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:

- Temporary Measures: Those measures during the construction phase that will be completely removed once permanent measures are installed and/or vegetative cover is established; and
- Permanent Measures: 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				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	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
	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
	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				Comments	
			Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	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
	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
	Storm Drain Inlet/Sediment Barrier	6			✓		Temporary measure; easy to install and remove	Limited sediment entrapment capacity; requires regular clean-out maintenance
	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.