Saskatchewan Environment

RECLAMATION MANUAL

CONCERNING IMPACTS CAUSED BY
WILDFIRE SUPPRESSION

Saskatchewan Environment

Parks Canada Parcs Canada

ABSTRACT

Forest fires are a natural and important function of Saskatchewan's ecosystems, whether it occurs in grasslands, parklands, or the boreal forest. Since fire is a natural disturbance, reclamation is usually not required on burned area. However, wildfire suppression efforts often cause negative disturbances to ecosystems as wildfire personnel work to extinguish fires that threaten values at risk. Creating fireguards, stream crossings, access trails, fire camps, and other activities are manmade disturbances that allow access to otherwise inaccessible areas, alter or damage fish and wildlife habitat, remove and windrow valuable topsoil, productive vegetation and forest stands. This manual introduces and presents basic methods to avoid fire suppression impacts, considerations to reduce impacts of fire suppression disturbances, and measures and methods to reclaim and rehabilitate these disturbed sites.

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1. INTRODUCTION

Government agencies create and enforce environmental laws designed to protect and sustain natural resources and to minimize impacts caused by resource use. Resource industries, resource users, and government agencies are required to follow these laws and regulations. However, fire suppression is usually undertaken in hurried circumstances that constrain the time allowed for planning. Using heavy equipment to suppress and control wildfires always results in some disturbance, and given the time constraints it is difficult to select the best alternative that will cause the least impact. Saskatchewan Environment's (SE) resource stewardship goals are to return the disturbed sites back, as much as possible, to acceptable conditions.

SE forest managers are developing standards and guidelines for the woods industry, which SE Fire Management and Forest Protection (FMFP) will strive to follow for similar disturbances. FMFP is improving its management practices in part by developing an internal guideline directing reclamation efforts caused by fire suppression activities.

This manual will accompany SE FMFP Guideline #505 – Environmental Reclamation. This is the first manual edition that contains improved alternative methods, mitigation recommendations, and reclamation methods concerning impacts and disturbances caused by fire suppression activities (i.e. fireguards, camps, helipads, access trails). The manual cannot possibly deal with all possible field situations. It provides alternative methods of fire suppression and direction for dealing with the most common impacts of wildfire suppression. Comments and suggestions are welcome and may be used for improvements in subsequent editions.

This manual is targeted at any SE fire management personnel who in the discharge of their duties used heavy equipment for fire suppression or are responsible for fire line reclamation. It may be applicable to a wider audience of fire or forest management agency personnel operating within in the boreal forest.

Reclamation should be recognized as an integral part of forest fire operations and a major factor in determining suppression methods and alternative approaches to minimizing suppression disturbance. The information within this document should be considered when conducting wildfire assessments, selecting suppression tactics, completing a Wildland Fire Situation Analysis (WFSA) for related costs, and choosing equipment for the best application.

"Prior to beginning fire operations, we need to think of the effects of our actions on the environment and the costs of our actions. Cost of rehabilitation can be decreased through implementation of a proper, educated fire suppression operation. Unnecessary guards impact the environment negatively by increasing site loss, erosion potential, and increasing cost to rehabilitate and possible criminal/civil actions from other agencies or governments." – Ray Mikolash, 2001, S-346 Fire Rehabilitation

2. FIREGUARDS

2.1 ALTERNATIVES

The following is a list of alternatives to consider instead of constructing fireguards with heavy equipment (indirect methods of attack). The objective is to avoid causing negative impacts and disturbances from suppression efforts wherever it is possible:

1. Use existing trails and roads wherever possible.

2. Deploy pump crews across streams instead of constructing a stream crossing with the heavy equipment.

3. Deploy a feller-buncher or other mechanized equipment to cut a fuel break if soil exposure is not required and if time permits. Note: This may facilitate the wood fiber being utilized by woods operators instead of being buried in a windrow.

4. A hydro-axe or a mulcher is an alternative similar to a feller-buncher. A hydro-axe will mulch brush and dead organic material and create a control line without exposing mineral soil. However, this would only be effective in more open forest stands where the equipment could maneuver in between the mature trees. A mulcher can push down smaller trees, which are then broken, chipped and mulched into the uppermost level of duff and topsoil.

The path of a hydro-axe through a low-density aspen stand.

Picture of a mid-size mulcher (400hp).

5. Whenever possible utilize natural barriers as fire breaks, such as, lakes, streams, bogs, wetlands, and existing trails and roads. Use these and other natural barriers to **backfire** or **burnout** from to halt the fire progress.

6. Deploy sprinkler systems, irrigation systems, or water delivery system where the equipment and water source is available. This works well if a control line is created by a feller-buncher, hydro-axe, or mulcher. If soil exposure is not required, crawlers are effective at tramping and removing brush and deadfall with the blade in an up position. This will minimize surface disturbance.

Sprinkler line set up along an old trail where the brush was cleared off to allow access down the line.

7. Where possible deploy ground crews and pump crews to build control lines using hand tools, water packs, water pumps, and hose.

2.2 MITIGATION RECOMMENDATIONS

Building fireguards with crawlers is most efficient when three machines work together as a unit. When more than three crawlers are used there is a tendency to create more disturbance than is needed (fireguards become wider and more material is pushed into windrows). There must always be a **line locator** with the machines. The line locator is responsible for marking the most efficient fireguard route. This task should receive assistance from an aerial observer to best select the preferred fireguard route. If an observer is not available to assist, the line locator should fly over the area. The line locator should have knowledge of environmental concerns, reclamation methods, and should be familiar with the details in this manual. Good communication, operator briefings, and careful supervision all help to prevent excessive impacts from occurring. (Mikolash, 2001)

It is recommended that one support unit capable of hauling water and one ground crew work with the crawler unit. This support can extinguish hotspots, jump fires, burnouts, and monitor unburned fuels between the fireguard and the fire. This support can effectively reduce the need to create wider fireguards, resulting in fewer jump fires, less reclamation, and lower expenditures.

"The substantial costs of fire rehabilitation operations demand that protection staff have a better understanding of potential environmental impacts of suppression operations, how to mitigate these impacts and reduce overall costs to the government." – Mikolash, 2001

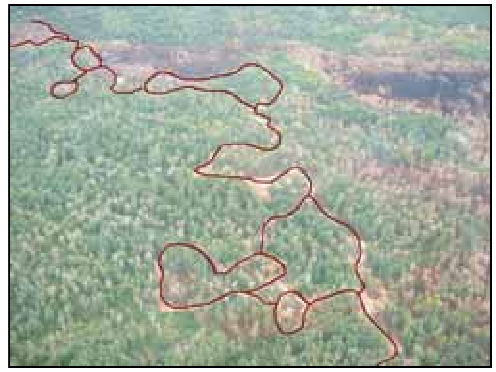
The following are **mitigation** recommendations (i.e. considerations before and during fire suppression efforts) to reduce the amount of impact caused by heavy equipment:

1. Keep the amount of fireguard built to a minimum by utilizing natural barriers such as streams, lakes, man-made barriers (roads, fields, pipelines, etc.), and the alternatives previously listed.

2. Construct fireguards as narrow and shallow as possible to minimize the amount of **duff** and **topsoil** removed. Shallow fireguards will result in more of the existing root system remaining intact, enhancing **regeneration,** especially in **hardwood** and **mixed-wood** stands.

3. When constructing fireguards in standing timber, fall the trees and push them into a windrow so that the trees are parallel to the fireguard. This makes rolling the windrow back onto the fireguard easier during reclamation. This also decreases the volume of timber that is shattered and allowing for more salvageable timber.

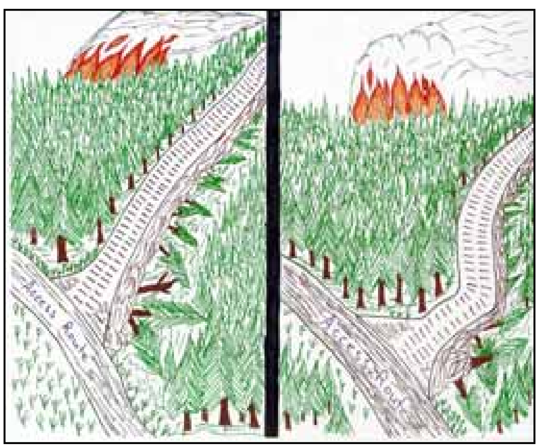
Do: Include fingers and spot fires with one fireguard.



Don't: Encircle spot fires with fireguards.

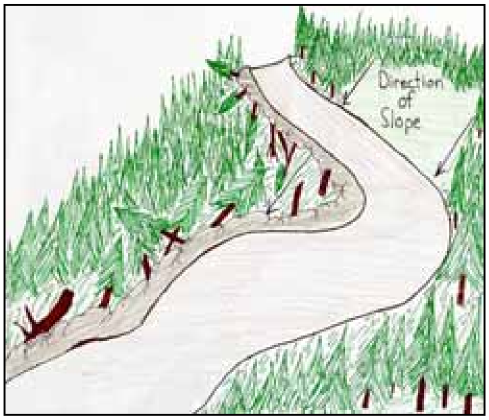
4. Avoid "chasing" spot fires and surrounding the edges of narrow fingers with fireguards. Include spot fires and fingers together wherever possible.

5. When starting a fireguard from a road/trail or approaching a road/trail, create a bend or "dogleg" (i.e. 30 degree angle) to minimize sight lines from the access point. This applies to any location the fireguard intersects a main access point.



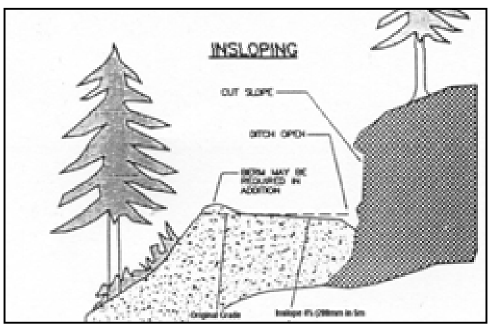
The "dogleg" (right) near the start minimizes the sightlines down the fireguard from a road or trail as compared to the straight fireguard (left).

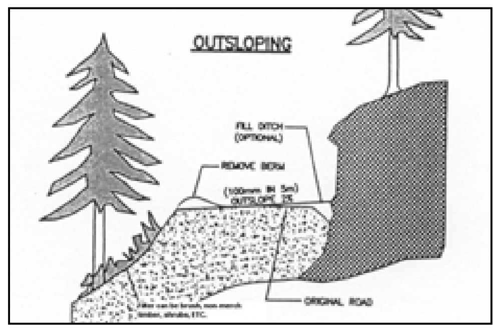
6. Avoid tree clearing and soil stripping on sandy sites and steep slopes (>15%) whenever possible. If on a steep slope, avoid constructing it directly on an up/down slope. Insert doglegs and/or run the guard at an angle. Where possible, leave patches of undisturbed ground and maintain or create surface contours to direct water from the fireguard into the surrounding vegetation to reduce erosion.



Placing a bend or a "dogleg" in the fireguard (avoiding construction straight up and down slope) minimizes the distance of water flow before it reaches the berm or enters the undisturbed adjacent vegetation.

7. On a side slope avoid pushing the berm and windrow material to the down side. Pushing material to the down side makes it is difficult to roll the material back over the exposed soil (typically a track hoe is required). Side slopes may require **insloping** or **outsloping** to direct water away from erosion prone areas until reclamation is completed.





(B.C. Ministry of Forests, 1993))

8. If a sprinkler system or an irrigation system is installed, minimize the amount of duff and topsoil removed from the fireguard to reduce the risk of erosion. The duff and vegetation will help longer-term site moisture retention.

9. Avoid stripping vegetation from boggy sites. If this is unavoidable, keep the fireguard as narrow as possible. Avoid obstructing subsurface water flow. Minimize the use of heavy equipment to prevent rutting. Note: Skidders cause the most damage in these wet areas and should only be used on dry ground.

Ruts from a skidder in a treed muskeg. All equipment can cause damage in these situations. Skidders should not be used in these areas unless equipped with high flotation tires. Ruts need to be leveled before the windrow and berm is rolled back over the fireguard.

A fireguard in a low area with water flow just below the surface. Water flow down the heavy equipment ruts created an erosion channel on exposed soil.

10. Avoid areas with dry peat moss. Dry peat moss may be several feet deep before mineral soil is reached. Constructing a fireguard down to mineral soil may result in excessive deep trenching. Where possible, construct the guard on higher ground adjacent to the peat moss where mineral soil is at a shallower depth. This also applies to ground fires burning in peat. It is less damaging and more cost effective if the fire is allowed to burn safely up to a fireguard constructed on mineral soil. <u>Utilize landscape features</u>.

A deep trench created in dry peat moss attempting to reach mineral soil. The exposed peat moss on the sides of the trench, are ideal sites for ground fires to start. This trench needs to be filled in and the surface reclaimed.

11. Avoid sensitive habitat such as nesting sites (heron colonies, nesting trees), silviculture sites, cultural sites, recreational sites, and conservation sites. Be aware of regulations outside of *The Prairie and Forest Fire Act, 1982*. When such situations are encountered, contact local SE representatives or inform the Reclamation/Rehabilitation Unit Leader on a project fire.

12. Wherever possible include diseased or insect infested forest stands within the burn. This may be difficult without ideal conditions, however fire can be beneficial to the health of jack pine infected with **mistletoe**, **decadent aspen**, spruce budworm **infested spruce**, and the surrounding forest.

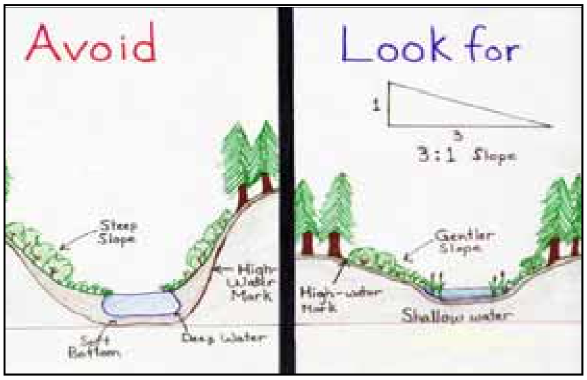
 

An example of a decadent aspen stand (left) and "witches broom" caused by mistletoe on an infected jack pine (right).

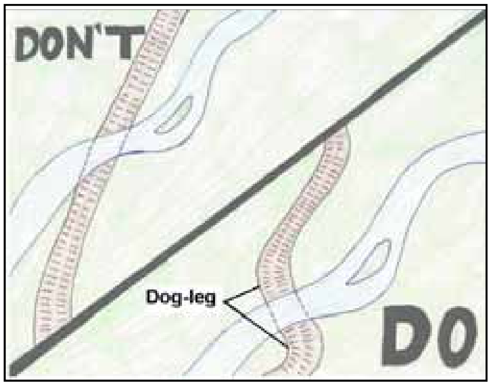
13. **Avoid crossing streams where possible!** Unnecessary stream crossings cause unnecessary damage. Avoid disturbing vegetation and soil between the **high water mark** and the stream bank or lakeshore, referred to as the **riparian area**. Ideally, there should be no mineral soil exposure in riparian areas. When other types of vehicles do not require access, cross streams with the dozer's blades in the up position.

