Provide the following submittals.

.2 A post-disturbance assessment report of each Contractor provided Borrow Area within [30] days after the completion of the reclamation work including Topsoil placement at each borrow area.

1.4 INITIAL POST-DISTURBANCE ASSESSMENT BY THE MINISTER

.1 Notify the Minister when reclamation work including Topsoil placement has been completed.

.2 Within [10] days of such notification, the Minister will undertake an initial post-disturbance assessment including inspection of the on-Site areas, except for Contractor provided Borrow Areas. The post-disturbance assessment will be conducted in accordance with Alberta Transportation's Post-Disturbance Reclamation Criteria and Assessment Procedures for Borrow Excavations for Road Construction document, with the exception that the vegetation component of the assessment will not be carried out. The Minister will notify the Contractor of the results of the assessment, including any deficiencies, within [15] days of the post-disturbance inspection.

.3 Contractor to repair any deficiencies and repeat the post-disturbance assessment at no cost to the Minister.

1.5 POST-DISTURBANCE ASSESSMENT BY THE CONTRACTOR

.1 For each Contractor Provided Borrow Areas, conduct a post-disturbance assessment in accordance with Alberta Transportation's Post-Disturbance Reclamation Criteria and Assessment Procedures for Borrow Excavations for Road Construction document, with the exception that the vegetation component of the assessment will not be required.

.2 Retain the same soil specialist who performed the pre-disturbance assessment as specified in Section 02234 – Topsoil and Subsoil Stripping to conduct the post-disturbance assessment of each Contractor Provided Borrow Area.

.3 Complete the post-disturbance assessments within [15] days of the completion of the reclamation work including Topsoil placement.

.4 Repair any deficiencies and repeat the post-disturbance assessment at no cost to the Minister.

1.6 MINISTER SUPPLIED MATERIALS

.1 The following existing stockpiled materials [are available for use], [are to be used] to the extent required for the Work.

Material	Location of Stockpile	Quantity
[Topsoil]	[ ]	[ ]
[Subsoil]	[ ]	[ ]

2.0 PRODUCTS

2.1 MATERIALS

.1 Provide materials in accordance with the following:

.2 Topsoil: Refer to Section 02234 – Topsoil and Subsoil Stripping for material specifications. Provide Topsoil from [stockpiles of materials produced from required stripping operations] [, and stockpiles of Minister supplied Topsoil].

.3 Subsoil: Refer to Section 02234 – Topsoil and Subsoil Stripping for material specifications. Provide Subsoil from [stockpiles of materials produced from required stripping operations] [, and stockpiles of Minister supplied Subsoil].

3.0 EXECUTION

3.1 PREPARATION

.1 Locate and protect utility lines, fencing, survey reference points, instrumentation, structures, culverts, and all other items before commencement of the Work.

3.2 SUBSOIL PLACEMENT [IN BORROW AREAS]

.1 Remove snow, ice, excess water, and deleterious materials from surfaces to receive Subsoil. Do not commence Subsoil placement until the Minister has inspected the prepared surface areas. Rectify any defects identified by the Minister.

.2 Prior to placement of subsoil, scarify foundation 500 mm deep once in the longitudinal direction and once in the perpendicular direction in areas with a width greater than 10 m or in a diagonal direction if the width is less than 10 m. Pick rocks 70 mm or larger.

.3 Place Subsoil to a uniform thickness on prepared surfaces of the borrow areas as directed by the Minister, prior to placement of Topsoil.

.4 Place Subsoil in an unfrozen condition in continuous horizontal lifts not exceeding 300 mm in thickness without voids or bridging of material. Spread and compact each lift to obtain a Standard Proctor Density of between 75% and 85% in accordance with ASTM D698.

3.3 SUBGRADE PREPARATION PRIOR TO TOPSOIL PLACEMENT

.1 Remove excess water from subgrade surfaces.

.2 Grade the subgrade area to eliminate uneven areas and to provide proper drainage.

