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 at construction projects as follows:

- Erosion Control is the process whereby the potential for erosion is minimized; and
- Sedimentation 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 sedimentation control should be viewed as a contingency plan. As such, a greater emphasis shall 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 sedimentation control are required for most sites.

The design of erosion and sedimentation 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 sedimentation control measures should be expected to evolve throughout construction to varying degrees based on site conditions and field performance of implemented measures.

Erosion and sedimentation control measures are classified into the following categories and best management practices (BMPs):

- 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 sedimentation control measures required to meet the objectives as outlined above can be classified into two categories:

- Temporary Measures: Those measures during the construction phase that will eventually be completely removed to facilitate further construction that has other erosion control measures associated with it, and
- Permanent Measures: Incorporated into the overall design of the development to address long-term post construction erosion and sedimentation control.

Temporary erosion and sedimentation control measures should be constructed at the start of the construction phase. However, additional measures will likely need to be constructed throughout construction. Permanent erosion and sedimentation control measures can be constructed during or at the end of the construction phase.

A listing of erosion and sediment control measures (BMPs) are presented in Tables C-1, C-2 and C-3 in Appendix C. Examples of temporary measures include topsoiling, seeding, slope texturing, straw bale check dam, synthetic permeable barrier, mulching, RECP coverings, silt fence, fibre rolls and wattles, straw bale barriers, etc. Examples of permanent measures include offtake ditch, energy dissipator, earth dyke, 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. Examples of good practice to be undertaken by the contractor at the beginning of construction phase may include:

1) Silt fence and sediment pond/basin along site perimeter for sediment control;
2) Offtake ditch to intercept and divert runoff from construction area;
3) Proper planning and scheduling for timely implementation of appropriate BMPs.

7.2 Minimum Requirements (Planning Strategy)

Proper planning generally constitutes the minimum requirements for preparing an erosion and sedimentation control strategy. 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 sedimentation control measures implemented on a site is highly dependent on proper implementation of the minimum requirements for an erosion and sedimentation control plan.

The minimum requirements for an erosion and sedimentation control strategy are presented in Table 7.1.

7.2.1 Understand the Practice of Erosion and Sediment Control (ESC) as a Whole System

It is important that the designer/contractor recognizes that a successful implementation of ESC measures requires a good understanding of the principles of the ESC process both by the design and field staff. The correct installation of BMPs to specific site conditions and ongoing timely upgrading and maintenance are essential for successful outcome. The planning strategies and structural BMPs presented in this document are as equally important as the conceptual understanding of the principles of their implementation to ensure good construction performance and protection of the environment.

It is essential to practice ESC measures in a wholesome manner with interaction at the education, learning, planning, construction and post-construction stages.

Table 7.1: Minimum Requirements (Planning Strategies) for Erosion and Sediment Control Plan

BMP Name	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Minimize Exposed Soils	X	X	X	X	Decrease of disturbed soil area decreases erosion potential and decreases quantity of sediment and sediment control measures required thus decreasing costs	May require efficient scheduling of topsoiling/seeding completed areas before stripping of new areas
Operate During Fisheries Windows	X	X	X	X	Minimizes possible negative impacts on aquatic wildlife	May affect schedule of adjoining works
Maximize Favourable Weather	X	X	X	X	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	X	X	X	X	Early installation of sediment and erosion control measures ensures sediment losses are minimized during construction and provide good housekeeping	May cause difficulties with site access or traffic
Avoid Wet Weather Periods	X	X	X	X	Avoiding construction in wet weather periods minimizes erosion potential	Shutdowns may prolong/delay construction activities
Topsoil and Seed Early	X	X	X		Topsoiling and seeding as early as possible covers exposed soil and reduces erosion potential	
Surface Roughen (Slope Texturing)	X		X	X	Texturing of soils along contours reduces erosion potential by as much as 10%	Equipment may need to be retasked at a slight increase in costs
Preserve and Use Existing Drainage Systems	X	X	X	X	Preserve existing drainage and vegetation.	Care must be taken to observe drainage directions
Control Construction Traffic				X	Controlling where traffic is allowed avoids over-trafficking sensitive areas or areas with increased disturbance	Forcing traffic into localized areas may increase disturbance in high-traffic areas
Signage	X	X	X	X	Clearly labeling sensitive zones or areas not to be disturbed ensures all workers on-site are aware of where work can occur and where it cannot thus minimizing confusion	Increased costs of signs
Scheduling of Work	X	X	X	X	Placement of topsoil and seeding should be scheduled throughout construction phase. New sections should not be stripped well in advance of construction.	May require construction to be completed in one area before starting in another.
Stockpile Control				X	Stockpiles should be located well away from watercourses and environmentally sensitive areas.	May result in longer haul distances.
Direct Surface Water Flow Around Site	X	X	X	X	Keeps surface water from off-site from increasing potential for erosion and sedimentation.	Diversion ditches may require erosion and sedimentation. Control measures to be implemented.