Although this fireguard stops before the lakeshore, it should stop where the main tree line meets the riparian area.

- Cross streams at level areas where banks are low, the stream is shallow, and the streambed is solid. This will minimize cutting the bank and rutting. Construct crossings where the stream bank slope is less than 3:1.



- Construct the fireguard at a right angle to the stream instead of crossing at other significantly different angles. Use a dog-leg entry and exit to minimize erosion into the stream. Water flow down the fireguard must be directed to, and filtered through, an undisturbed area.



- If stream crossings are necessary, use logs and brush to build the crossing to minimize the amount of sediment entry into the stream. Logs and brush are easier to remove than soil material and if constructed correctly it allows some stream water to flow through.


- The removal of the riparian vegetation when constructing a crossing has many adverse effects. Riparian vegetation is critical for bank/channel stability and for preventing sediment and pollutants from entering the water.

- Assume the waterway is potential **fish habitat** (i.e. spawning beds) and minimize the amount of sediment that enters the water flow. Critical habitat may include areas with riffles, rapids, or cobble bottoms. Important lake habitat may include cobble shoals or flooded grass areas.
- When fireguards are used as access trails, that will be continuously transporting people and supplies, install stream culverts to maintain water flow. Remove them when the fire action is completed. Removing culverts may cause additional disturbances. Consult local SE staff or the Reclamation/Rehabilitation Unit Leader before installing culverts at a stream crossing.
- Fireguards crossing streams or approaching lakes should have temporary drainage and erosion controls installed. This will prevent sedimentation into the water body until proper reclamation is completed.
- Use of pump crews and ground crews around creek crossings is recommended instead of fireguards.
- Avoid disturbing fish habitat during critical spawning periods (spring spawn: April 1 – June 1; fall spawn: Sept. 15 – Nov. 1). It is especially important to avoid blocking fish-bearing streams with crossing materials.

Table 1. Timing Windows for the southern boreal forests of Saskatchewan.

	Geographic Region	
Species in Watercourse	**South of Churchill River**	**North of Churchill River[3]**
Spring Spawners Only[1]	16 April – 30 June	16 April – 15 July
Fall Spawners Only[2]	15 October – 15 May	1 October – 31 May
Fall and Spring Spawners	15 October – 30 June	1 October – 15 July
Lake Trout Present	Fall Closure Begins 15 September	Fall Closure Begins 1 September
Brook Trout Present	Fall Closure Begins 1 October	Fall Closure Begins 15 September
Lake Sturgeon Present	Extend Spring Closure to 15 July	

1. *Spring spawners include sauger, walleye, yellow perch, lake sturgeon, northern pike, bass, mooneye, goldeye, suckers, cutthroat trout, rainbow trout, and arctic grayling.*
2. *Fall spawners include lake trout, brook trout, brown trout, lake whitefish, cisco, and burbot (winter).*
3. *Includes the Churchill River itself.*

2.3 RECLAMATION METHODS

(For the definition of reclamation as it is used in this manual refer to the glossary.)

2.3.1 Rollback of Windrows and Berms

- Windrows and berms created by fireguard construction (including “spot fire” guards) should be rolled back across and tramped over exposed soil. This spreads seed sources and duff layer back over the exposed soil, which is important for re-vegetation of the fireguard.

A track hoe rolling back and tramping windrows and berms on a fireguard. Note: An image of a crawler conducting similar work appears on the cover of this manual.

- Rolling back windrows and berms also helps prevent vehicle access and the resultant impacts, such as increased pressure on wildlife.
- Rolling back berms may be difficult in wet areas. This may delay reclamation until the ground is frozen. One alternative is to direct equipment to work in a reverse direction, backing out and working on top of the berm. This will reduce further rutting.
- When rolling berms back, larger **coarse wood material** should be compacted, broken up and in contact with the soil to increase rate of decomposition.
- Rollback of berms and windrows must restrict vehicle access after reclamation is complete.
- Any ruts caused during fireguard construction should be ripped and leveled before berm material is rolled back. Rutting should not exceed 15cm in depth and 5m in length (current FMA standard).
- Soils on fireguard compacted from extensive travel should be ripped with a crawler or with a ripping attachment for a track hoe. Compacted soil should be ripped with spacing intervals less than 2m and de-compacted under frost-free conditions to an average minimum depth of 30cm, except when soil types are comprised of more than 50% sand, then windrows and berms should be spread back over the fireguard (current FMA standard).
- Typically soil compaction occurs on silty clay soils underlying heavily traveled access roads, fireguards, and landings.
- Breaks in the berms may be required every 100m if berms are higher than 2m, or the rolled back material needs to be tramped to 2m or lower to accommodate wildlife movement.

2.3.2 Blocking Access to the Fireguard

- When the windrow material is rolled back over the fireguard vehicle access should be blocked.

Windrow and berm rolled back over the fireguard, blocking access from an oil and gas road.

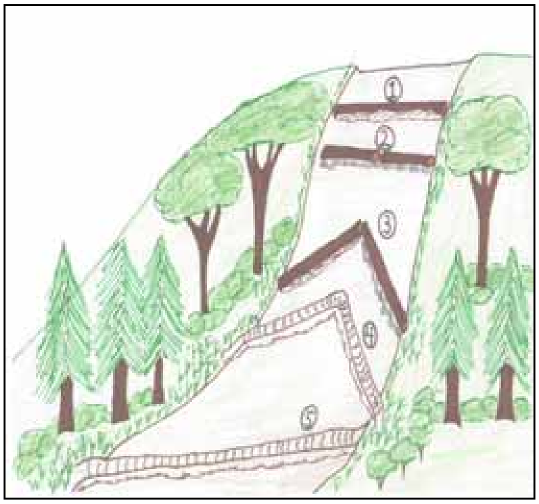
- If there is insufficient material to roll back over the fireguard to block vehicle access, consider constructing a berm or other barrier at a location further from the access point utilizing natural barriers such as muskegs creeks or other features.

2.3.3 Steep Slopes

- The primary concern with fireguards on any slopes is erosion. Several tools/methods can be used to prevent erosion, especially where eroded soils may enter aquatic habitats. The objective is to minimize erosion and enhance stability, while controlling drainage.
- On steep and/or sandy slopes, woody debris should be placed and packed into the soil in a herringbone pattern. This directs runoff to the outside edges of the fireguard and into the neighboring undisturbed vegetation. Diversion ditches or ditch run-outs can also be used to redirect water flow into the adjacent vegetation. Ensure diverted water will not cause additional eroding.
- Leave as much organic matter on the surface as possible when constructing fireguards on steep slopes.

Reclamation on a steep slope with a track hoe (excavator). In-berm topsoil is spread over the fireguard with brush mixed in and trees are placed perpendicular to the slope. Track hoe is able to separate different materials and place them strategically to prevent erosion.

- Erosion prevention methods on the slopes such as water bars, diversion ditches, and de-compaction (if required) should be completed before rolling back berms and windrows.



Erosion prevention methods on slopes:
(1-2) waterbars straight across the slope to slow the water flow down slope. Can be reinforced with rocks or small berm of soil from a slight depression made in front of the waterbars;
(3) logs placed in a "herring-bone" pattern to slow and divert water to the vegetation adjacent to the fireguard;
(4) shallow diversion ditches in a "herring-bone" pattern to divert water flow; and
(5) diagonal diversion ditch across the fireguard diverting water into vegetation. "Herring-bone" pattern is more appropriate for wider fireguards than waterbars placed perpendicular.

- The following points are summarized from Ontario Ministry of Natural Resources (1988) and Chillibeck et al. (1992):
  - Brush barriers and rollback materials filter water runoff by reducing flow velocity and trapping sediment in the branches and limbs. The estimate of the sediment trapping efficiency is 75 – 85%. This method provides immediate protection, it requires no additional disturbance width and is inexpensive.
  - **Erosion control blankets and fabric (erosion matting)**, **silt fences**, and seeding may be needed to enhance re-vegetation. Erosion matting and/or silt fences must be held in place by logs, rocks, or spikes. Erosion matting is available that is 100% biodegradable. Refer to **Appendix A** for placement directions for both erosion control blankets and silt barrier fences.

Erosion-matting on a steep slope to prevent erosion and enhance re-vegetation.

  - Native plant mixes should be used when seeding to prevent exotic species introduction. Seeding should occur as soon as possible after reclamation is complete. Reclamation occurring in fall or winter should be seeded with dormant seed in late fall or seeded the following spring. Use mulches and soil stabilizers applied with a hydro-seeder on steep slopes and banks. **(Refer to Section 8: "Re-vegetation of Disturbed Sites")**

- Planting trees is recommended to enhance re-vegetation and stabilization of a site. (Aesthetic purposes along roads and trails as well.)
- An option on less severe slopes is surface roughening. A crawler moving down slope dropping its blade every two to three feet creates small ridges. On gentler slopes a tracked machine can move up or down slopes leaving tread imprints parallel to slope contours, this is called **'track walking'**. The track imprints in the soil are ideal for trapping seeds and creating favorable micro-sites for seedlings. These methods reduce runoff, reduce flow velocity, increase infiltration, and help trap sediment.

Crawler creating shallow troughs and ridges on a gentler but sandy slope to slow water flow and prevent erosion.

- Slopes should be re-contoured as close to their original state as possible or to a slope no steeper than 4:1 and that is consistent with surrounding terrain. Soil that is replaced should be mixed with woody debris to hold it in place. It should be covered with woody debris and compacted to prevent erosion. Fabric, seeding, or other measures can be added as required.

Before and after pictures of a slope that was cut down to accommodate an irrigation system and later re-contoured during reclamation.

- Re-contoured slopes should be monitored for at least three years. If needed, additional action should be taken until re-vegetation is sufficient to prevent erosion.

2.3.4 Stream crossings, Lakeshores, Wetlands and Riparian Areas

- Material pushed into a stream for a crossing must be removed and placed far enough away from the stream to keep it from eroding back into the stream. This also applies to lakeshores. Excess spoil material should be placed a minimum of 5m from the top of the high water mark and separated from the watercourse by an area that is well vegetated.

Debris pushed into the lake (left). Debris pulled out and away from the water and the bank of the lakeshore, re-contoured with rocks, logs, brush and soil (right).

- When removing the crossing material from the stream or lake be sure not to cause further sedimentation problems.
- Disturbed stream banks need to be re-contoured to a 3:1 or flatter slope and covered with slash. Depending on the conditions erosion matting may be required. Seed the area with a native seed mix. These sites require stabilization as soon as possible to prevent further erosion.

A stream crossing behind a dam where water levels are low. Crossing was constructed with soil from the area adjacent to the stream. Soil and debris removed from the crossing down to the original streambed. **(Left)**

Stream banks re-contoured, material removed and spread back over exposed soil and tramped. Brush spread over top, willow stakes/cuttings (live staking) inserted to facilitate re-growth, and straw bales placed to prevent sediment from eroding back into the stream channel. **(Right)**

- Stabilization of all components of the stream is important for fish habitat in fish-bearing streams and adjacent riparian areas.
- Limit the amount and duration of in-stream work.
- To prevent sediment from being carried into the water from spoil materials consider creating a small berm with a depression above the water line. The depression acts as a pool, slowing water from the slope above and allowing larger particles of sediment to settle. These sediment traps are only effective for a short time – a temporary measure until there is enough vegetation present to prevent erosion.

Small berm constructed before the lakeshore to stop and redirect upslope water flow. The water will be diverted to the vegetated area and sediment will be filtered out before flowing into the lake.

- A berm can be made by hand with **jute logs (hollow woven mesh tube)** filled with native materials. Once the hand–tooled berms are in place, insert willow stakes (branches of willows with the branches and leaves removed) into the ground around the berm. If properly inserted they will grow and help support the bank.

- Unless the stream is identified as temporary spring runoff drainage, all streams should be treated as possible fish habitat and advice should be obtained from a fisheries biologist.
- Reclamation work can be done progressively throughout the fire operation. Start reclamation where suppression access is no longer required and while heavy equipment is still present at the fire. Reclamation operations will be considered part of the fire suppression plans and operations.

3. ACCESS TRAILS

Adapted from Chris Dunn's paper, "Guidelines to Minimize Ecological Impacts: Wildfire Suppression" (East Boreal Ecoregion) (Dunn, 2002)

3.1 ALTERNATIVES

1. Use existing trails and roads wherever possible.

2. Keep the crawler blade up (above the surface) and use it to push debris off the access trail without exposing soil wherever possible.

3. Alternatives to constructing a stream crossing with logs and brush may include (if available or feasible) the following information on culverts, low-level rock ford crossings, rig-matting/swamp mats, and culverts received from personal communications with Rick Courtney of DFO:

   - Culverts: (6 months or less)
     - These are generally the typical corrugated steel pipe culverts but include any type of closed bottom culvert. Follow the General Conditions below for Closed Bottom Culverts. If a culvert crossing is to be constructed for longer-term use, it should be reviewed by DFO pursuant to the Fisheries Act and the Navigable Waters Protection Act.
     - General Conditions:
       i. Culvert inlet and outlet should be adequately armored to prevent erosion. Alternatively, the inlet and outlet and any loose material on the roadside within the watercourse should be covered with a geotextile, heavy plastic or similar material and staked to prevent sediment from eroding in the watercourse.
       ii. Roads should not cross watercourses at riffles or rapids because this may be critical fish habitat.
       iii. Culvert bottom should be at least 20cm or 20% of the culvert diameter below the thalweg (deepest part of channel) of the watercourse, whichever is greater. Installing the culvert at least 20% into the streambed will provide better conditions for fish passage at both high and low flow water conditions.

- Low-level rock ford crossings:
  - For installation of a ford crossing the General Conditions and these following conditions should be implemented:
    1. The ford should be excavated, then filled with coarse material to return it to the pre-construction bed elevation. The ford should not constrict the stream (make it narrower) or make it shallower.
       a. Maintaining the natural channel cross-section and using coarse natural material will ensure the streams ability to provide fish passage at high flows will be equal to or better than the natural channel.
       b. Maintaining the natural channel cross-section and bed elevation will ensure fish passage at low flow will be equal to or better than the natural channel.
       c. Raised ford crossings should not be used unless they have a culvert.
    2. Cobble or cobble/gravel mixtures should be used in the ford. Concrete or other smooth, man-made material that produces a smooth bottom should not be used. No material finer than sand should be used.
    3. Locate the crossing site where bank excavation would be minimized during construction of the approaches. Dispose of all spoil as described in the General Conditions. (i.e. locate all material such that it can not re-enter any watercourse)
- Rig-matting/swamp mats:
  - Swamp mats are typically used on a temporary basis. General Conditions apply for swamp mat use and:
    1. Mats should be installed disturbing as little vegetation as possible.
    2. Swamp mats should be removed from the site when the use of the crossing is complete.
- Portable bridges: (used by the forestry industry)
  i. Bailey bridges
  ii. railcar bridges
  iii. portable trailer bridges (pulled behind a ½ ton)
  iv. high density polyethylene pipe bundles
  v. logs chained or strapped together in bundles (logs taken from above the high water mark)
  vi. portable beam bridges

If any of the above alternatives are considered, consult with the Reclamation/Rehabilitation Unit Leader, local fire staff, and local SE staff.

