FOREST RESOURCES TEAM
PRINCE GEORGE FOREST REGION

DESIGN GUIDELINES FOR EROSION and SEDIMENT CONTROL PLANS for FORESTRY OPERATIONS in the PRINCE GEORGE FOREST REGION

prepared by:
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30 June, 1995.
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BRITISH COLUMBIA

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EXECUTIVE SUMMARY

An erosion and sediment control (ESC) plan consists of a written document with attached maps, prescriptions and detailed technical specifications, of what on-site activities will take place and the measures to be used to control erosion, drainage and sediment transport at each step of a logging, silviculture or rehabilitation plan. A good ESC plan coupled with adequate compliance monitoring has been demonstrated to be an effective tool for minimizing sediment problems (Adamson and Harris 1992, Cook 1996). A good **drainage plan** is the foundation of an effective ESC plan, as water is the major eroding source in British Columbia. Because it is impossible to control erosion and sediment transport without controlling drainage, a drainage plan becomes an integral part of a good ESC plan.

This document outlines important elements of an erosion and sediment control plan and provides limited descriptions of methodologies and techniques of sediment and erosion control. The idea of producing such a plan is to put thoughts and expectations down on paper before the construction phases commences, and to provide the field construction crews with specific sediment and erosion control designs and methodologies, so that they know what is expected and who is ultimately responsible for implementation of the plan.

Most levels of ESC plans can be developed by an individual who understands the basics of erosion and sediment control and also understands the biological and social consequences of excessive sedimentation. This could be a professional or technical biologist, forester, engineer or an experienced construction foreman. Only very complicated situations would require a specialist in erosion and sediment control. As mentioned previously, effective erosion and sediment control is mostly a matter of common sense and simply requires putting your mind to the problem and developing a plan and contingency measures before the construction phases begin.

In erosion and sediment control work it is important to have a clear understanding of what type of control is needed and what are the corresponding appropriate practices. There are three general categories of controls that have distinct treatments associated with them;

1) Erosion control
2) Drainage control
3) Sediment control

These concepts are fully described in this document. The document also provides a set of technical drawings for some of the most popular sediment control measures used in forestry and a complete example of an erosion and sediment control plan.

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1.0 INTRODUCTION

Forestry activities that remove the protective organic matter and expose the mineral soil can create numerous sources of sediment. These sources include: forest access roads, stream crossings, ditches, sidecast, cut and fill slopes, landings, skid trails, yarding trails, fire guards, borrow pits, slope failures, site preparation treatments and logging camps (Reid and Dunne 1984, Bilby et. al. 1989, Bilby 1985). Forest practices can also create sediment delivery pathways which will accelerate sediment transport from the source to the stream. Examples of sediment delivery pathways include: ditches, road surfaces, yarding related gouges in the soil surface and landslide paths. From a watershed management point of view, accelerated surface erosion caused by forestry activities and subsequent transport and deposition of the sediment can lead to several severe problems. Examples of negative impacts include:

1) Sediment deposition can:

- destroy spawning areas by infilling intragravel voids and smothering fish eggs and alevins
- infill pools and riffles reducing the quality and quantity of spawning, overwintering and juvenile rearing habitat
- smother and displace aquatic organisms which are an important food source for most fish species.

2) Impairment of water quality by suspended sediments can negatively impact fish by:

- clogging and damaging fish gills
- impairing the ability of fish to feed by sight due to reduced water clarity
- displacing fish more susceptible to disease due to the added stress of a turbid environment (Everest et. al. 1987, Saunders 1965).

3) Reduction in the quality of drinking water in community watersheds.

4) Reduction in fishing opportunities for the recreational and native food fishery.

The effective control of erosion and sedimentation requires some front end planning before operations commence, to minimize possible negative impacts to the aquatic environment. This document describes the elements required to build an effective plan and provides some technical drawings of various sediment control measures.

2.0 LEGISLATION AIMED AT CONTROLLING EROSION AND SEDIMENTATION

2.1 The Forest Practices Code of British Columbia Act (administered by the Ministry of Forests)

There are numerous direct and indirect references in the Act and the Regulations for the need to minimize erosion, optimize drainage and minimize sedimentation associated with forestry operations. The following is a list of the most relevant legislation.