7.3 Best Management Practices (BMPs) for Erosion Control

BMPs for erosion control are various measures that have been proven to work on past 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. They are listed as follows:

- Source Control BMPs for protection of exposed surfaces; and
- Conveyance BMPs for control of runoff.

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 ensure that BMPs are appropriate for site conditions.

An erosion control plan may involve the use of bio-engineering methods. Bio-engineering methods are a permanent erosion control measure that involve using the roots, stems and leaves of vegetation to reduce the potential for erosion. This is achieved by increasing the mechanical and hydrological benefit to the soils by introducing foliage that decreases impact erosion of rain drops, increases infiltration of rain into the soil and anchoring the soil with root systems. As the plants grow, the strength of the bio-engineered erosion control system strengthens. Typically bioengineering is used to prevent erosion where there are environmental or aesthetic enhancement requirements; however, if properly selected, it will provide simple and cost effective measures for controlling long-term erosion problems. Re-vegetation of exposed soil with locally compatible grass growth on topsoil is the main bio-engineering erosion control method utilized in highway construction in Alberta.

BMPs commonly utilized in highway construction in Alberta are presented in Appendix C.

<u>Protection of Exposed Surfaces</u>

The protection of exposed surfaces from the erosive energy of rain splash, surface runoff flow and wind should be the primary goal when selecting appropriate control measures. Cover is the single most effective erosion control practice or 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 protection of exposed surfaces is presented in Table 7.2 with their respective advantages and limitations.

Control of Runoff

During construction it will not always be possible or practical to provide surface cover for all disturbed areas. Commonly used methods for protecting exposed ground surfaces 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 control of runoff is presented in Table 7.3 with their respective advantages and limitations.

Table 7.2: Erosion Control Measures – Protection of Exposed Surface

BMP Name	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Topsoiling	X	X	X	X	Placing topsoil provides excellent medium for vegetation root structure to develop in; organic content promotes plant growth, reuse organics (topsoil or peat) stripped from the site at start of grading; absorb 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
Seeding	X	X	X	X	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
Mulching	X	X	X	X	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 not commonly used in typical highway construction
Hydroseeding-Hydromulching	X	X	X	X	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 dust and 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
Sodding	X	X	X	X	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 (hand installation), 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)
Riprap Armoring	X	X			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, flexible lining for ditches with ice build-up	Expensive, may require heavy equipment to transport rock to site and place rock, may not be feasible in areas of the province where appropriate rock is not readily available, may be labour intensive to install (hand installation); generally thickness of riprap is higher when compared to gabion mattress