Note: Bridges may be an option only on project fires where sustained action may continue for an extended period of time, where it may be economically feasible and ecologically beneficial. More detailed information about these options can be found on the FERIC web site): www.feric.ca/en/ed/html/streams.htm.

3.2 MITIGATION RECOMMENDATIONS

Trails are created to access certain portions of the fireguard, water sources, or fire camps. These are generally well traveled during fire suppression.

1. Follow the same mitigation recommendations as for fireguards and stream crossings.

2. Construct access trails no wider or longer than required.

3. If crossing a stream is necessary, choose crossing sites that will minimize the impacts on stream banks and will require the least reclamation effort. Locate stream crossings considerations (from FMA Standards and Guidelines):

   - Higher in the watershed basin.
   - Not proximal to lake inlets and outlets.
   - Upstream from barriers to fish passage.
   - Where the stream is the narrowest.
   - Not proximal to important/critical fish habitat.
   - Where the banks are flat or the slope is shallow.
   - Perpendicular to stream.

4. Retain as much vegetation as possible on the traveled portion of the trail.

3.3 RECLAMATION METHODS

1. Reclamation methods and procedures should follow the same methods used for fireguards (Section 2.2).

2. Due to the high volume of traffic typical on these trails, compaction and rutting will likely be more severe.. Compaction may occur if used for a long period and if used by heavy vehicles and equipment. If compaction occurs, rip the immediate surface by using a crawler with a ripper or a track hoe that has a ripping attachment to loosen the topsoil creating a seedbed. Ruts should be filled and leveled.

3. Reclamation efforts on trials crossing streams and low areas will follow the same recommendations used for fireguards.

4. HELIPADS AND HEAVY EQUIPMENT STAGING AREAS (Dunn, 2002)

4.1 MITIGATION RECOMMENDATIONS

1. Use natural openings as much as possible for helipads to avoid clearing areas. Use sites already disturbed, such as gravel pits, abandoned roads, etc. that are at least 30m from any water bodies.
2. At equipment staging areas and helibases where large volumes of fuel will be stored, the sites should be at least 200m from a water body and have a clay base below the topsoil. This will prevent spilled fuel from entering the water table.
3. Helipads cleared by hand are preferred over those created by crawlers that remove vegetation and topsoil. Fuel storage on smaller helipads should be kept on high solid ground with a spill containment system.
4. Equipment should be clean to prevent the invasion of exotic plant species. Equipment should not be washed near streams or lakes.

4.2 RECLAMATION METHODS

1. Decommissioned helipads and equipment staging areas should be treated similar to fireguards. Windrows should be rolled back and spread over the disturbed area.
2. Ensure contaminated soils are treated and disposed of properly. Guidelines are in place advising when action must be taken on spills. The Saskatchewan Environment Spill Hotline (1-800-667-7525) is available to provide advice. See section 7.2 on spill treatments required.

5. WATER PUMPS AND DOCKS (Dunn, 2002)

5.1 MITIGATION RECOMMENDATION

1. High–volume pumps used in fish bearing waters require fish screens on the intake. This will apply most notably to irrigation and sprinkler systems used on fires. Contact a SE fisheries biologist for advice. Water intake lines should have a fish screen that meets DFO's "Freshwater End-of-Pipe Fish Screen Guidelines". A copy of this guideline can be obtained from the DFO or at http://www.dfo-mpo.gc.ca/habitat/media/guidelines/Freshwater-Intake-End-of-Pipe_e.pdf.

Effective Screen Area Table

Pump Type	Width of openings in screen material	Effective Screen Area
BB-4 (Vanguard)	2.54 mm (0.100")	0.27 m^2 (2.9 ft^2)
BB-4 (I/C engine)	2.54 mm (0.100")	0.3 m^2 (3.2 ft^2)
Watrous Floto-Pump (standard)	2.54 mm (0.100")	0.4 m^2 (4.3 ft^2)
Watrous Floto-Pump (high-pressure)	2.54 mm (0.100")	0.2 m^2 (2.2 ft^2)
Mini-Mark II	2.54 mm (0.100")	0.2 m^2 (2.2 ft^2)
Mark-3	2.54 mm (0.100")	0.27 m^2 (2.9 ft^2)

2. Avoid placing the intake in areas that may be potential fish habitat, especially on rock/gravel shoals and riffle areas used for spawning beds during the spawning periods. The sediment should not be disturbed.

3. Ensure the fuel and oil containers and the pump do not leak. Avoid spillage when refueling the pumps and store fuels 15m from the water's edge.

4. Use intake locations such as beaver runs, beaver dams, etc., as much as possible to avoid excavating an intake site to accommodate the pump. Secure the intake above the mud and bottom of the water source. Locate pumps to prevent erosion problems. If excavation is required for deeper water, the preferred option is a **bell hole** dug into the stream bottom. Minimize in-stream sedimentation. Locate excavated material where it will not re-enter the water.

5. Excess water from pumping should be dissipated onto low-lying vegetated areas to prevent sediment re-entering the water.

6. All damming methods of obtaining water sources for pumping should be avoided. Any berms or dams built must be removed and the site reclaimed.

5.2 RECLAMATION METHODS

1. If material is excavated to accommodate the pump, replace only if it will not erode and if it prevents the bank from eroding. If more damage may be caused by replacing the material, locate it in an area that will prevent it from eroding back into the water body.

2. Level off and remove spoil piles from the bank and ensure spilled fuels or lubricants are cleaned up.

3. Temporary docks built for pumps need to be removed from the water edge.

Temporary docks like this one at a fire camp must be removed when the camp is demobilized or the pump is removed and fire suppression activities are finished.

6. FIRE CAMPS (Dunn, 2002) (referring to small tent camps along the fire line unless otherwise stated)

6.1 MITIGATION RECOMMENDATIONS

1. Fire camps should be set up on level, well-drained sites at least 15m from any body of water. Use naturally open sites or existing cleared sites where possible.

2. Where possible, avoid creating new access trails.

3. Do not damage trees, vegetation, and soil unnecessarily.

4. Keep camp area clean, free of food wastes, and remove camp garbage at least every second day, if not daily, to avoid bear problems. This also applies to the fire line. All packaged lunch debris should be returned to camp for transport out.

5. Used batteries from handheld radios (camp and fire line) must be containerized separately from other garbage and taken to proper disposal sites.

6. Install solar-powered electric fences around camps to avoid bear problems and to mitigate impacts on wildlife.

7. Domestic wastes ("gray water") and human sewage should be hauled from centralized accessible camps. In bush camps, bush privies should be located at least 30m from any water body and where drainage to a water body is unlikely.

6.2 RECLAMATION METHODS

1. Before crews leave their camps, camp sites should be 'naturalized':

    i. All garbage should be removed from the site.
    ii. *The Litter Control Act* states that, "No person shall abandon any manufactured article, processed material or any waste: a) on land owned by another person; b) on Crown Land; or c) into or upon any water (sec 3). **It is an offence to abandon any "waste" on land owned by another person, the Crown or into water.**
    iii. All foreign building material should be removed, such as nails, rope and boards used to build tables, tent poles, clothes lines, docks, privies, camp stoves, etc.
    iv. All structures built on site with natural materials should be torn apart and scattered around the camp (tents, lean-to's, camp stoves, tables, etc., along with all brush and other woody debris).
    v. Soil from the camp stove should be leveled off and privy holes filled in.
    vi. Reclaim any access trails that were built to access the camp.
    vii. Task force leaders and sector bosses should inspect the camps regularly to ensure that no unnecessary damage occurs.

A camp table and benches abandoned in tact. (left)

Structures need to be torn down, nails removed or rendered harmless, and spread around like the camp. (right)

7. FUEL STORAGE (AND OTHER HAZARDOUS MATERIALS) AND FUEL SPILLS

7.1 FUEL STORAGE

1. Fuel bowsers and fuel storage tanks need containment measures.

   i. Bowsers should be placed on dry ground at least 200m away from any water source.
   ii. Where possible, place fuel bowsers in existing open areas with minimal vegetation (i.e. old gravel pits with clay base well away from water sources).
   iii. Spill sumps (tray-like containers with grate on top), pop-up pools, or rubber mats with sides should be placed underneath bowser pumps and spouts in case of spills or leaks.
   iv. A portable spill kit should accompany the fuel bowser to a fire.
   v. Each fuel storage tank should have two shut-off valves, one of which can be the handle.
   vi. When fueling, never leave the nozzle unattended. Nozzles should be mounted above the drip catchments.
   vii. Do not fuel equipment or vehicles within 100 m of the high water mark.

2. Fuel drum storage should follow the same measures as fuel bowsers but on a smaller scale.

   i. Fuel drums should be stored on a solid, dry surface.

Fuel drums should not be stored at a wet site as in the image. If this cannot be avoided fuel drums must be set on a containment device.

   - Fuel drums located on fireguards, (diesel, gas or aviation fuel), should be stored at helipads built on dry level surfaces at least 200m from water sources.
   - Fuel drums should not be stored in wet, boggy areas or where drums may roll into, or leak into, a water source or wetland area.

   ii. Fuel drums should be placed on a containment unit (utility tray or pop-up pool) to prevent any spills or leaks from seeping into groundwater whenever possible.

iii. Empty drums should be stored in the same safe manner until they are retrieved. Opened fuel drums are more likely to leak lying on their sides than when upright.

7.2 FUEL SPILLS

- Fuel and oil spills are to be reported to Environmental Spill Control when a specified volume has been spilled.

- Fuel spills are to be reported if amounts spilled equal or exceed 100 litres (L). This includes gasoline, diesel fuel, aviation fuel, and jet fuel.

- Spills of lubricating oils must be reported if amounts spilled equal or exceed 50 L.

- To report a spill, call the spill hotline at 1-800-667-7525. Report the type of contaminant spilled, the amount spilled, and the situation at the spill site. The Environmental Protection (EP) staff or Conservation Officers (CO) will contact the individual or agency that reported the spill and will advise on the proper disposal of the contaminated materials.

- Spills less than the specified amounts stated should be reported to the EP or CO staff or the Reclamation/Rehabilitation Unit Leader, especially if the spill has occurred in a sensitive area such as near a stream or in a wet bog.

The track hoe is removing the contaminated material at this diesel fuel spill and loading it into the trucks to be hauled to a disposal site.

8. REVEGETATION OF DISTURBED SITES

The most effective way to prevent erosion and stabilize slopes and riparian areas is to re-vegetate the sites as quickly as possible. Most level upland sites in the boreal forest can naturally re-vegetate with species from the adjacent, unburned vegetation. However there are sites such as dry, sandy areas or compacted sites that may take longer to re-vegetate naturally than the objectives set in the reclamation plan. These sites may also need assistance to speed up the re-vegetation. For the most part, sites with erosion potential and risk of sedimentation are where methods will be employed to accelerate the re-vegetation process. The re-vegetation methods included in this manual are seeding, planting, and soil bioengineering methods. The methods used will depend on the access to the site, costs of re-vegetation, availability of resources and materials, and degree of impact on the site of concern. (Mikolash, 2001)

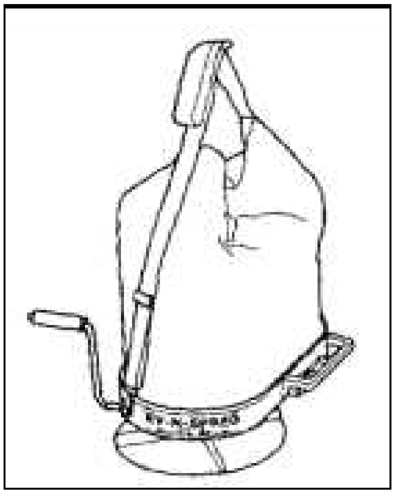
Vegetative cover protects the soil from erosion by protecting the soil from rain, wind, and surface runoff. The root systems of the vegetation help stabilize slopes and improve the biological properties of soil. This is especially important as most surface erosion occurs the first six weeks after it is disturbed and exposed to the elements. Quick re-vegetation of native species also helps to prevent invasive and undesirable species of vegetation from becoming established. (Mikolash, 2001)

8.1 SEEDING DISTURBED SITES

Native seed mixes are to be used when seeding disturbed sites caused by fire suppression activities on Crown Land. Adam Kosowan and J.R. Smith of SE compiled a guide to assist with the selection of species for re-vegetation. "Native Species Recommended for Site Restoration within the Mid-Boreal Upland, Mid-Boreal Lowland, and Boreal Transition Ecoregions of Saskatchewan". The species are organized into the following site categories: dry, fresh, moist, wet, and organic. Seed mixes are also determined by the native species of grasses and forbs present in the area. A survey of plant species adjacent to the disturbed site should be completed when deciding on a seed mix. Local SE staff should be consulted as well before a seed mix is chosen.

- Seeding should be completed as soon as possible along with reclamation. Allow at least four weeks of growing season if seeding in the summer.
- If reclamation will be completed in the fall or winter, then dormant seed in late fall or seed early in the spring.
- Seed with a high live pure seed (LPS) percentage should be used (also recommended that the seed be certified weed-free).
- Under the Mineral Exploration Guidelines for Saskatchewan, all native seeds require a certificate of seed analysis to be submitted to SE for approval. Those completing the reclamation must ensure that the seed being used is free of noxious weeds as specified under the Seeds Act (Canada) and the Noxious Weeds Act (SK).
- Application rates should generally be 40 kg/ha. (Mikolash, 2001)
- A good seedbed should have loose granular soil on the surface, the subsoil firm but not compacted, moisture in the soil, and sufficient nutrients available for establishment. (Mikolash, 2001)
- If the topsoil has been removed down to the subsoil, the topsoil should be spread back over the site during reclamation to provide a better seedbed.
- For sources of native seed refer to the Native Plant Society of Saskatchewan's website: http://www.npss.sk.ca
- Broadcast Seeding:
  - Least expensive method to seed.

- Can be done with a handheld seed spreader, with an ATV, truck or helicopter (latter methods for larger areas).
- Coverage about 1ha/hour with ATV or truck and 7ha/hour with helicopter. (Mikolash, 2001)
- Require a good seedbed.
- For dry sites, wet seeding can be done using a mixture seed, fertilizer and water.



Example of a handheld dry seeder commonly used for broadcast seeding.
(Diagram from Ernest Conservation Seeds Website, 2005)

- ➢ Hydroseeding (Mikolash, 2001)
  - A slurry of seed, water, soil binders, fertilizer, and mulch are mixed together.
  - The slurry is sprayed onto a surface or slope with a high volume pumping system, usually mounted on a truck, but can also be lifted with a helicopter.
  - This method is more expensive than broadcast seeding.