2.1.1 The Act.

Section 45 - Protection of the environment.

(1) A person must not carry out a forest practice that results in damage to the environment

(2) A person must not carry out a forest practice if he or she knows or should reasonable know that, due to weather conditions or site factors, the carrying out of the forest practice may result, directly or indirectly, in

- (a) slumping or sliding of land,
- (b) inordinate soil disturbance, or
- (c) other significant damage to the environment

Section 60 - Road layout and design.

(2) Before a road is constructed or modified under section 121 of the Forest Act, the district manager must prepare a road layout and design in accordance with the regulations and standards, unless the road is immediately required for fire control or suppression or another emergency.

Section 63 -
Road maintenance ..

(1) Subject to subsection (5) a person who uses a road under the authority of a road permit, a timber sale license that does not provide for cutting permits or a special use permit must **maintain** it until

- (a) the road is temporarily, semi-permanently or permanently deactivated,
- (b) a road permit or special use permit for the road is issued to another person, or
- (c) the road is declared a forest service road under section 115 (5) of the Forest Act.

Section 64 - Road deactivation.

(1) Subject to subsection (11), a person who uses a road under the authority of a road permit must deactivate the road temporarily, semi-permanently or permanently, or a combination of temporarily, semi-permanently or permanently, as required by, and in accordance with

(a) any forest development plan,
(b) this Act, the regulations and standards
(c) the road permit, cutting permit, timber sale licence that does not provide for cutting permits or special use permit, and
(d) any road deactivation prescriptions

Section 67 - Timber harvesting - general.

(1) and (2) A person who carries out timber harvesting and related forest practices must (a) conduct forest practices in and around stream in accordance with the regulations and standards.

2.1.2 Forest Road Regulation

Section 5 - Soil erosion field assessments in community watersheds
Section 6 - Content of road layout and design
Section 8 - Road design
Section 9 - Drainage design
Section 11 (7) - Road site preparation

A person must not deposit slash and debris or erodible soil, capable of damaging fish habitat or reducing water quality, into any of the following:

(a) a lake;
(b) a wetland;
(c) a fisheries-sensitive zone or a marine sensitive zone;
(d) a fish stream;
(e) a stream in a community watershed;
(f) a stream with a licensed domestic water intake that is identified in the road layout and design and is downstream of the road;
(g) a stream that
  (i) can transport the slash and debris or erodible soil into any of the waterbodies listed in paragraphs (a) to (f), or
  (ii) may be destabilized by the accumulated slash and debris or erodible soil, and result in increased sediment deposition in the waterbodies listed in paragraphs (a) to (f).

Section 12 - Subgrade construction or modification
Section 13 - Drainage construction

Most of this section, which has numerous components, deals with the need to provide effective road drainage to minimize erosion and sedimentation during the road construction phase, an example being

Section 13 :When constructing the drainage system for a road
(c) ensure that the drainage system
(i) intercepts surface or subsurface drainage from the cut slope,
(ii) drains ditches and controls ditch erosion
(iii) prevents ponding of water where road stability may be compromised
(iv) prevents water from being directed onto potentially unstable slopes or soil material
(v) **minimizes the amount of sediment entering streams**, and
(f): at culvert outlets protect fill that is unstable or susceptible to erosion with erosion resistant materials or drainage structures.
(i) install ditch blocks immediately downstream of all cross-drain culvert inlets, except where ditch water converges at the culvert inlet
(k) construct a catch basin or other sediment control device adjacent to cross-drain culverts if sedimentation may adversely affect improvements and forest resources.

Section 14 - Road surfacing

Section 15 - Revegetation

Section 18 - Road inspection and maintenance

(1) Maintain and inspect the road to ensure:
(b) the drainage systems of the road are functional
(c) the **transport of sediment from the road prism and its effects on other forest resources are minimized, and**
(2) Road maintenance inspections must be carried out at a frequency that takes into account
(a) the risk to fish streams caused by the road's proximity to the streams.