.3 Prior to placement of Topsoil, scarify foundation 500 mm deep once in the longitudinal direction and once in the perpendicular direction, pick rocks 70 mm or larger.

.4 If Subsoil was placed, disc the Subsoil area to a minimum depth of 100 mm but not deeper than thickness of Subsoil. Disc the entire subgrade area once in the longitudinal direction, and once in the perpendicular direction.

.5 Remove roots, rocks greater than [70] mm in diameter, debris, and other deleterious materials that are on top of the subgrade.

.6 Disc the subgrade area when lumps larger than 70 mmm are prevalent.

3.4 TOPSOIL PLACEMENT

.1 Do not commence Topsoil placement until the Minister has inspected the prepared subgrade. Rectify any defects as required by the Minister.

.2 Topsoil placement will not be allowed to proceed, if in the opinion of the Minister, there is inadequate soil moisture after seeding for germination and there will be insufficient time left in the growing season to allow the vegetation to root and thereby minimize soil erosion.

.3 Place Topsoil in an unfrozen condition, in dry, calm weather.

.4 Spread the Topsoil to provide a uniform thickness over the entire area as specified in the Contract Documents or as directed by the Minister.

.5 Remove weeds, roots, rocks greater than [70] mm in diameter, debris, and other deleterious materials from the Topsoil.

.6 Manually spread Topsoil around structures, culverts, fences, instruments, or other obstructions.

.7 Grade the Topsoil to eliminate uneven areas, and to provide positive drainage.

.8 Use the track weight of a crawler tractor or dozer to compact Topsoil.

.9 Minimize traffic on placed Topsoil to prevent over–compaction [beyond the compaction results determined in the pre-disturbance assessment as specified in Section 02234 – Topsoil and Subsoil Stripping]. If Topsoil becomes over-compacted, rework to meet specified requirements.

3.5 FINISH GRADING (SURFACE PREPARATION) PRIOR TO SEEDING

.1 Fine grade Topsoil areas to remove humps and hollows.

.2 Cultivate to a depth of 150 mm and in a direction perpendicular to the local drainage pattern. Harrow the Topsoil surface to produce a loose friable bed to a depth of not less than 25 mm prior to seeding.

.3 Provide a finished Topsoil surface that is ready for seeding, and that does not require additional preparation of any kind.

.4 Seeding will not be permitted on hardened, crusted or rutted soil.

3.6 SURFACE TRACKING PRIOR TO HYDROSEEDING

.1 Surface Tracking is the roughening of the Topsoil moving a tracked tractor or dozer, or other mechanical means acceptable to the Minister, up and down the slope leaving depressions perpendicular to the slope direction, to provide a serrated texture that will reduce erosion potential.

.2 Perform Surface Tracking in accordance with Alberta Transportations B.M.P. #34 (a-c) of the Field Guide for Erosion and Sediment Control, except as modified herein.

.3 Perform Surface Tracking prior to Hydroseeding.

.4 During Surface Tracking, avoid turning movements or changes in directions that causes loosening or disturbance of the Topsoil. Limit the number of track passes to 1 or 2 times to avoid overcompaction.

.5 Surface Track the following areas:

 .1 All cut and fill slopes with slopes steeper than 3H:1V with a vertical height greater than 1.5 m.

 .2 All cut and fill slopes with a slope length greater than 8 m regardless of the actual slope.

3.7 CLEAN-UP

.1 Dispose of roots, debris, and other deleterious materials at the specified waste disposal area or at an off-Site waste disposal facility.

.2 Pick and dispose of any rocks greater than [70] mm diameter that appear prior to the date of [Substantial Performance of the Work] [Warranty Performance of the Work].

END OF SECTION

14. AT Civil Works Master Spec 02930
Soil Erosion Protection

1.0 GENREAL

1.1 [REFERENCES]

.1 Provide soil erosion protection in accordance with the following standards (latest revision) except where specified otherwise.