Table 7.2: Erosion Control Measures – Protection of Exposed Surface

BMP Name	Applications				Comments	
	Slopes	**Ditches and Channels**	**Large Flat Surface Areas**	**Borrow and Stockpile Area**	**Advantages**	**Limitations**
Gravel Blankets	X	X			Stabilizes soil surface with rock lining thus minimizing erosion, permits construction traffic in adverse weather, may be used as part of permanent base construction of paved areas, easily constructed and implemented, can be used to stabilize seepage piping erosion of slope	Must be designed by qualified geotechnical personnel, expensive, may not be feasible in areas of the province where gravel is not readily available, areas of high groundwater seepage may require placement of non-woven geotextile underlay and additional drainage measures
Rolled Erosion Control Products (RECP)	X	X			Provides a protective covering to bare soil or topsoiled surface where degree of erosion protection is high, can be more uniform and longer lasting than mulch, wide range of commercially available products	RECP use must be based on design need and risk assessment of site, certification on QA/QC of RECP products must be issued by the AT approved supplier on pre-approved products, certification of physical properties and performance criteria (tractive resistance) is required (permissible velocities can be provided as reference), 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
Cellular Confinement System	X	X		X	Lightweight cellular system and easily installed, uses locally available soils or grout for fill to reduce costs	Not readily used in Alberta highway construction, expensive, installation is labour intensive (hand installation), not suitable for slopes steeper than 1H:1V
Planting Trees and Shrubs	X		X	X	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 readily 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
Chemical Stabilization	X	X		X	Increase cohesion of soil thus reduces soil moisture evaporation and erosion, easily applied, may be applied in conjunction with hydroseeding-hydromulching, longevity increases as application rate increases	Not commonly used in highway construction projects, may be expensive, site must be accessible to spraying equipment, may require specialized equipment, temporary measure only, higher application rates may prevent seed germination and growth, crust-forming chemical stabilizers may crack during freeze-thaw cycles, requires specialized design
Riparian Zone Preservation	X	X	X	X	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	Stipulate construction activities with careful planning to include preservation areas, freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment

Table 7.2: Erosion Control Measures – Protection of Exposed Surface

BMP Name	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Scheduling	X	X	X	X	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; good construction practice	
Slope Texturing	X			X	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 – Control of Runoff

BMP Name	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Slope Texturing	X		X	X	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
Offtake Ditch	X		X	X	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
Energy Dissipator	X	X			Rip rap or sandbags slow 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 rip-rap 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
Slope (Down) Drains	X				Directs surface water runoff into drain pipe instead of flowing over and eroding exposed soils of slope face	Pipes 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
Gabions		X			Relatively maintenance free, permanent drop structure, long lasting (robust), less expensive and thickness than rip-rap, 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		X		X	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
Aggregate Filled Sand Bag Check Dam		X		X	More effective as energy dissipator to slow flow velocities, cheaper than gabions or armouring entire ditch, easily constructed and reusable	Not appropriate for channels draining areas larger than 2 ha (5 acres), requires extensive maintenance after high flow storm events, low filtering capabilities, labour intensive to install (hand installation), temporary measure only

Table 7.3: Erosion Control Measures – Control of Runoff

BMP Name	Applications				Comments	
	Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Log Check Dam		X			Equally effective as silt fences for sediment trapping and straw bale barriers as drop structure, may include timber salvaged from site during clearing operations, most applicable at clearing/grubbing stages of construction	May be expensive, not commonly used after stripping stage, not appropriate for channels draining areas larger than 4 ha (10 acres), labour intensive to construct, gaps between logs may allow sediment laden runoff to escape, logs/timbers will rot over time (not permanent)
Straw Bale Check Dam		X		X	Temporary drop structures appropriate for channel slopes with 3% to 5% grades, straw bales are readily available in most areas of the province, biodegradable	Temporary measure only; not appropriate for: channels draining areas larger than 2 ha (5 acres), channels steeper than 5%, and/or flow velocities greater than 0.3 m/s; requires extensive maintenance after high flow storm events, must be installed by hand with keying and staking; maximum height of one straw bale
Synthetic Permeable Barriers		X			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
Groundwater Control (Subsurface Drain)	X				Relief subsurface groundwater seepage and winter ice build-up; lower groundwater table to minimize piping erosion; enhance slope stability performance	Requires design by a geotechnical engineer; can be a slope instability issue
Fibre Rolls and Wattles	X				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
Scheduling	X	X	X	X	Identifies protection issues and plans for efficient, orderly construction of BMPs; minimizes bare soil exposure and erosion hazard; early installation of perimeter control for sediment entrapment; and early installation of runoff control measures; good construction practice	

7.4 Best Management Practices (BMP) for Sedimentation Control

BMPs for sedimentation control are various measures that have been proven to work on past construction sites when they were properly planned and constructed. These measures reduce off-site sedimentation potential by promoting sedimentation before surface water flows leave the construction site. There are generally two types of BMPs that can be used in conjunction with the minimum requirements and an erosion control plan. They are as follows:

- Filtering (and Entrapment) BMPs; and
- Impoundment 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 ensure that BMPs are appropriate for site conditions.