Section 20 - Road deactivation prescriptions

(1) A person who prepares a road deactivation prescription under section 64 of the Act must ensure that the prescription provides for, and the deactivation work addresses, all of the following matters:
(b) restoration and maintenance of the surface drainage patterns, and control of subsurface drainage, consistent with natural drainage patterns;
(g) **control of silt and sediment at stream crossings;**.

Section 23 - Temporary deactivation

Section 24 - Semi-permanent deactivation

Section 25 - Permanent deactivation

2.1.3 Timber Harvesting Practices Regulation

Section 12 - Requirements when constructing excavated or bladed trails

A person constructing an excavated or bladed trail must comply with all the following requirements:

(a) must not deposit soil material, that has been excavated to construct the trail, or slash in a stream, wetland, lake or fisheries-sensitive zone, or in a

position where the material can be transported by water into any of these watercourses;

(b) must not create cutslopes and fill slopes that are subject to slumping and continuous raveling;

(c) must maintain surface drainage patterns;

(d) must prevent subsurface seepage water, intercepted by the trails, from being diverted into areas that would not naturally have received the water, and that are

i) slopes that are potentially unstable or subject to a moderate or high likelihood of landslides , or

ii) stream channels or gullies;

(e) **must do so in a way that minimizes soil erosion and the amount of sediment entering streams;**

Sections 15, 16 and 17 - Requirements when constructing, deactivating and rehabilitating a landing

A person constructing (section 15), deactivating (section 16) or rehabilitating (section 17) a landing must:

incorporate drainage systems to **minimize** runoff flowing onto the landing and erosion of the landing fill and material.

2.1.4 Operational Planning Regulations

Section 14 - Watershed assessments required before review of forest development plans

(1) Before making a forest development plan available for review under section 27, a person must have carried out a watershed assessment within the previous 3 years of the submission date for the following areas under the plan:

(a) a community watershed;

(b) a watershed that significant downstrean values as determined by the District Manager and the Designated Environmental Official.

(c) a watershed for which the district manager determines an assessment is necessary.

Section 33 - Logging plan content

A person must ensure that a logging plan describes:

(a)(iii) the drainage control measures that will be implemented, throughout all phases of the proposed operation, to control soil erosion for the period from initial construction of those structures until their rehabilitation.

2.2 Federal Fisheries Act (Administered by the Fisheries and Oceans Canada)

2.2.1 Pollution of Fish Habitat

Section 36(3): Subject to subsection 36(4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance that results from the deposit of the deleterious substance may enter any such stream.

2.2.2 Obligations of Proponents

Section 37(1): Where a person carries on or proposes to carry on any work or undertaking that results or is likely to result in the alteration, disruption or destruction of fish habitat, or in the deposit of deleterious substance in water frequented b fish or in any place under any conditions where that deleterious substance or any other deleterious substances that results from the deposit of that deleterious substance may enter any such waters, the person shall, on the request of the Minister or without request in the manner and circumstances prescribed by regulations made under paragraph 37(3)(a), provide the Minister **with such plans, specifications, studies procedures, schedules, analyses, samples** or other information relating to the work or undertaking and with such analyses, samples, evaluations, studies or other information relating to the water, place or fish habitat that is likely to be affected by the work or undertaking as will enable the Minister to determine

a) whether the work or undertaking results or is likely to result in any alteration, disruption or destruction of fish habitat that constitutes or would constitute an offence under subsection 40(1) and what measures, if any, would prevent that result or mitigate the effects thereof; or
b) whether there is likely to be a deposit of a deleterious substance by reason of the work or undertaking that constitutes or would constitute an offence under subsection (40)(2) and what measures, if any, would prevent that deposit or mitigate the effects thereof.

2.2.3 Destruction of Fish Habitat

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

2.3 Province of British Columbia Water Act (Administered by the Ministry of Environment Lands and Parks).

2.3.1 Definitions:

"debris" means

(a) clay, silt, sand, rock or similar material, or
(b) any material, natural or otherwise, from construction or demolition

2.3.2 Prohibition against introducing debris into stream

40.1(1) Unless authorized by or under this or another enactment or excepted under subsection (2), a person must not

(a) introduce debris into a stream, stream channel or area adjacent to a stream, or
(b) cause or allow debris to be introduced into a stream, stream channel or area adjacent to a stream,

if, as a result, harm or damage is caused to

(a) the stream or stream channel,
(b) use, diversion, storage or works authorized under this Act,
(c) the property of riparian owners, or
(d) fish or fish habitat.