.2 American Society for Testing and Materials (ASTM)

.1	ASTM D4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
.2	ASTM D4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
.3	ASTM D4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
.4	ASTM D4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
.5	ASTM D4751	Standard Test Method for Determining Apparent Opening Size of a Geotextile.
.6	ASTM D4833	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.

1.2 SUBMITTALS

.1 Provide the following submittals.

.2 Product data at least 30 days prior to delivering the materials to the Site.

.3 Manufacturer's written instructions for handling, storing and installing materials prior to performing the work.

1.3 DELIVERY, STORAGE, AND HANDLING

.1 Inspect each shipment of material and timely replace any damaged materials.

.2 Handle and store products in accordance with the manufacturer's written instructions and protect them from damage, contamination, or deterioration. Store all packaged or bundled products in their original packaging. Do not remove products from the packaging or bundling until required.

2.0 PRODUCTS

2.1 MATERIALS

.1 Provide materials in accordance with the following.

.2 Silt Fences:

.1 Silt fence consisting of a woven polypropylene fabric having the following physical properties:

Property	Requirement	Test Method
Mass Per Unit Area	[ ] g/m^2	
Grab Tensile (MD/CD)	[ ] N	[ASTM D4632]
Grab Elongation (MD/CD)	[ ] %	[ASTM D4632]
Trapezoidal Tear Strength	[ ] N	[ASTM D4533]
Puncture Strength	[ ] N	[ASTM D4833]
Apparent Opening Size	[ ] microns	[ASTM D4751]
Ultraviolet Resistance (min.)		[ASTM D4355]

OR

.2 Fence fabric consisting of a woven polypropylene fabric. Products and manufacturers include [ ].

.3 [50 mm by 50 mm] wooden stakes.

.4 [wire mesh] backing to support the fence fabric.

.3 Straw Crimping Material: Flexible oat straw free of weeds, and growth and germination inhibiting ingredients, in a form suitable for crimping.

.4 Hydro-Mulch and Tackfier:

.1 Hydro-Mulch: Wood or wood cellulose fibre mulch, 100% biodegradable, compatible with the environment, free of growth and germination inhibiting factors, free of weeds, and free of other deleterious matter.

.2 Tackifier: A polymer or resin tackifier, for use with the mulch, capable of joining the mulch particles together and securing the mulch to the ground.

.3 Provide hydro-mulch and tackifier that does not form an impervious seal which prevents moisture from reaching the underlying soil.

.4 Water: Free of impurities that would inhibit or adversely affect germination and growth.

.5 Application rate:

.1 Apply the hydro-mulch at the rate [of 1150 kg/hectare] [recommended by the manufacturer],

.2 Apply the tackifier at the rate recommended by the manufacturer.

.5 Natural Fibre Blankets:

.1 Blanket consisting of 100% agricultural straw layered with [2 photodegradable polypropylene nets, and having a minimum mass of [ ] g/m^2.] Products and manufacturers include [ ].

.2 Blanket consisting of 30% agricultural straw and 70% coconut fibre layered with [a photodegradable polypropylene top net and a UV stabilized bottom net, and having a minimum mass of [ ] g/m^2.] Products and manufacturers include [ ].

.3 Blanket consisting of 100% coconut fibre layered with [2 UV stabilized polypropylene nets, and having a minimum mass of [ ] g/m^2.] Products and manufacturers include [ ].

.6 Synthetic Fibre Blankets:

.1 Blanket consisting of 100% agricultural straw layered with 2 photodegradable polypropylene nets, and having a minimum mass of [ ] g/m^2. Products and manufacturers include [ ].

.7 Natural Fibre Mats:

.1 Mats consisting of biodegradable woven jute with an open area of [ ]% and a minimum mass of [ ] g/m^2. Products and manufacturers include [ ].

.8 Synthetic Fibre Mats:

.1 Turf reinforcement mat consisting of a 3 dimensional structure formed by mechanically securing 2 high strength and high modulus bi-axially oriented grid above and below a corrugated centre grid, and manufactured from UV stabilized polypropylene or polyolefin fibres.