Hydroseeder being used to spray a foam line.

Hydroseeding with a helicopter. (picture from Mikolash, 2001)

8.2 Planting on Disturbed Sites

This re-vegetation method is uncommon for reclamation on fires in Saskatchewan, but it has been used. Planting trees and shrubs would be costly on all sites disturbed by fire suppression activities, however the sites to be considered for planting include:

- Highly visible areas to the public such as along main roadways.
- Areas with high aesthetic value where quick re-vegetation is desired.
- Within parks or protected areas if specified by the appropriate land managers.
- Areas where natural re-growth of tree and shrub species is unlikely to happen due to lack of seed source (i.e. an area of jack pine that was burned previously, fire occurs again and the young trees are burned. No natural seed source available after the second burn.)

Use tree and shrub species native to the area. Select species likely to survive and conform to the natural composition and structure of the area.

8.3 SOIL BIOENGINEERING METHODS

Soil bioengineering is an effective method to prevent erosion and to assist re-vegetation on disturbed sites such as slopes and stream banks. Living plant materials are used to construct live structures that not only help stabilize slopes and prevent erosion, but grow as well. These methods can be inexpensive as the materials used are usually on-site or nearby. However it may be labour intensive work. Methods and diagrams of soil bioengineering are explained in further detail in the Appendices. In **Appendix B**, the paper by David F. Polster explains soil bioengineering techniques for riparian restoration and slope stabilization.

The following information about "**live staking**" is from another paper by David F. Polster:

- The use of live cuttings to stabilize slumping materials or to pin sods to a slope.
- Flowing silty materials where the growth of roots will bind the unstable materials.
- Cuttings to be inserted into the soil ¾ of the length of the cut underground.
- Cuttings a minimum of 40 cm in length, 2 cm in diameter.
- Make sure that the 'top' of the cutting is facing up out of the ground.
- Spacing of the cuttings varies depending on the eroding materials.

9. FIRE SUPPRESSION AND RECLAMATION ON REPRESENTATIVE AREA ECOLOGICAL RESERVES AND PROVINCIAL PARKS

9.1 REPRESENTATIVE AREA and ECOLOGICAL RESERVES SITES AS PART OF THE REPRESENTATIVE AREA NETWORK

Fire is an important natural disturbance that helps maintain the ecological integrity of these areas. Ecological integrity is the ‘naturalness’ of an area, the presence of the native biotic communities and long-term ecological processes.

- Where aggressive fire suppression is required in order to protect personal property, infrastructures, aboriginal cultural sites, or to prevent an escaped fire from spreading into adjacent full response protection areas, on-site disturbance shall be kept to a minimum.
- Where disturbance from fire suppression activities within a Representative Area Ecological Reserve is unavoidable, site reclamation shall be considered to restore ecological integrity, including reclamation of fire breaks/guards and roads, removal of litter, etc.

9.2 PROVINCIAL PARKS

Local FMFP staff should keep in close communications with the local Parks staff and be familiar with the land management objectives of the Parks designations within their Fire Protection Area.

Disturbances from top soils and other features resulting from fireguard construction, access trails, and other actions should be kept to minimum. Disturbances within the various park designations should be reclaimed in consultation with SE Parks staff. These actions may include any discussed within this manual with potential emphasis in areas with high scenic, visitation or ecological values.

10. FIRE SUPPRESSION IMPACTS AND RECLAMATION ON PRIVATE LAND

Guideline #178: Fire Suppression Operations on Private Land states:
“Only minor reclamation work can be authorized by the Incident Commander or Fire Protection Officer for removal of bulldozed material from crossing roadways, trails, creeks, fence lines, etc. SE FMFP reclamation work shall not be done until the department has prepared a reclamation plan and the landowner or lessee has signed a Release/Consent form.

Developing a reclamation plan for private land requires an assessment and treatment recommendations for disturbances the same as it would be conducted for Crown Land. The standards used for reclamation on Crown Land should be the same used for Private Land. As stated above, the landowner or lessee must sign a Release/Consent form stating they agree with the reclamation plans before the reclamation work can be initiated. It is recommended an SE designate inspect the completed reclamation work and both parties agree in writing the work is satisfactory. This will conclude work.

11. RECLAMATION NEAR PETROLEUM AND NATURAL GAS (PNG) FACILITIES

Reclamation near or around PNG facilities should follow the guidelines stated in Guideline #216: Petroleum and Natural Gas Facilities. The appropriate company officials should have a chance to review the reclamation plan before the work starts, as they may be involved with the development of the reclamation plan.

When assessing a fire near PNG facilities the following points should be considered:

- GPS and photograph all pipeline crossings, and work near above-ground facilities;
- Heavy equipment crossing pipelines should be done at existing crossings;
- If none, a track hoe should be used to remove material at the crossing and returned to where it was taken from;
- The PNG company should be involved to asses the crossing;
- Avoid crossing a pipeline on organic soils;
- No equipment shall work within 5 meters of a pipeline unless directed otherwise by the PNG company.

When working near above ground facilities the following points should be considered:

- No vehicular or heavy equipment traffic is within 25 meters unless directed otherwise by the PNG company;
- Facilities used for fuel storage or as a fueling area should be documented and photographed in case there are soil contamination issues;
- Diesel engines including reclamation equipment working within 25 meters of an above ground facility will require positive air shut offs. This causes the engine to shut off if gas from a hydrocarbon source enters the air intake of the engine.

Images of above ground facilities can be found in **Appendix C**.

12. RECLAMATION/REHABILITATION UNIT LEADER

(The following “Reclamation / Rehabilitation Unit Leader” document was developed by Guy Levesque, Incident Command Coordinator, SE FMFP)

Reclamation/Rehabilitation Unit Leaders include personnel with specialized knowledge in one or more of the following areas: provincial lands, fish and wildlife habitat, timber resources, cultural and heritage resources, the impact of wildfire on boreal forest ecosystems in Saskatchewan, and post fire site reclamation/rehabilitation requirements. Reporting to the Plans Section Chief, the Reclamation/Rehabilitation Unit Leader is expected to provide information that will assist an Incident Management Team in making strategic and tactical decisions geared towards the most environmentally beneficial method for managing a wildland fire. The Reclamation/Rehabilitation Unit Leader is also responsible for contacting Technical Specialists (if required) who will assist in developing reclamation/rehabilitation plans for disturbed areas.

Qualifications Required

1. Five years' experience in a resource related discipline, i.e. fisheries, wildlife, forestry, water quality, provincial lands, provincial parks, wildland fire.

2. Must have successfully completed the following courses/training:

    a) ATV training
    b) Restricted Radio Operator's Certificate
    c) AvSafe
    d) ICS-100
    e) Heavy Equipment Management
    f) Integrated Resource Management or equivalent two year diploma program

3. Ability to anticipate the impact to natural resources as wildland fire suppression action evolves.

4. Excellent report writing and oral communications skills.

5. Experience in the use and capabilities of heavy equipment including dozers, track hoes, Nodwells, etc.

6. Thorough familiarity with SE booklet "Reclamation Manual, Concerning Impacts Caused by Wildfire Suppression", and Fire Management and Forest Protection Branch environmental reclamation guidelines.

7. Ability to operate all terrain vehicles, GPS unit, digital camera, and word processing software.

Organizational Reporting

The Reclamation/Rehabilitation Unit Leader reports to the Plans Section Chief on large wildfire incidents.

General Responsibilities

The Reclamation/Rehabilitation Unit Leader, working with a Type 1 Incident Management Team, is responsible for completing reclamation/rehabilitation plans on large wildland fire incidents. Responsibilities include:

1. Provide resource protection and management advice to the incident management team concerning “values at risk” (private property and other developments, sensitive habitat, cultural sites, rare species, protected areas, resource uses, etc.).

2. Contact and make arrangements with area forestry staff to assess fire for potential salvage operations.

3. Act as a liaison between the incident management team and other department streams, industry, and the public regarding ecological issues associated with a wildfire.

4. Assess the need for and contact additional Technical Specialists for advice as required.

5. Provide advice on fireguard construction techniques that will minimize impact in sensitive areas.

6. Assess fire suppression impacts and develop a reclamation/rehabilitation plan for submission to the Incident Commander on site.

7. Maintain Unit Log

Note: This description is the Reclamation / Rehabilitation Unit Leader position on an Incident Command Team. Fires not managed by an IC Team, will require and alternate usually from the local FPA or other designated SE staff. The individual developing the Reclamation Plan should remain on site until the plan has been developed and explained to the staff who will be implementing the reclamation work.

13. FIRE SUPPRESSION IMPACT ASSESSMENTS AND RECLAMATION PLAN

Once the fire is classed as ‘being held’, disturbances and impacts caused by fire suppression activities should be mapped and assessed. The reclamation plan should be initiated as soon as possible to maximize the availability of equipment and manpower while on site. The Incident Commander or Fire Protection Officer will assign the assessments and reclamation plans duties to the appropriate staff.

Three forms have been developed to assist fire suppression impact assessment and identifying treatments. The forms and procedures were developed by Dan Frandsen of the Prince Albert National Park, Parks Canada. These are not mandatory, but are useful for personnel engaged in planning reclamation work.

The Fire Suppression Impacts Assessment, Reclamation Prescription and Expected Outcome Forms are very useful for assessing and developing a reclamation prescription for sensitive sites such as stream crossings and steep slopes. These areas typically require a higher degree of reclamation, and the information provided with this form can be very useful.

The Site/Segment Summary Impacts Form and the Site/Segment Reclamation Form are useful on large fires for tracking and summarize total impacts and disturbances. This is especially helpful when developing the Reclamation Plan and estimating the cost of reclamation. These are accompanied with instructions on the assessment procedures and a guide to using them. They are found in Appendix D. Further a Reclamation Plan Form is provided for estimating reclamation costs attached to Guideline #505: Environmental Reclamation.

13.1 FIRE SUPPRESSION IMPACTS ASSESSMENT

The following is a checklist of items to consider during the assessment. Refer to the assessment procedures and the guide to the forms in Appendix D.

13.1.1 Equipment Needed:

- Digital camera
- GPS (Global Positioning System)
- Handheld radio
- Compass
- Scaled ruler, pen/pencil, and paper
- Personal Protective Equipment (PPE), and a cruise vest if available
- ATV and truck
- Plant ID book: Recommend – "Plants of the Western Boreal Forest and Aspen Parkland" by Johnson, Kershaw, Mackinnon, and Pojar
- "Field Guide to Ecosites of the Mid-Boreal Ecoregions of Saskatchewan" by Beckingham, Nielson, Futoransky, Natural Resources Canada (use with Assessment Forms)

13.1.2 Before Assessing the Fire:

- Meet with Plans Chief or appropriate staff to receive an update on the situation and to become familiar with the operation.
- Review the most recent maps of the fire and identify possible values at risk, sensitive sites, and areas of concern.
- Become familiar with all stakeholders, resource users and land management objectives for the area affected by the fire.

13.1.3 Start the Assessment:

- Large fires: Conduct an aerial reconnaissance; track progress along fireguards with a GPS and mark all helipads, access points, access trails, stream crossings, slopes and any other disturbances observed to be ground assessed. This will help to prioritize areas of the fire that require work.

- On smaller fires: an aerial reconnaissance is not usually needed; It is recommended to assess as much area as possible from the ground to accurately determine the severity of disturbances and appropriate reclamation prescriptions.

13.1.4 Data/Information to Record:

- Mark all specific disturbances with GPS and take pictures. These are of great assistance when developing the Reclamation Plan and to accurately reference if monitoring is required. Document image details the facing direction.
- Be aware of any legislation that may affect the reclamation process for the area.
- Document fireguards and access trail details including:
  - Length of fireguard and access trails
  - Segment fireguards into similar plant communities, disturbances and reclamation prescriptions
  - Windrow and berm heights and widths
  - Rutting or compaction locations
  - Soil conditions (ex. Wet, organic/dry, sandy/compacted clay)
- Steep slopes where there is a potential for erosion to occur:
  - Measure length and width of disturbance
  - % slope
  - Is the disturbance a straight up and down slope, an angle, doglegged, etc.?
  - Degree of slope stabilization is needed – seeding, rollback, drainage ditches, water bars, erosion control matting, etc.
  - Connectivity of slope a riparian area or watershed?
- Stream crossings, lakeshore disturbances, and damages to riparian areas concerns:
  - Has fish habitat been altered, disturbed or damaged.
  - Does DFO or Resource Stewardship need to be contacted?
  - Is there potential for erosion – disturbed banks, slopes, stream bed
  - Has material been pushed in stream or lake (mineral soil, brush, trees)
  - Is there a need for drainage ditches, water bars, erosion control blankets, silt fences, seeding, etc.
  - Are docks, pump set-ups, bell holes, dugouts present
  - Are pictures of adjacent, undisturbed area needed for pre disturbance as comparison?
- What are the number and sizes of helipads/helispots.
- Access points to fireguards from roads and trails.
- Camps – recommended demobilization and clean up.

- Damage caused by fire suppression activities to roads or trails used by the public and industry.
- Damage or disturbances to private land or property caused by fire suppression.
- All staging areas and fuel bowser storage areas.
- All disturbances on Park Lands, RAN sites, protected representative areas.
- Watch for rare species of plants and important habitat sensitive to disturbance.

13.2 RECLAMATION PLAN

13.2.1 Reclamation Plan Format (Large Fires >1000 ha)

A good example of a large fire reclamation plan is the “Leaf Fire Reclamation Plan” prepared by J.B. Smith, Forest Services Branch, and Saskatchewan Environment.

- Title Page:
  - Fire Name
  - Fire Number
  - Author – name of individuals developing the Reclamation Plan
  - Name of the Plans Chief on the fire or the District FPO/Fire Management Area
- Table of Contents - Table of Figures.
- Introduction:
  - Area or district the fire occurred:
  - Actual location of the fire (Lat. and Long. or UTM coordinates)
  - Size of fire
  - When fire started and conditions
  - General topography and plant communities/fuel types
  - Access to the fire – roads, highways
  - Land designation of area where fire burned– Crown land, Parks, RAN sites, private land, rural municipality, First Nations, etc.
  - IC team or Fire Management Area in charge of the fire.
- Reclamation Objectives and Recommendations:
  - Soils – fireguards, access trails, helipads, staging areas
  - Stream crossings and riparian area disturbances
  - Steep slopes
  - Fire camps
  - Docks and pump set-ups
  - Litter and garbage issues
  - Fuel bowsers/storage sites
  - Any other sites of concern
  - All of the above sites to be GPSed and specific sites such as stream crossings and steep slopes should have pictures included

  - Suggested equipment to be used to complete the reclamation work
- Stakeholders and other Resource Objectives:
  - Timber salvage operations – FMA holders, landowners
  - Traditional users
  - Outfitters
  - Residents/private landowners
  - Recreational users
- Cost Estimation/Budget Rationale:
  - The estimated costs to reclaim fireguards, slopes, stream crossings, helipads, staging areas, camps, etc.
  - Rates of equipment to be used
  - Estimated time to complete reclamation
  - Work schedule
  - Reasoning and rationale used to estimate reclamation costs
  - Refer to Section 13.2.3 for further direction on cost estimation
  - Use Reclamation Plan Form in Guideline #505 for cost estimate
- Further Recommendations and Conclusion:
  - Closing remarks
  - Future recommendations for suppression and reclamation methods based on assessment
  - Improvements and new strategies – what worked well and where
  - Monitoring requirements and scheduling to ensure reclamation objectives are met
- Appendices and Attachments to Reclamation Plan:
  - Pictures – these could also be included within the plan
  - Maps and diagrams
  - GPS Locations
  - Reclamation Forms:
    - Site Assessment Forms
    - Assessment summary Forms
    - Reclamation Plan/Cost Estimate Form (Guideline #505)

13.2.2 Reclamation Plan Format (Small Fires < 1000 ha)

For most small fires, the Reclamation Plan can follow the same format as for large fires, however a brief report with maps, pictures, and the cost estimate will be sufficient. If the fire is complex or has affected important values, a more detailed report may be needed. Fires near homes, sensitive habitat, within a Park or Representative Area, may require a higher level of reclamation specifying several methods of reclamation (e.g. seeding, tree planting, fence repair, mulching, etc). The key is to ensure those completing the work understand the Reclamation Plan.