The Federal Fisheries Act and the Provincial Water Act legislate against the introduction of any level of sediment that may be deleterious to fish, this is essentially a zero-tolerance standard. This is somewhat different than the approach taken by the Forest Practices Code which requires that forest operations be implemented in such a way that they **minimize** soil erosion and the amount of sediment entering streams, regardless if the stream is fish bearing or not. Regardless of the different philosophical approaches, it is clear that the intent of all three Acts is to protect the aquatic resources from sediment and other deleterious substances. This can be achieved by appropriate planning and appropriate use of available erosion and sediment control techniques.

3.0 GENERAL CONCEPTS OF EROSION AND SEDIMENT CONTROL

The principles of erosion and sediment control design are based on simple common sense. Erosion control stops or reduces the problem at its source. Controlling erosion at its source is far more efficient and effective than trying to intercept sediment in transit. **Erosion control is the only effective long-term solution.**

According to McCullah (1997) erosion and sediment control practices are not effective until the following three conditions have been met:

1) The appropriate control was selected after careful consideration of site conditions
2) The appropriate control was properly installed and implemented, and
3) The necessary inspection and maintenance have been specified and adhered to.

In erosion and sediment control work it is important to have a clear understanding of what type of control is needed and what are the corresponding appropriate practices. There are three general categories of controls that have distinct treatments associated with them;

1) Erosion control
2) Drainage control
3) Sediment control

Erosion control

Erosion control is any practice that protects the soil surfaces and prevents the soil particles from being detached by rainfall or melting snow. Erosion control, therefore, is a source control that treats the soil as a resource that has value and should be kept in place (McCullah 1997). Effective erosion control can dramatically reduce the amount of sediment associated with runoff waters. Whenever possible **do erosion control and drainage control first** and sediment control second. Erosion and drainage control is generally more cost-effective than sediment control and requires less maintenance and repair. Examples of erosion control could include: grass seeding, mulching, erosion control blankets and mats, live staking, wattles and culvert outlet protection.

Drainage control

Drainage control measures are those practices, which mitigate for the erosive and sediment transport forces of runoff water (e.g. ditch, road surface, skid trail and diversion channel runoff) (McCullah 1997). Drainage control also includes practices that are implemented to maintain the natural drainage patterns of the landscape and to route potential sediment laden waters away from stream channels onto "natural vegetative filters" such as the forest floor. Some examples of drainage control might include, cross drains, check dams, rolling dips and water bars, diversion dikes, grass lined channels, and temporary stream crossings.

Sediment control

Sediment control is used to keep sediment, the product of erosion, from entering stream waters. Sediment control involves the construction of structures that allow sediment to settle out of suspension before they reach the stream. Sediment control structures, therefore, require frequent inspection and maintenance. Generally, sediment is retained

on-site by two methods: a) slowing runoff velocities, sufficiently so that sediment cannot be transported, and b) impounding sediment laden runoff for a period of time so that the soil particles settle out. Structural sediment control can be divided into three general types; 1) sediment basins, 2) sediment traps, 3) sediment barriers (McCullah 1997).

Several Forest Practices Code Guidebooks are available to help in the planning of the location and placement of forest access roads and stream crossings to minimize and control erosion and prevent sedimentation, these include the Forest Road Engineering Guidebook, the Community Watershed Guidebook and the Stream Crossing Guidebook. **This document is intended to provide a process by which problems sites and difficult erosional situations are identified up front at the planning stage, well before the construction phase commences, and where specific plans are made and approved to avoid, control and mitigate erosion and sedimentation problems.**

This document does not provide extensive descriptions of methodologies or techniques of sediment and erosion control, but rather it simply outlines important elements of an erosion and sediment control plan. The idea of producing such a plan is to put thoughts and expectations down on paper before the construction phases commences, and to provide the field construction crews with specific sediment and erosion control designs and methodologies, so that they know what is expected and who is ultimately responsible.