.2 Turf reinforcement mat to have the following physical properties:

Property	**Requirement**	**Test Method**
Mass Per Unit Area	[ ] g/m^2	
Tensile Strength	[ ] kN/m	[ASTM D 4595]
Tensile Elongation	10% min., [ ]% max.	[ASTM D 4595]
UV Resistance @ 1000 hours	80%	[ASTM D 4355]
Ground Cover Factor	[ ]%	[Light Projection Analysis]

OR

.3 Products and manufacturers include [ ].

.9 Cellular Confinement System:

.1 [Perforated] [Non-perforated] honeycombed high density polyethylene cell confinement system fabricated from minimum [1.25] mm thick UV stabilized polyethylene sheet. Minimum density of polyethylene to be [0.96] g/cm^3. Cell size [mm by mm by mm deep] when expanded. Products and manufacturers include [ ].

.10 Anchors:

.1 Staples or other anchors as recommended by the [blankets] [mats] manufacturer.

.2 Mild steel J-pin anchors or rebar fitted with Atra clips for the honeycombed polyethylene cell confinement system.

.11 [ ].

3.0 EXECUTION

3.1 INSTALLATION - GENERAL

.1 Install soil erosion protection at the locations and areas, and to the lines, grades, slopes, and elevations specified in the Contract Documents.

.2 Install soil erosion protection materials in accordance with the manufacturer’s written instructions.

.3 Prepare receiving surfaces in accordance [with the Contract Documents] [with the manufacturer's written instructions] and have them inspected by the Minister prior to installing soil erosion protection materials. Rectify defects.

.4 Do not allow any construction equipment or vehicles to travel on the soil erosion protection materials. Replace any materials that are damaged or displaced.

3.2 SILT FENCE

.1 Anchor the bottom of the fabric by excavating a 150 mm deep trench, placing the fabric, and backfilling as specified in the Contract Documents.

.2 Drive stakes into the ground as specified in the Contract Documents.

.3 Install [wire mesh backing and] the fabric.

.4 Inspect, maintain, remove and dispose silt fencing as specified in Section 01392 – Environmental Management.

3.3 CRIMPING

.1 Carry out straw crimping after Topsoil placement and seeding are completed.

.2 Use equipment fitted with notched coulter blades or other straw crimping equipment as authorized by the Minister.

.3 Spread oat straw at [2.0] tonnes/hectare on areas to be crimped.

.4 Push straw 50 mm into the ground to form rows [200] mm apart. Crimp evenly so that the straw is folded, not broken, and the ends are nearly vertical.

3.4 HYDRO-MULCH AND TACKIER

.1 Measure the quantities of materials by weight.

.2 Use hydraulic application equipment including slurry tank, agitation system, pumps, hoses, and nozzles.

.3 Apply the materials during calm weather.

.4 Add materials into the hydraulic applicator under agitation to produce a thoroughly mixed slurry.

.5 Apply the slurry uniformly, and at the optimum angle for adherence to surfaces.

3.5 FIBRE BLANKETS

.1 Install blankets after Topsoil placement and seeding are completed.

.2 Anchor the blanket at the top of the slope by excavating a trench, installing the blanket, and backfilling as specified in the Contract Documents. Unroll the blankets in a [downslope] [downstream] direction.

.3 Place blankets loosely and in full contact with the ground.

.4 Overlap the side edges of adjacent blankets so that they are shingled away from the [prevailing wind] [water flow] direction. Provide a minimum overlap of [150] mm.

.5 Overlap the bottom edge of the [upslope] [upstream] blanket on top of the top edge of the [lower] [downstream] blanket. Provide a minimum overlap of [300] mm.

.6 Staple or anchor edges in accordance with the manufacturer’s written instructions.

3.6 FIBRE MATS

.1 Install mats after Topsoil placement and seeding are completed.

.2 After installation, fill the mat structure with 15 to 20 mm of Topsoil.