It may range from the two pages to an extensive document with diagrams and schedules, depending on the size and impact of the fire.

Example A 300 ha fire that has 5 km of fireguard, with no stream crossings, two steep slopes and five access points. The fireguards were constructed through a jack pine forest with sandy soils.

Reclamation Plan requirements include a brief description of the area where the fire occurred and the treatments required for the fireguards, slopes and access closure. In this case rollback of all fireguards on dry sandy soils, rollback of windrow and berm material on slopes, and block access to the fireguards. Supply an accompanying map of the fireguards, slopes, and access points and a reclamation cost estimate form (4-5 pages total).

13.2.3 Reclamation Cost Estimation

Developing an estimate of reclamation costs on any given fire is dependent on many factors. SE FMFP reclamation experience lead to the relying on the “$1000/km rule” to make a rough estimates of reclamation costs. (e.g. 50 km of fireguard reclamation may cost of $50,000) . However, there are many other influencing factors that can decrease of increase the cost of reclamation. The most common factors include:

- Terrain / topography
- Stream crossings, riparian disturbances
- Dry upland sites vs. wet lowland areas
- Need for seeding or planting trees
- Erosion potential
- Amount of reclamation completed during fire operations
- Helicopter time needed for assessment
- Forest cover
- Semi and low-bed access to the fire
- Distance of fire from home location of contractors
- Availability of appropriate, required equipment
- Equipment combinations (i.e. crawler/crawler, crawler/excavator)
- Quality of equipment (break downs)
- Operator experience
- Dead-end fireguards (will equipment have to be walked to the end and reclaim on the way back out)
- Amount of staff needed and associated costs
- Possible costs of accommodations, food and fuel

14. HEAVY EQUIPMENT AND USAGE

Heavy equipment causes the majority of disturbances during fire suppression. The same heavy equipment is used to reclaim these disturbances. Crawlers and excavators are the most common machines used for reclamation. Crawlers are faster moving machines, but have limited uses for reclamation. Reclamation work that can be done with crawlers includes:

- Rollback and tramping of windrows and berms over fireguards, helipads, staging areas and access trails
- Break up coarse materials
- Track-walking / shallow water bars
- De-compaction (with rippers)
- Leveling ruts

Excavators are slow moving but are better suited for detailed reclamation work including:

- Rollback on fireguards, helipads, staging areas (slower than crawler)
- Stream crossings, lakeshore disturbances, riparian areas
- Steep slopes – diversion ditches, water bars, live staking
- Placement of individual logs and material (with thumb attachment)
- Culvert and temporary crossing installment and removal
- De-compaction (with ripping teeth)

Combinations of equipment types also work well. Two crawlers working in tandem is faster and safer than one working alone. On large windrows and berms, compacted or criss-crossed it is difficult for crawlers to roll the material back over the fireguard. An excavator pulling material out for the crawlers to push across the fireguard speeds up the process. Different combinations and different machines can be used for reclamation to best fit the conditions encountered. In the future new machines better suited for reclamation may become available, such as Nodwells with excavator attachments and mulchers.

Two crawlers working together and a Nodwell with a hoe/excavator attachment.

15. SALVAGE OPERATIONS

Before reclamation begins, the potential for salvage operations should be considered, possibly even during suppression when planning fireguards locations. If time permits, fireguards used for indirect attack may be harvested for merchantable timber. If this not possible ensure merchantable timer is placed paralled to the fireguard increasing the salvage potential.

Fireguards or access trails constructed for fire suppression are often utilized for access during timber salvage operations. Reclamation of the fireguards and access trails used for salvage may become the responsibility of the salvage operator. Collaboration with area SE forest management staff is essential to efficiently coordinate fire reclamation activities in areas with potential salvage operations.

16. MONITORING

Reclamation work may need to be monitored and tracked over time to verify treatment effectiveness. This is especially important on sensitive sites, such as stream crossings, steep slopes, sandy, wet, or organic (peat) areas where more reclamation may be needed after the initial work to is completed. To ensure sensitive sites stabilize and regenerate they should be monitored for at least one year following treatment, and until the treatment objectives are met. If treatment objectives are not being met (e.g. erosion and sedimentation are still occurring), further treatments may be required which should also be monitored.

Photos of the reclaimed sites should be taken to compare success with pre-treatment conditions. Document the dominant vegetation re-generating on the site, any persistent problems, and if treatment objectives have been met. Ensure effective monitoring plans allow for an objective assessment of treatment objectives by collecting sufficient data during the treatment period.

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17. GLOSSARY

backfiring: A form of indirect attack where extensive fire is set along the inner edge of a control line or natural barrier, usually some distance from the wildfire and taking advantage of in drafts, to consume fuels in the path of the fire, and thereby halt or retard the progress of the fire front.

bell hole: A hole dug into a stream bottom where deeper water is required for pumping activities.

berm: In this manual, "berm" is referred to in two separate ways: (1) a low earth fill constructed in the path of flowing water to divert its direction, or hold water in a sediment trap; and (2) the material pushed into rows of grasses, forbs, duff, and soil while constructing a fireguard. Berms typically contain the finer materials while windrows contain larger, coarse materials such as trees and shrubs.

biodiversity: Refers to the variety of life on earth; the number of plants and animals and other organisms that exist on our planet and the variety within these species and the ecosystems they inhabit.

burnout: A fire suppression operation where fire is set along the inside edge of a control line or a natural line or a natural barrier to consume unburned fuel between the line and the fire perimeter, thereby reinforcing the existing line and speeding up the control effort. Generally a limited small-scale routine operation as opposed to backfiring.

critical range of variability: The range or spectrum of ecosystem states (age classes of forest stands, species richness and diversity) and processes (natural disturbances) encountered over a long period of time that ensure the ecological integrity of the ecosystem.

decadent aspen stand: A trembling aspen (Populus tremuloides) forest stand that has reached a stage of maturity or has been stressed by drought, disease, or insect infestation to a point where a high percentage of the trees are dead and unhealthy.

duff: In this manual, duff or duff layer will refer to the top layer of soil that contains decomposed and decomposing organic material, organic litter such as leaves, twigs, needles and bark that are on the surface of the ground. This layer of duff contains important nutrients and seed sources as well help to hold moisture and prevent soil erosion.

ecological integrity: "An ecosystem has integrity when it is deemed characteristic for its natural region, including the composition and abundance of native species and biological communities, rates of change and supporting processes." In other words, ecosystems have integrity when they have their native components (plants, animals, and other organisms) and processes (such as growth and reproduction) intact. (Parks Canada Agency, 2000)

erosion: (surface soil) the transport of individual soil particle movement primarily as a result of water or wind action.

erosion control blankets and fabrics (erosion matting): A blanket-like product made of natural or synthetic fibres manufactured in woven or loose-woven manner and are used as a soil reinforcement agent and as a filter medium.

erosion logs: These are tight mesh rolls (can be either synthetic or natural materials, same as used for erosion matting) that can be filled with bark, chips, sawdust or whatever materials you want to use. They are used for side slope runoff control.

fish: "Includes parts of the fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat, and juvenile stages of fish, shellfish, crustaceans and marine animals." (*Fisheries Act*, sec.2)

fish habitat: "Spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes." (Section 34[1] of the *Fisheries Act*)

HADD (Harmful Alteration, Disruption, or Destruction of Fish Habitat): Any change in fish habitat that reduces its capacity to support one or more life processes of fish.

hardwood: "Hard" wood tree species, which includes trembling aspen, balsam poplar, and white birch.

high water mark: The high water mark is the highest level on stream banks and lakeshores that water levels will reach during a flood event. The high water mark is usually determined in the field by the level where wetland species of vegetation meet the tree line of the forest.

hydro-axe: A machine that chops and mulches small trees, brush and organic debris that creates an opening or path without exposing the soil.

inslope: "Sloping a road/trail/fireguard surface to direct the water away from the cutslope side. Used to keep water from flowing on to unstable fill slopes for short distances." (Mikolash, 2001)

line locator: The line locator, working with a crawler unit, is responsible for locating and marking the control line/fireguard prior to and during construction. The qualifications for line locators include being in good physical condition, having a good understanding of fire behavior, extensive knowledge of heavy equipment use and limitations, and sound knowledge of environmental concerns and reclamation techniques included within this manual.

mistletoe: Parasitic seed plants affecting several coniferous tree species in forested ecosystems in North America. Dwarf mistletoes are integral parts of these forested ecosystems and can have both detrimental effects on the health, function and productivity of forests. Negative effects include reducing tree growth, lowering wood quality and causing mortality. Dwarf mistletoe causes the deformed branches commonly referred to as "witches broom" on jack pine and sometimes white spruce and black spruce. (British Columbia's Forest Practices Code Website)

mitigation: An activity aimed at reducing the severity, avoiding or controlling environmental impacts of a project, through design alternatives, scheduling, or other means.

mixed wood: A mixed stand of trees that contains both hardwood and softwood species.

mulcher: An attachment for heavy equipment that is capable of breaking up large, coarse woody material and mixing the chipped woody material into the uppermost layer of duff and topsoil. Mulchers range in size from bobcat/skidsteer equipment to large crawlers. They can be on tracked or wheeled machines.

outslope: "Sloping road/trail/fireguard surface to direct the water away from the cutslope side. Outslope surfaces provide a means of dispersing water in a low energy flow from the road surface." (Mikolash, 2001)

RAN (Representative Area Network): A network of protected lands including Representative Area Ecological Reserves, other ecological reserves, parks, wildlife refuges, and wildlife habitat lands.

Reclamation: To avoid complicating this manual, reclamation will represent the following four terms:

Remediation	- The process of removal, reduction, or neutralization of **contaminants** from a site to prevent or minimize any adverse effects on the environment now or in the future.
Reclamation	- The process of attempting to return the land to its former or other productive uses.
Rehabilitation	- The process of returning a disturbed site to a structure and function similar to the original system; recognition that all components cannot or are not desired to be restored; a simplified system.
Restoration	- The process of assisting the recovery and management of **ecological integrity** which includes a **critical range of variability** in **biodiversity**, ecological processes and structures, regional and historical context.

(Rasheed et al., 2002)

regeneration: The growth of vegetation (trees, shrubs, forbs, grasses, lichens, etc) after a disturbance whether it is a natural disturbance such as fire or human-caused disturbance such as logging or the construction of fireguards.

Representative Area Ecological Reserve: Areas that are designated to be protected and to be used as ecological benchmarks for comparisons with areas under integrated resource management.

rig-matting: This is a portable structure consisting of four I-beams with I-beam crossbeams. Wood timbers are laid across the mat. These rig-mats are laid on the streambed and equipment and vehicles are able to cross streams without damaging the streambed.

riparian area: Transition zone between terrestrial and aquatic ecosystems in a complex and dynamic landscape of upland forests, wetlands, streams, and lakes. (Barten, 2001) “Riparian areas occur next to the banks of streams, lakes, and wetlands and include both the area dominated by continuous high moisture content and the adjacent upland vegetation that exerts influence on it.” (Riparian Management Area Guidebook, 1995)

sedimentation: The deposition of eroded materials into water.

sediment trap: Temporary water retention ponds used to trap and retain sediments.

silt fence: A small barrier made of stakes and erosion control fabrics that slows water runoff on slopes and captures silt.

softwood: “Soft” wood tree species, which includes jack pine, white spruce, black spruce, tamarack, and balsam fir.

topsoil: “The uppermost soil layer, usually the top 20-25cm of mineral soil, where the bulk of the rooting zone is located. The topsoil and forest floor contain large reserves of plant nutrients and the organisms that influence soil nutrient cycling.” (Mikolash, 2001)

windrow: The woody debris including trees, brush, and other vegetation that is pushed into rows or piles during the construction of a fireguard. Windrow contains the larger, coarse vegetation, while a berm contains soil, duff, and forest floor litter and smaller, finer vegetation.

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19. APPENDICES

APPENDIX A

PLACEMENT OF EROSION CONTROL BLANKET AND SILT FENCE BARRIER(Manitoba Transportation and Government Services, 2005)

Directions for Placement of Erosion Control Blanket

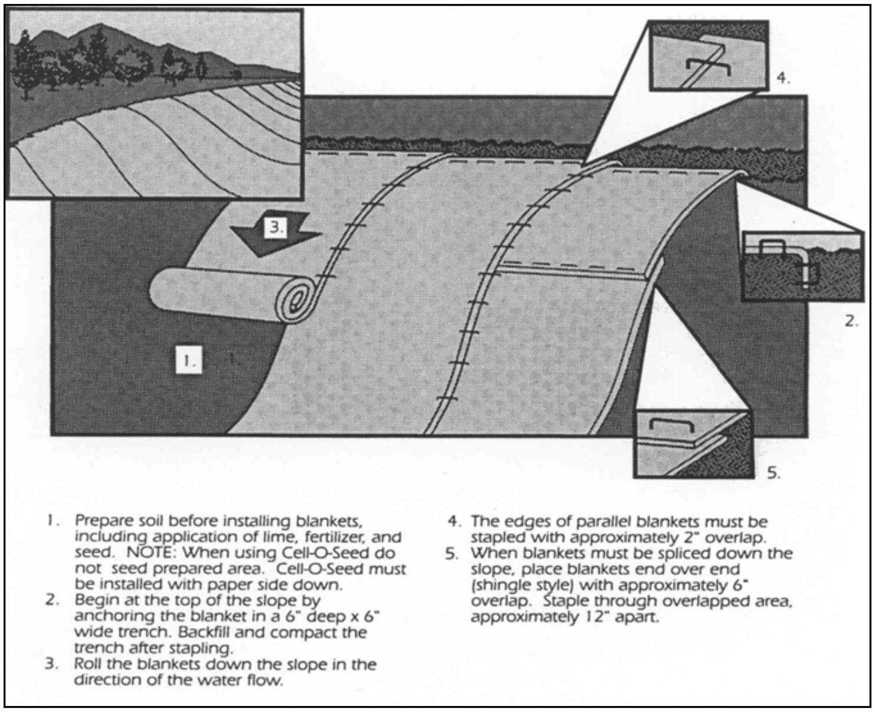
- It is important to remember that erosion control blanket material must be stored in a covered area to protect it from deterioration from rain and sun as it is often biodegradable.