A sedimentation control plan may involve the use of bio-engineering methods. Bio-engineering methods are a permanent sedimentation control measure 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 7.4 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 fiber filters). Filtering can be effectively applied to concentrated channels flows at inlets of permanent or temporary drainage systems and outlets of sedimentation ponds. This application requires careful maintenance to ensure continued effectiveness as sedimentation can clog these measures during storm events.

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 sedimentation control.

The most commonly used filtering method is silt curtains or fences. These measures are 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^3/sec) and gentle grade (<3%). This method should only be used when there are small runoff flow rates and volumes. Otherwise, effectiveness decreases and the system will be undermined or breached. Bales of straw do not filter sediments, however, straw bales can be used as temporary drop structures to slow down flow velocity and trapping sediments. Check dams constructed from coarse granular material should be selected for situations for steep grades where high flow velocity or volumes are anticipated.

The design of filtering BMPs is discussed in Appendix G.

Impoundment BMPs

The temporary impoundment of sediment-laden flow surface runoff lowers its internal energy by reducing flow velocity which promotes sedimentation. However, sedimentation may take a long time if the suspended sediments have 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. The types of impoundment structures are listed as follows:

- Sedimentation basin/trap designed for large runoff area; and
- Temporary filter barriers (silt fence, synthetic weave barrier, rock check) along ditch or slope toe areas.

The design of impoundment BMPs are discussed in Section 12. A number of variations to the basic design could be used ranging from relatively small single basins to multiple interconnected basins.

Ideally, impoundment BMPs should be located within the site near the sediment source. Roadside ditches and old drainage channels can also be used as sediment entrapment areas upon installation of permeable or impermeable berms. Sediment traps/basins should be installed at perimeters of the site, especially adjoining the sensitive environmental areas. Sedimentation traps/basins may be formed through excavation and/or earth dyke together with installation of granular berm as outlet flow structure. 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 would be required to ensure that adequate capacity and drainage is maintained.

Extended detention ponds would 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 7.4: Sediment Control Measures

	BMP Name	Applications: Slopes	Applications: Ditches and Channels	Applications: Large Flat Surface Areas	Applications: Borrow and Stockpile Area	Comments: Advantages	Comments: Limitations
Filtering and Entrapment	Riparian Zone Preservation	X	X	X	X	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	Stipulate construction activities with careful planning to include preservation areas, freshly planted vegetation for newly created riparian zones requires substantial periods of time before they are as effective as established vegetation at controlling sediment
Filtering and Entrapment	Straw Bale Barrier		X	X	X	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
Filtering and Entrapment	Brush or Rock Filter Berm	X	X	X	X	More effective than silt fences, uses timber and materials salvaged from site during clearing and grubbing, can be wrapped and anchored with geotextile fabric envelope	More expensive than silt fences, temporary measure only, not effective for diverting runoff, expensive to remove, not to be used in channels or ditches with high flows
Filtering and Entrapment	Fibre Rolls and Wattles	X				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
Filtering and Entrapment	Pumped Silt Control Systems (Silt Bags)		X			Filter bag is lightweight and portable, simple set up and disposal, sediment-laden water is pumped into and contained within filter bag for disposal, different aperture opening sizes (AOS) available from several manufacturers; for emergency use only under overflow conditions	May be expensive, requires special design needs for use, not 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)
Filtering and Entrapment	Silt Fence	X		X	X	Economical, most commonly used sediment control measure, filters sediment from runoff and 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 filter fence may occur during sediment removal, usable life of approximately one year