.3 Anchor the mat at the top of the slope by excavating a trench, installing the mat, and backfilling as specified in the Contract Documents. Unroll the mats in a [downslope] [downstream] direction.

.4 Place the mat loosely and in full contact with the ground.

.5 Overlap the side edges of adjacent mats so that they are shingled away from the [prevailing wind] [water flow] direction. Provide a minimum overlap of [150] mm.

.6 Overlap the bottom edge of the [upslope] [upstream] mat on top of the top edge of the [lower] [downstream] mat. Provide a minimum overlap of [300] mm.

.7 Staple or anchor edges in accordance with the manufacturer's written instructions.

3.7 POLYETHYLENE CELL

.1 Place the polyethylene cell on the subgrade and expand it in the downslope direction. Use anchors to correctly position, align, and uniformly expand the polyethylene cell to the required dimensions.

.2 Join adjacent cell panels using galvanized staples is accordance with the manufacturer's written instructions.

.3 Avoid displacement of the expanded cells by placing Topsoil starting from the top and working in a downslope direction.

.4 Limit the vertical drop of the Topsoil to a maximum of 500 mm.

.5 Overfill the cell slightly with Topsoil and lightly tamp or roll the Topsoil to leave it flush with the top edge of the cells.

3.8 [ ]

END OF SECTION

15. AT Civil Works Master Spec 02244 Fish Capture

1.0 GENERAL

1.1 GENERAL

.1 Fish capture is required [location].

.2 Fish capture is required prior to dewatering the [downstream portion of the canal] [ ].

.3 Provide the services of a Qualified Aquatic Environmental Specialist (QAES) as defined in the Alberta Environment's Code of Practice for Watercourse Crossings to do the following:

.1 Determine the presence of fish.

.2 Develop a written Fish Capture and Release (FC&R) Management Plan outlining the following:

.1 Site preparations for FC&R.

.2 The locations of fish capture.

.3 The fish isolation methods.

.4 The locations for cofferdams, nets, and other capture structures.

.5 The locations for related equipment and set up.

.6 The water depths required for fish capture including drainage of draw-down methods.

.7 The fish capture, mobilization and release methods.

.8 The fish release location.

.9 The number of working days for fish capture activity.

.10 The pump intake screens in accordance with Regulatory Requirements including the Department of Fisheries and Oceans.

.11 The size and location of the ice-free pool for FC&R operations.

.12 The methods of protection of the fish during all operations of the FC&R.

.3 Obtain the Fish Research License from Alberta Sustainable Resource development.

.4 Obtain and follow policies with respect to fish capture and release including Alberta Fisheries Management Policy respecting injuries to fish

.5 Supervise the FC&R operation in accordance with the FC&R Management Plan, including on-site supervision for the capture and release activities.

.6 Record fish capture and release activities and results and submit to the Minister.

.7 The Contractor shall have the option of obtaining the services of the Minister's QAES to perform the capture, salvage and release Work, provided the QAES is not a direct employee of the Minister's Assistants. The name and contact information of the Minister's QAES will be provided by the Minister's Assistants upon request.

1.2 REFERENCES

.1 Provide fish capture and release in accordance with the following standards (latest revision) except where specified otherwise.

.2 Water Act [Definition of QAES].

.3 Alberta Fisheries Management Policy [re: injuries to fish].

.4 [Policies regarding fish capture and release.]

1.3 SUBMITTALS

.1 Provide the following submittals.

.2 FC&R Management Plan as outlined in clause 1.1.3.2, 7 days prior to commencement of FC&R activities.

.3 Field activity and results records and an additional copy as required by the Fish Research Licence upon completion of the FC&R activities.

1.4 PAYMENT

.1 Fish capture and release will be valued in accordance with Section 00725 – General Conditions, clause 8.3 - Valuation of Changes in the Work.

2.0 PRODUCTS - NOT USED

3.0 EXECUTION - NOT USED

END OF SECTION