Placement in Channels:

- Roll out the material in the direction of the water flow.
- The upper edges of the blanket on the side slope and the edges at the terminal ends of the installation shall be placed in a 15 x 15cm (6” x 6”) trench.
- Staple the upper edges at 1m (3’) intervals and the terminal ends at 30cm (1’) intervals.
- Backfill and compact the trench.
- The side and end seams should be overlapped (as you would with shingles) with a 10 – 15cm (4” – 6”) overlap.
- Sides and seams will be stapled at 1m (3’) intervals; ends at 30cm (6”) intervals.
- At 10m (30’) intervals, a double row of staggered staples at 10cm (4”) intervals should be inserted to secure the blankets.
- The remainder of the blanket shall be stapled at a rate of 4 staples per square meter.

Placement on slopes:

- Harrow and seed the slope surface.
- Anchor the blankets at the top of the slope.
- Bury the upper edge of the blanket in a 15 x 15 cm (6” x 6”) trench.
- Staple at 1m (3’) intervals then backfill and compact the trench.
- The side seams should overlap 15cm (6”) and stapled every 1m (3’).
- The end seams should overlap 15cm (6”) and stapled every 30cm (12”).
- The remainder of the blanket should be stapled at a rate of 2 staples per square meter.



(North American Green Website, 2005)

Directions for Placement of Silt Fence Barriers

- Posts shall be spaced a maximum of 2.5m (7.5') apart, and driven into the ground to a minimum depth of 60cm (2').
- Excavate a 20 x 20cm (8" x 8") trench on the 'inside' side of the fence.
- Geotextile material from the silt fence shall extend into the trench a minimum of 30cm (1').
- The fence should be installed with no sagsand overlap 45cm (18") if more needs to be added.
- Backfill and compact the trench.
- Completed fence should have a minimum height of 60cm (2') above ground surface.
- Remove the silt fence when there is no longer a risk of erosion after it is removed.

APPENDIX B

SOIL BIOENGINEERING TECHNIQUES FOR RIPARIAN RESTORATION [1]

David F. Polster, M.Sc. R.P.Bio.

Polster Environmental Services Ltd.
5953 Deuchars Drive
Duncan, B.C., V9L 1L5
e-mail d.polster@telus.net

ABSTRACT

Soil bioengineering is the use of living plant materials to perform some engineering function. Soil bioengineering techniques can be used to treat eroding banks, excess gravel and unstable slopes and can provide a finished product that treats the problem as well as providing appropriate riparian vegetation. The natural successional process associated with development of a healthy, functioning riparian vegetation cover is the model that is used to design repair systems that encourage restoration of riparian values. By providing a living, growing system for repair of damaged sites, possibly with wood and rock, the repair can contribute to living riparian area.

Soil bioengineering systems have been used to treat a variety of degraded riparian areas. Live bank protection can be used to form defensive walls of vegetation along the eroding banks of rivers, streams and ponds. Live palisades can be used to re-establish riparian forests quickly. Live gravel bar staking can be used to treat areas where excessive gravel deposits from up-slope erosion threatens downstream channel morphology. Wattle fences, live pole drains, live smiles and a variety of other techniques can be used to treat bank instabilities. This paper presents descriptions of where soil bioengineering treatments have been used for riparian restoration. Examples are drawn from over twenty years of experience by the author.

[1] Paper presented at "High Elevation Mine Reclamation" conference sponsored by the Canadian Land Reclamation Association and the B.C. Technical and Research Committee on Reclamation. September 9-13, 2002, Dawson Creek, B.C.

INTRODUCTION

Soil bioengineering is the use of living plant materials to provide some engineering function. Soil bioengineering is an effective tool for treatment of a variety of unstable and / or eroding sites. Soil bioengineering techniques have been used for many centuries. More recently Schiechtl (1980) has encouraged the use of soil bioengineering with a variety of European examples. Soil bioengineering is now widely practiced throughout the world (Gray and Leiser 1982; Clark and Hellin 1996) for the treatment of erosion and unstable slopes.

This paper presents soil bioengineering techniques that can be used to initiate restoration riparian areas and allow natural processes to provide a sustainable vegetation cover on the treated site. A discussion of plant materials that can be used in soil bioengineering projects is presented initially followed by a discussion of the various different techniques that can be used and the situations in which they are appropriate. Although some of the techniques are common to those practiced in Europe (Schiechtl and Stern 1996 and 1997), many of the soil bioengineering methods that are presented have been developed specifically for situations that are found in British Columbia. The frequent occurrence of marginally stable glacial and glaciofluvial deposits throughout British Columbia combined with areas of high rainfall, frost sensitive soils, saturated soils during snow melt, fast flowing rivers and streams and a host of other circumstances make British Columbia a province where surface stability and erosion problems abound. Soil bioengineering can provide excellent solutions to these problems. Maintenance of completed soil bioengineering work is presented following the discussion of techniques.

PLANT SELECTION, COLLECTION AND HANDLING

Soil bioengineering methods use living plant materials to build structures to stabilize the problem site. As such, the construction materials must be strong enough to withstand the forces acting on them. In addition, since the intention of building the structures of living materials is that these materials will sprout and grow, the materials must be in a condition that will promote their subsequent growth. The plant materials are typically stem cuttings and must therefore be capable of forming new roots and shoots without special mist tents and bottom heat used in nurseries for plant propagation. Willows (*Salix* spp.), cottonwood (*Populus balsamifera* L.) and red-osier dogwood (*Cornus stolonifera* Michx.) are the only woody native British Columbian species that have been found to reliably root from stem cuttings.

Willows are most commonly used for soil bioengineering projects although cottonwood is becoming more frequently used due to its aggressive growth on disturbed sites. The nomenclature of willows is notoriously difficult and the exact identification of the willows used in a soil bioengineering project is not necessary. Typically common willows such as Scouler's willow (*Salix scouleriana* Barratt in Hooker), Pacific willow (*Salix lucida* Muhlenberg), pussy willow (*Salix discolor* Muhlenberg) and glaucous willow (*Salix glauca* L.) are used. Although the nomenclature of the willows that are used is not important, it is essential that species be selected from habitats that approximate those found on the reclamation site. For instance, treatment of a dry raveling slope composed of sandy gravel would not be very effective with willows that were collected from around a marsh. Red-osier dogwood is particularly useful where the treatment site is under the canopy of other vegetation and not in direct sun.

Cuttings used in soil bioengineering projects should follow the "rule of thumb" that is, if it is not as big in diameter as your thumb it is too small. Minimum diameter of the cuttings at the tip end should be at least 2 cm, and larger cuttings tend to work better than smaller ones as long as they are not old and decadent. In terms of length, cuttings should be at least 40 cm long and where structures such as wattle fences are being built, the cuttings should be as long as possible. Cuttings that are 6 or 7 m in length can be used to make very strong structures. Trim all of the small branches and twigs from the cutting before using it in a structure. Where live pole drains are being built, some of the smaller twigs can be left on the cutting as long as they do not have leaf or twig buds on them.

The cuttings that are collected for soil bioengineering projects need to be handled in such as way that they will retain their viability. Keeping the cuttings cool and moist and avoiding excessive damage to the cambium will help to retain viability. In addition, soaking the cuttings in water for up to 10 days has been found (Becker 2002) to stimulate root development in unrooted cuttings. Cuttings should be collected during the dormant period for the plant (late fall to early spring) and where timing does not permit immediate use of the cuttings, they can be stored in a cold storage facility (0 to 1 degree C) for several months as long as they are kept moist. Storage of collected cuttings in snowbanks has been found to be very effective.

SOIL BIOENGINEERING TECHNIQUES

Wattle Fences

Wattle fences are short retaining walls built of living cuttings. Figure 1 shows the typical design for wattle fences. Wattle fences are used on sites where oversteepened slopes are preventing growth of vegetation. As the cuttings are fairly well exposed, wattle fences work best where there is ample moisture available to sustain the growth of the cuttings. Other techniques such as modified brush layers can be used where sites are drier. Wattle fences can be used on very steep slopes as long as the slope itself is globally stable. At the University of British Columbia wattle fences have been effective at revegetating the sand cliffs with an average slope of the in-situ materials of 70 degrees (see www.serbc.org restoration projects section). Wattle fences can be particularly useful where moisture sensitive soils are sliding down the slope as they will hold the soil and allow the moisture to drain, improving the stability of the soil.

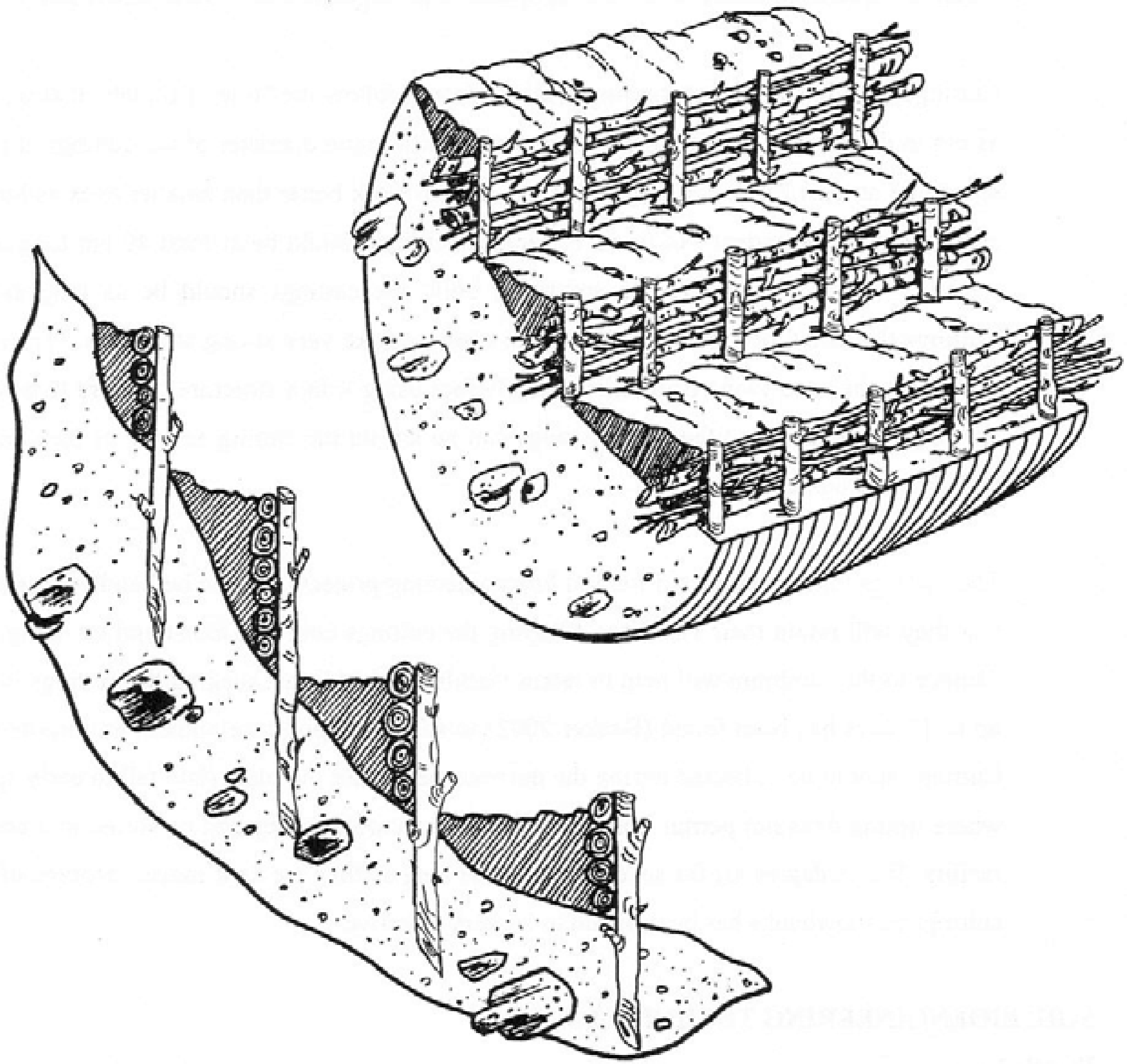


Figure 1. Wattle fences can be used to treat oversteepened slopes. The terracing created by the wattle fences reduces erosion while the growth of the cuttings provides a dense cover of pioneering woody species on the slope.

The support for wattle fences can be either stout cuttings as shown in Figure 1 or 15 mm steel concrete reinforcing bars (rebar). Where rebar is used care must be taken to avoid the hazard created with steel bars protruding from the slope. Where cuttings are used, care must be taken while installing the cuttings to ensure they are not damaged too much. Creation of pilot holes and the use of steel caps to drive the cuttings in with can prevent excessive damage. When cuttings are used the cuttings as well as the cross pieces grow and contribute to the vegetation on the slope.

Live Bank Protection

Live bank protection consist of wattle fences along the bank of the stream to create a woody buffer against further erosion. The construction of the live bank protection must be sufficiently dense so that erosion is avoided. Sometimes twigs and trimmings from the cuttings can be used to fill in gaps between the cuttings and thus avoid erosion. Once the cuttings used in the live bank protection sprout and grow, the resulting vegetation provides good protection against erosion. Live bank protection can be particularly effective along the edges of newly constructed ditches. Brush mats (see Schiechtl and Stern 1997) can be used with live bank protection where erosion is excessive.