Table 7.4: Sediment Control Measures

BMP Name		Applications				Comments	
		Slopes	**Ditches and Channels**	**Large Flat Surface Areas**	**Borrow and Stockpile Area**	**Advantages**	**Limitations**
Filtering and Entrapment	Earth Dyke/Barrier			X	X	Easy to construct, relatively inexpensive as local soil and material is used; can be easily converted to Sediment Pond/Basin (BMP #18)	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		X			Relatively maintenance free, permanent drop structure, long lasting (robust), less expensive and thickness than rip-rap, 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		X		X	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
	Aggregate Filled Sand Bag Check Dam		X		X	More effective as energy dissipator to slow flow velocities, cheaper than gabions or armouring entire ditch, easily constructed and reusable	Not appropriate for channels draining areas larger than 2 ha (5 acres), requires extensive maintenance after high flow storm events, low filtering capabilities, labour intensive to install (hand installation), temporary measure only
	Log Check Dam		X			Equally effective as silt fences for sediment trapping and straw bale barriers as drop structure, may include timber salvaged from site during clearing operations, most applicable at clearing/grubbing stages of construction	Not commonly used after stripping stage, not appropriate for channels draining areas larger than 4 ha (10 acres), labour intensive to construct, gaps between logs may allow sediment laden runoff to escape, logs/timbers will rot over time (not permanent)
	Straw Bale Check Dam		X		X	Temporary drop structures appropriate for channel slopes with 3% to 5% grades, straw bales are readily available in most areas of the province, biodegradable	Temporary measure only; not appropriate for: channels draining areas larger than 2 ha (5 acres), channels steeper than 5%, and/or flow velocities greater than 0.3 m/s; requires extensive maintenance after high flow storm events, must be installed by hand with keying and staking; maximum height of one straw bale

Table 7.4: Sediment Control Measures

	BMP Name	Applications				Comments	
		Slopes	Ditches and Channels	Large Flat Surface Areas	Borrow and Stockpile Area	Advantages	Limitations
Filtering and Entrapment	Synthetic Permeable Barriers		X			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	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 (earth-filled geotextile) Berm	X		X	X	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
Filtering and Entrapment	Storm Drain Inlet/Sediment Barrier			X		Temporary measure; easy to install and remove	Limited sediment entrapment capacity; requires regular clean-out maintenance
All BMPs	Scheduling	X	X	X	X	Identifies protection issues and plans for efficient, orderly construction of BMPs; minimizes bare soil exposure as erosion hazard; early installation of perimeter control for sediment entrapment; early dimension planning of runoff control measures; good construction practice	
Impoundment	Sediment Pond/Basin		X		X	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	Normally requires 250 m3/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,

7.5 Selection Considerations for Bioengineering Methods

The following should be evaluated when bioengineering methods are considered for use in an erosion and sedimentation control plan:

- Transport of Weeds The consultant and contractor responsible for design and implementation of bioengineering methods must ensure damaging, invasive or foreign species of plants do not get 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 an erosion and sedimentation control strategy.

- Availability of Suitable Plants An area where suitable plants for use in bioengineering methods must be within an economical distance from the proposed construction site. Furthermore, permission to harvest plants from other locations should 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 bioengineering 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 bioengineering system.

- Labour / Skill Requirements Crews can be easily trained to install bioengineering systems and the capital / energy requirements are typically low. Bioengineering can be installed using heavy equipment, however the harvesting and installation of the living plant material is conducive to a non-mechanized labor force working on sensitive sites that limit heavy equipment.

- Costs The majority of bioengineering 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, plants in bioengineering provides non-intrusive systems that enhance aesthetics as well as fishery and wildlife habitat. It is important to recognize the site sensitivities before selecting plants to be used in bioengineering. Harvesting plant species that are well climatized and appropriate to the installation site will provide the most effective bioengineering.

- Access Bioengineering 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 access sites 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 bioengineering installation by transportation of supplies and equipment and preparation of earthworks.

- Timing Bioengineering 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, bioengineering systems that experience heavy growth may require trimming particularly on projects where sight lines are important.