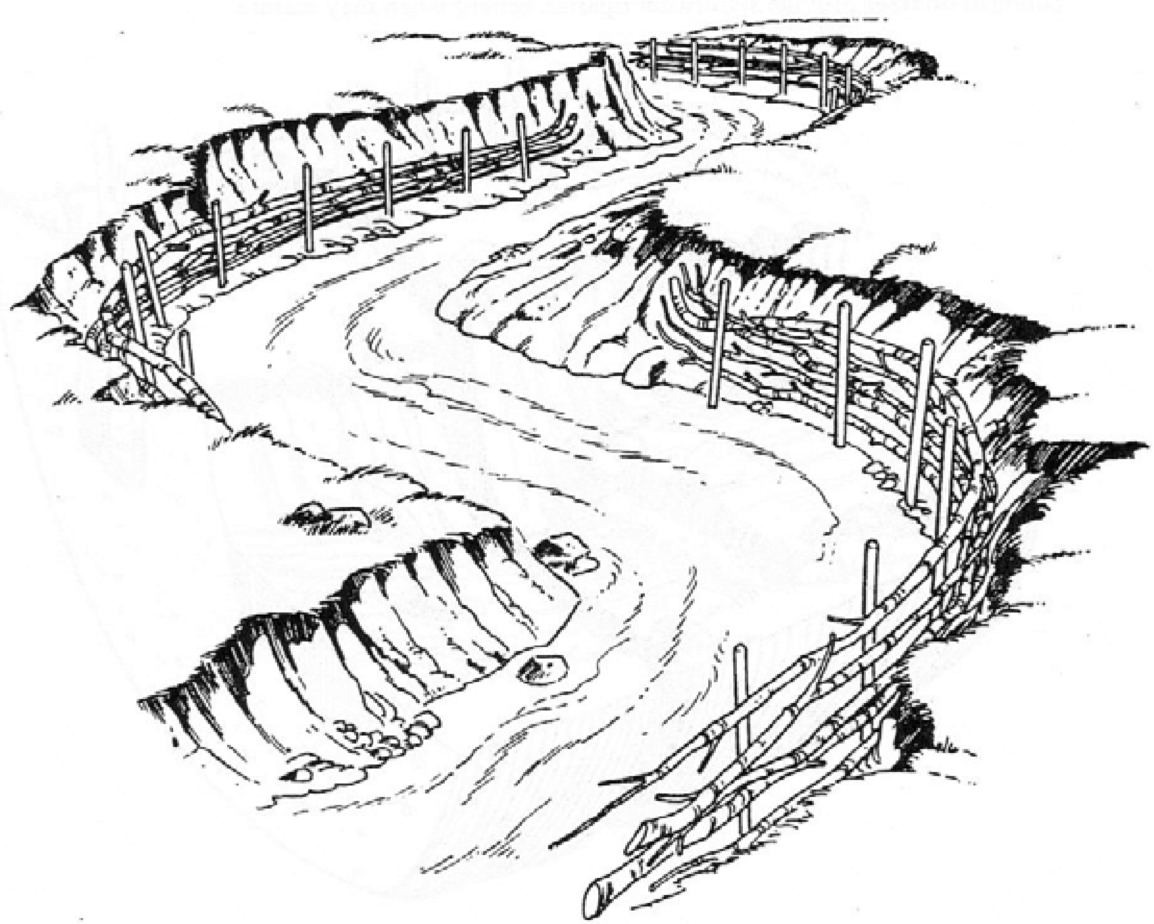


Figure 2. Live bank protection shown here without backfill. Note that the ends of the structures are carefully placed to avoid areas where the current is actively eroding the bank.

Live Palisades

Live palisades are large cottonwood posts installed in trenches adjacent to the eroding stream or river where the natural riparian vegetation has been lost due to clearing or erosion. Figure 3 shows the typical design for live palisades. The key is to get the cottonwood posts down into the water table so that the trees will grow even during dry weather. Large cottonwood posts (15 to 20 cm diameter by 3 to 4 m long) are inserted into a trench dug by an excavator a few meters away from the actively eroding bank. The cottonwood post is expected to root along its entire below ground length and thus produce a dense cylinder of roots that will protect the bank from erosion as the steam encroaches on the palisade. The large cottonwood posts are placed about 50 cm apart so that the growth of the roots will overlap within one growing season. Cottonwood roots can grow as much a 1 cm per day during the growing season (Braatne and Rood 1998). Riparian cottonwood trees provide significant riparian benefit when they mature.

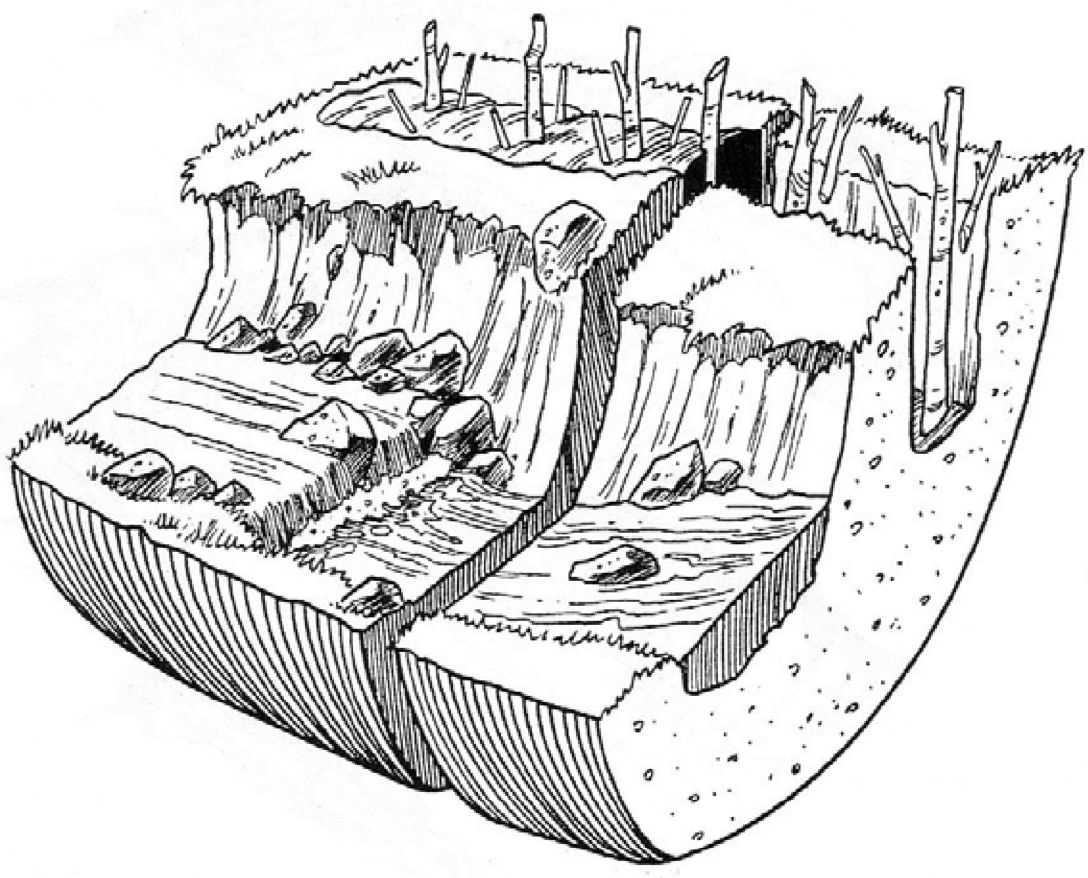


Figure 3. Live palisades consist of a row (or rows) of large cottonwood posts sunk into the water table. Smaller cuttings of willow and red-osier dogwood are inserted in the trench as it is backfilled to provide some diversity to the riparian stand as it develops.

Live Gravel Bar Staking

Excess gravel deposits in streams and rivers can occur in areas of resource development from erosion of upslope areas. These in turn cause avulsions in the stream that results in greater accumulations of sediments downstream. This cycle continues until the stream ends up as a broad expanse of bare gravel with a braided channel and no fish habitat. Live gravel bar staking is designed to establish the natural successional processes that would revegetate the gravel bars and eventually lead to a single channel with well-vegetated banks. The key to live gravel bar staking is to get the cuttings well into the substrate. Use of an excavator is essential (Figure 4). Cuttings should be a minimum of 1 m long and should not protrude from the gravel bar surface more than 20 cm. Large diameter cuttings (4 to 10 cm) appear to work better than smaller stock.

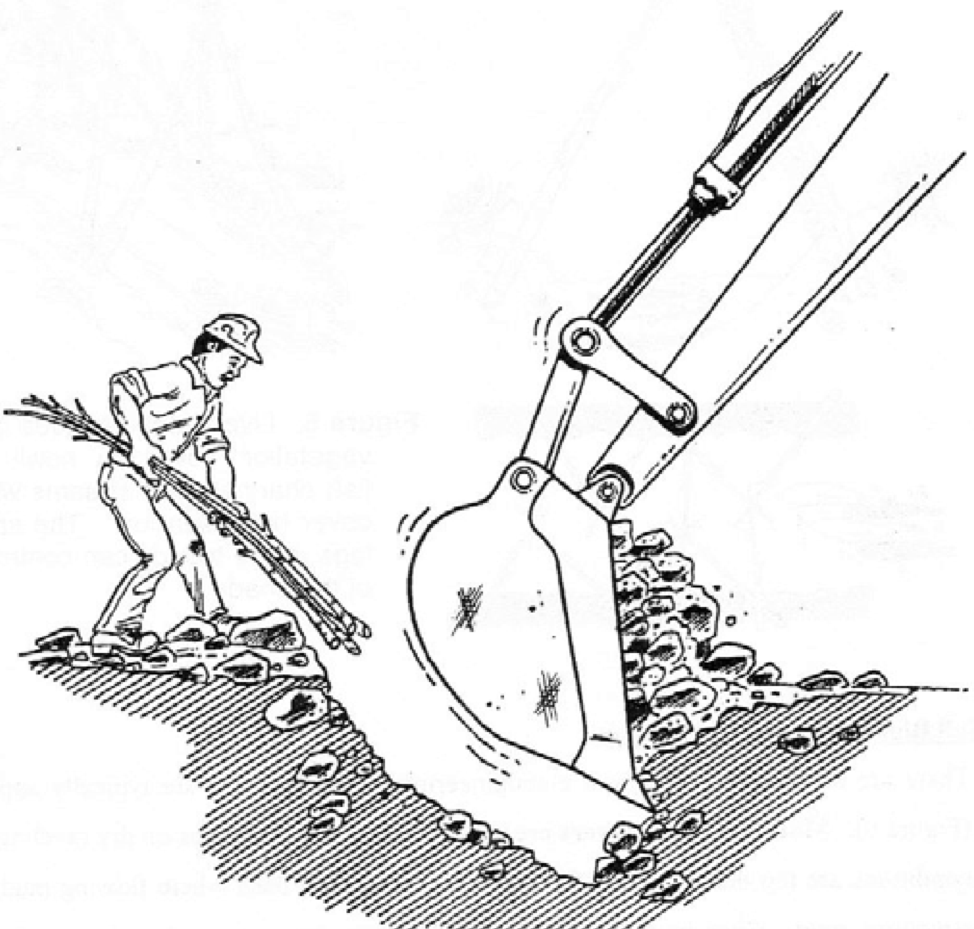


Figure 4. Live gravel bar staking is used to initiate natural succession on bare gravel bars. The sprouted cuttings trap small woody debris that in turn creates a flow disruption that results in deposition of sediment. Once the sediment builds to the point where the sprouts can no longer trap small woody debris there is no more sediment capture until the next year when growth of the sprout again traps woody debris.

Live Shade

Live shade is designed to provide an immediate vegetation cover over newly constructed off-channel fish habitat and small streams where the riparian cover has been lost. Live shade consists of tripods of living cuttings placed over the stream with the feet sunk into the banks about 50 cm so that ample moisture is assured. The cuttings need to be large enough and strong enough to easily span the stream and to support the weight of the new growth plus whatever snowfall might be expected in the region where they are applied. Figure 5 shows the typical design for live shade.

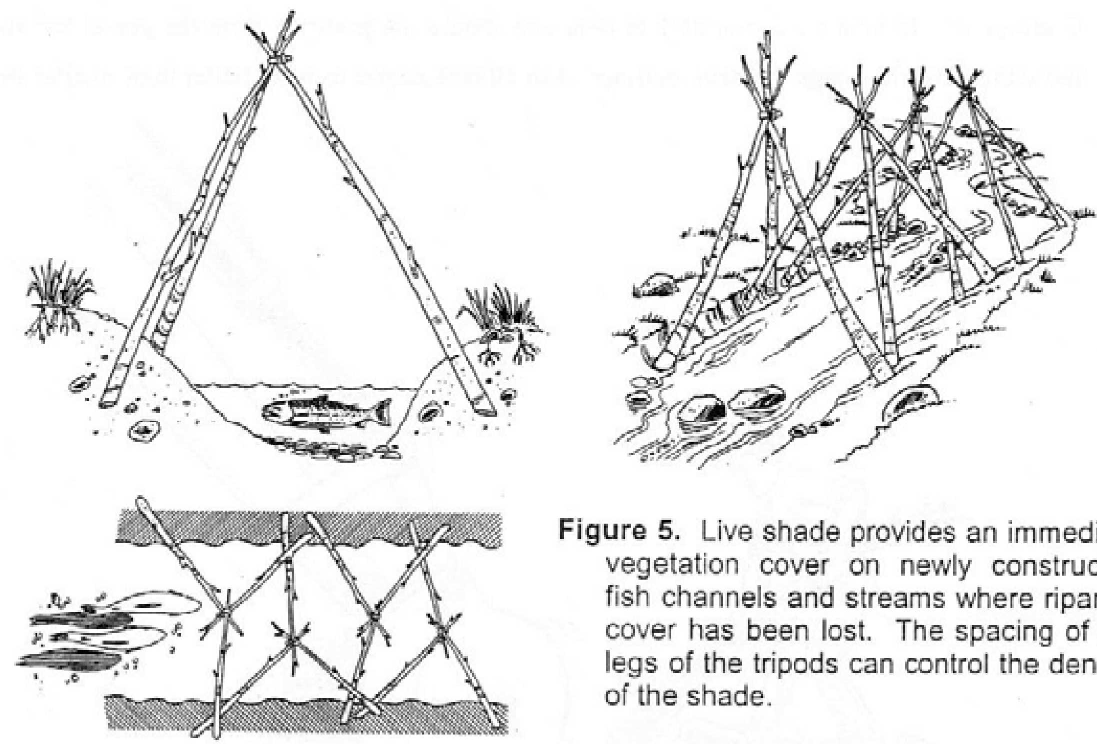


Figure 5. Live shade provides an immediate vegetation cover on newly constructed fish channels and streams where riparian cover has been lost. The spacing of the legs of the tripods can control the density of the shade.

Other Soil Bioengineering Techniques

There are a variety of other soil bioengineering techniques that are typically applied to slopes (Figure 6). **Modified brush layers** are used to create small terraces on dry raveling slopes where conditions are too dry for wattle fences. **Live smiles** are used where flowing mud pushes linear structures over. Sites must be relatively moist year-round to sustain live smiles. **Live pole drains** are used to drain excess moisture from seepage zones causing slope problems. They act like living French drains. **Live reinforced earth** walls perform like traditional soil reinforced structures except the construction elements sprout and grow. **Brush layers in a fill** act to prevent circular failures of the fill surface by providing sheer resistance while **brush layers in a cut** create a wall of vegetation to prevent raveling of the cut slope material.

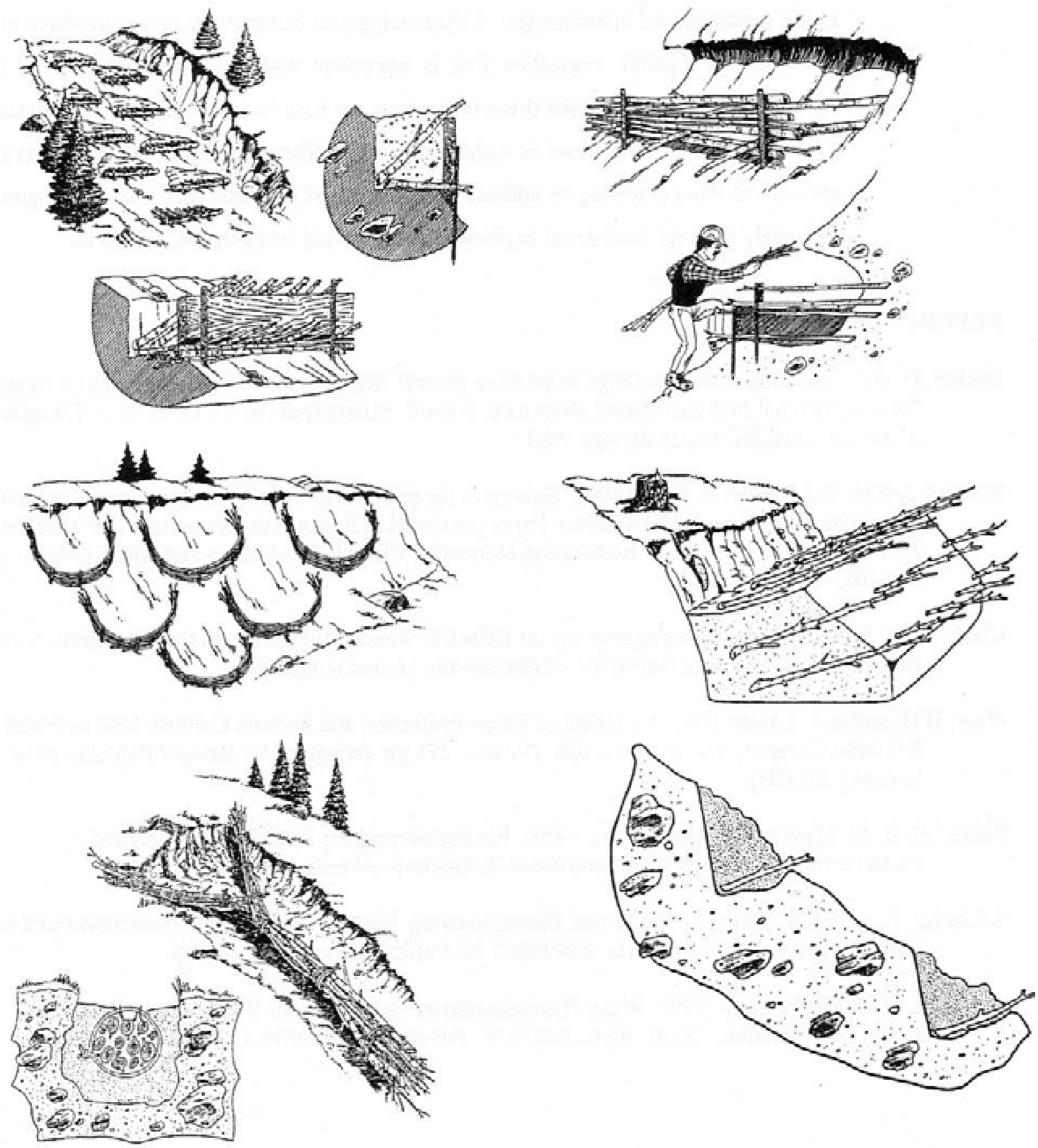


Figure 6. Modified brush layers (upper left), live smiles (middle left), live pole drains (lower left), live reinforced earth walls (upper right), brush layers in a fill (middle right) and brush layers in a cut (lower right) can be used to treat a variety of slope problems.

CONCLUSIONS

Soil bioengineering techniques can be used to treat a variety of problems that may arise in the restoration of riparian sites. These techniques can provide protection from erosion and effective riparian vegetation that is congruent with the natural vegetation in the riparian zone. In most cases these techniques are easy to install and can be constructed by relatively untrained crews or volunteer groups. The diversity of techniques available allows soil bioengineering to address a wide array of problem sites. Soil bioengineering fits nicely between traditional engineering and normal revegetation programs.

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APPENDIX C

PETROLEUM AND NATURAL GAS FACILITIES

(taken from Guideline #216)

Photo #1 - Typical Natural Gas Metering Station

Photo #2 – Typical Common Access Road (Bladed) and Pipeline Right of Way

Photo #3 – Typical Pipeline Right of Way

Photo #4 – Example of a Producing Natural Gas Well Site

Photo #5 – Pipeline Riser

Photo #6 – Example of a Compressor Site

APPENDIX D

Guide to Reclamation Assessment Forms and Procedures
Developed by Dan Frandsen of Parks Canada

The following is a guide to the attached forms: Fire Suppression Impacts Assessment, Reclamation Prescription, and Expected Outcome; Site/Segment Impact Summary; and Site/Segment Reclamation Summary. Use of these forms is not mandatory, but they are available if needed. It is recommended that the impact assessment and reclamation prescription form be used for specific, sensitive sites that require a higher level of reclamation such as stream crossings, lakeshore encroachments, riparian disturbance, steep slopes with high risk of erosion, etc. The Impacts and Reclamation Summary forms are useful tools to keep track of all disturbances caused from suppression activities and assist in the development of cost estimates for the reclamation plan. These two forms are recommended for use on larger fires.

Fire Suppression Impact Assessment and Reclamation Procedure

1) Obtain the necessary materials such as most recent fire maps, "Fire Suppression Impacts Assessment, Prescription and Expected Outcome" forms (Assessment Forms), information on all fire fighting activities that may have resulted in environmental impacts, biological information about the area that may point out sensitive sites, rare resources, current and likely future use of the area. The assessment process makes use of the Ecological classification system outlined in **"Field Guide to Ecosites of the Mid-Boreal Ecoregions of Saskatchewan" authored by J.D. Beckingham, D.G. Nielsen and V.A. Futoransky for the Canadian Forest Service, published by Natural Resources Canada in 1996.**
2) Useful equipment to conduct assessment: GPS unit, 30 m tape measure, digital camera, paper and pencil, maps and transportation (ATV, truck, helicopter)
3) Become familiar with the fire and the areas that have most likely suffered impacts resulting from fire suppression activities. Conduct an aerial reconnaissance of the fire to determine the most efficient way to complete a ground assessment.
4) Using the **"Guide** to the Fire Suppression Impact Assessment Form" complete as much on the Assessment Form as is possible at the time.
5) The impacts and the reclamation actions can each be organized and tabulated separately using the Summary Forms at the end of this section. This can be useful in preparing contracts or estimating the costs and time required to complete the reclamation work.

Guide to Fire Suppression Impact Assessment Form

Header Information:

Fire Name
- Name and number of the fire.

Site/Segment
- The portion of the impacted area that this form is dealing with, usually an area that has similar community description and similar impacts and thus likely similar prescribed reclamation. Example: **site** – helipad ; **segment**– section of fireguard with similar vegetation, soils, and impacts

UTM Limits
- Precise location of the outer edges of the site or segment expressed in UTM or Latitude and Longitude.

GPSed?
- Was the impacted area mapped with a GPS so that it can be visually displayed on a map of the fire? Yes or No and other information needed to access files.

Dimensions of Impact Site/Seg. (m)
- The approximate size dimensions or the impacted area in metres. If it is a fire guard the average width and approximate length of the site or segment should be recorded.

Area (ha.)
- The approximate area covered by the impact site or segment expressed in ha. (1 hectare measures 100 m X 100 m or 10,000 square meters or 2.47 acres.

Assessors' Name(s)
- The name(s) of the people conducting the field assessment, prescription and expected outcome

Assessment Date
- The date on which this field assessment was conducted

Column 1: Non-impacted Area Description
- An area that is adjacent to the impact area but appears to be representative of it. (Reference area: 100 square meters = 10m x 10m)

General
- Indicate the photo number, its precise location and the compass direction or orientation in which it was taken
- A general description of the topography in the area, i.e. flat, rolling, high hills, valley etc.
- A general description of the dominant vegetation community, i.e. mature pine stand
- Any other comments of a general nature you feel is important

Vegetation
- List the one or more predominant species in the area for each of the strata listed including average estimated diameter at breast height, in centimetres, for trees only and estimated percent ground cover for all plant species listed, including exotics.

Soil
- Organic Layer Thickness, soil type, texture, moisture and nutrient regimes. Use the "**Field Guide to Ecosites of the Mid-Boreal…"** referred to above.

Wildlife Activity
- Describe signs or evidence of wildlife activity in the area such as trail development, evidence of feeding, reproduction (dens, nests etc.) beds or other sign.

Previous/Future Human Use of Area
- Describe known or evident human activity previously occurring and likely to occur in the future.

Comment
- Additional information that is relevant to the description of the area.

Column 2: Impacted Site/Segment Description
- Area disturbed by suppression activities. Subdivide into sites and segments. Essentially an individual segment represents a section of impacted area that has similar original vegetation and soils and has had similar ecological impacts inflicted upon it. Therefore, the prescription for reclaiming the impacts will likely be similar for the entire segment. Sites are similar to segments except they are usually separate geographical areas requiring reclamation.

General
- Indicate the photo number, GPS location and the compass direction the picture was taken.
- Slope Position describes where the site/seg. is predominantly located on the topography.
- Aspect and Slope describes the direction a slope faces and its steepness in % (rise over run expressed in percent)
- Indicate other general impact considerations

Vegetation
- Indicate predominant species and their ground cover remaining on impacted area for each stratum, as indicated including exotic species if present

Aquatic/Riparian Impacts
- Describe impacts on riparian areas observed.

Soil Impacts
- Common impacts on soil surfaces include but are not limited to those listed.
- If a berm or pile of earth or wood or other debris is present describe its average height, width and length to indicate the level effort needed in reclamation.

Wildlife Impacts
- How have the fire suppression impacts affected wildlife on the site or segment?

Access Changes
- This space is to describe the changes in access that have occurred to the area as a result of the fire suppression activities

Aesthetics (enduring unnatural features)
- Describe impacts as a result of fire suppression that are likely to have lasting negative aesthetic impacts.

Column 3: Reclamation Prescription for Site/Segment

- The recommended treatment(s) for each type of impact noted are outlined.

General

- Any general comment regarding reclamation that should be considered on this site/segment

Vegetation

- Indicate any reclamation actions that are related to restoring a native vegetative cover on the impacted area. Some reclamation actions may include seeding with native seed, removal of exotic species, planting of tree seedlings, rollback and tramping of disturbed vegetation and soil to enhance decomposition and return nutrients to the soil, etc.

Aquatic/Riparian

- Any special actions needed to cope with riparian impacts such as special erosion concerns, debris in a stream channel, bank contours etc.

Soil

- Indicate the steps necessary to stabilize soil, cover exposed mineral soil, loosen compacted soil if needed, spread rolled back organic, use of water diversion strategies and erosion matting etc.

Wildlife

- Indicate measures needed to encourage the use of the impacted area by wildlife in a manner similar to that which occurred prior to disturbance

Access

- Indicate actions necessary to restore access to the level prior to disturbance or to the level desired by managers.

Aesthetics

- This will usually indicate actions necessary to remove enduring unnatural features.

Column 4: Expected Outcome of Reclamation

- Response to the reclamation actions.

General

- Record the photo #, location and direction of the photograph. Can be same as impact photo. Compare to photos taken in subsequent years.

Vegetation

- Indicated the expected short and perhaps longer-term outcome of the reclamation actions undertaken.

Aquatic/Riparian

- List expected outcomes and goals for the aquatic and riparian environments.

Soil

- How should the soil surface appear and behave when the work is completed and after certain stresses such as a heavy downpour, heavy wind or a long drought.

Wildlife

- How is wildlife expected to move through or use this area again over time.

Access

- Indicate the desired level of access and is it likely to be achieved or sustained over time.

Aesthetics

- Indicate the areas of aesthetic concern and how they should appear when work is completed and over time.

Fire Suppression Impacts Assessment, Reclamation Prescription and Expected Outcome

Fire Name: ___________________________________
Site/Segment: _________________________________
GPSed?: ______________________________________
Area (ha.): ____________________________________

Landscape Area: ________________________________
Ecosite Phase: _________________________________
Plant Community: _______________________________
Soil Type: _____________________________________

Assessors' Name: _______________________________________
UTM Limits: ____
Dimensions of Impact Site/Seg. (m): ________________________
Assessment Date: _______________________________________

Unimpacted Area Description	**Impacted Site/Segment Description**	**Reclamation Prescription for Site/Segment**	**Expected Outcome of Reclamation**
General: Photo# Located Direction - Topography - Community Description	**General:** Photo# Located Direction - Slope Position - Aspect and Slope	**General:**	**General:** Photo# Located Direction
Vegetation: - Tree sp., Ave. dbh (cm), %Cover - Pred. Shrub sp(s) % Cover - Pred. Herbs/Gram(s). % Cover - Pred. Non-Vasc. sp(s) % Cover - Exotic sp(s)	**Vegetation:** Sp(s), % Cover - Trees - Shrubs - Herbs/Graminoids - Non-Vascular **Aquatic/Riparian Impact:** (lake, stream, pond, shoreline) - siltation/debris - bank alteration - obstructions - other	**Vegetation:**	**Vegetation:**
Soil: (use CFS Field Guide to Ecosites for Ref. If needed) - Organic Layer Thickness (cm) - Surface Soil Texture (VC, C, MC, M, MF, F, O) - Moisture Regime (VX, X, SX, SM, M, SHg, Hg, SHd, HD) - Nutrient Regime	**Soil Impacts:** - organic/surface horizons (mineral soil exp.) - erosion/slumping - compaction - berm (ht. width. length) - other	**Soil:**	**Soil:**
Wildlife Activity: (Trails, feeding, reproduction, beds)	**Wildlife Impacts:** - movement - habitat	**Wildlife:**	**Wildlife:**
Previous/Future Human Use of Area:	**Access changes:**	**Access:**	**Access:**
Comments:	**Aesthetics:** (enduring unnatural features)	**Aesthetics:**	**Aesthetics:**

Site/Segment Impacts Summary

Fire Name: ______________________________ **Assessors' Name(s):** ______________________________

Site/Segment

Impacts:	1	2	3	4	5	6	7	8	9	10	Total
Trees removed											
Herb. Veg. Removed											
Lgth of Berm < 1 m											
Lgth of Berm > 1 m											
Deep Ruts											
Mineral Soil Exposed											
Sig. Soil Erosion											
Soil Compaction											
Wildlife Impacts											
Aesthetic Concerns											
Other											
Totals											

Site/Segment Reclamation Summary

Fire Name: ______________________ **Assessors' Name(s): ______________________**

Site/Segment

Reclamation Action:	1	2	3	4	5	6	7	8	9	10	Total
Roll back Sm. berm (m)											
Roll back Lg. berm (m)											
Crush/spread wood mat.											
Install water bars (num.)											
Erosion matting (sq. m)											
De-compact soil (sq. m)											
Re-contour/fill (sq. m)											
Stream/bank restor. (m)											
Access blocking (m)											
Seeding or planting											
Other											
Totals											