4.0 WHAT IS AN EROSION, DRAINAGE AND SEDIMENT CONTROL PLAN?

At present, soil erosion and sediment control activities in forest watersheds throughout British Columbia are generally undertaken on an ad hoc. As awareness of fish/forestry problems increases, however, programs to minimize the effects of soil erosion and sedimentation are being proposed. These programs require a structured approach to soil erosion and sediment control planning, to ensure operational efforts are focused and cost effective (Carr 1992). Erosion and sediment control plans provide such a structured approach.

An erosion and sediment control (ESC) plan consists of a written document with attached maps, prescriptions and detailed technical specifications, of what on-site activities will take place and the measures to be used to control erosion, drainage and sediment transport at each step of a logging and silviculture plan. A good ESC plan coupled with adequate compliance monitoring has been demonstrated to be an effective tool for minimizing sediment problems (Adamson and Harris 1992, Cook 1996). A good **drainage plan** is the foundation of an effective ESC plan, as water is the major eroding source in British Columbia. Because it is impossible to control erosion and

sediment transport without controlling drainage, a drainage plan becomes an integral part of a good ESC plan. **Thus any reference to an erosion and sediment control plan in this document includes by extension a drainage plan.**

These guidelines consider two types of ESC plans:

1) General watershed level plan, and
2) Detailed site specific plan.

4.1 The watershed level plan- Strategic Level

The **watershed level plan** should be used for watersheds ranging in size between 500 and 5,000 ha **that are scheduled for logging,** where serious surface erosion concerns have been identified either because of the high erodibility of the soils, steep terrain, steep road grades or wet climate or a combination of these factors. The plan should be developed and produced **before** road building or road re-activation occurs. This plan is more general in nature than the site-specific plan. Rather than identifying individual sediment control measures at each stream crossing, or other potential problem areas this plan takes a broader perspective. By using soils and terrain maps, problematic sites can be identified and possibly avoided and such practices as minimizing the amount of exposed mineral soil and the number of stream crossing within the watershed can be implemented.

The watershed plan should contain such elements as the identification and location of problem sites and how the erosion problems will be addressed both from a preventative nature and from a control and mitigative perspective. The watershed level plan would serve as a tool to help identify and highlight specific problem sites that need a detailed sediment control plan. The plan should also contain the type, the amount and the storage location of erosion control equipment that may be needed throughout the forestry operations and the location of quality gravel sources. Other information that should be included in such a plan would be specific names of company individuals responsible for the implementation of the plan, the names and qualifications of any environmental monitors hired to monitor the plan and the emergency measures that will be activated should the implemented erosion controls fail. A suggested checklist of what could be included in a watershed level plan can be found in section 9.0.

4.2 The site specific plan- Operational Level

The **site specific plan** is the document in which all of the details for avoiding, controlling and mitigating erosion and sedimentation problems are brought together for a particular water crossing project or other critical site. This plan should include a short narrative, scaled maps and technical drawings which detail how water and sediment are

to be controlled and disposed of for all of the phases of the crossing or critical site construction (short term erosion and sediment control) and for the entire duration of its use (long term erosion and sediment control). A detailed plan should include such elements as clear, concise project objectives, existing site conditions, a description of critical aquatic resources to be protected, a list of administrative measures that need to be completed, details of the sediment control measures, contingency plans, inspection and maintenance schedules and reports, a listing of who is accountable for the project, a detailed drawing of the work site. The required content of the road layout and design (Section 6 of the FPC Forest Road Regulations) will provide much of the information needed for an effective site specific ESC plan. The suggested contents of a site specific plan are described in greater details in Section 10.0 and an example is provided in Section 13.

4.3 Who should be developing these plans?

Most levels of ESC plans can be developed by an individual who understands the basics of erosion and sediment control and also understands the biological and social consequences of excessive sedimentation. This could be a professional or technical biologist, forester, engineer or an experienced construction foreman. Only very complicated situations would require a specialist in erosion and sediment control. As mentioned previously, effective erosion and sediment control is mostly a matter of common sense and simply requires putting your mind to the problem and developing a plan and contingency measures before the construction phases begin.

5.0 WHAT ARE THE BENEFITS OF PREPARING AN EROSION AND SEDIMENT CONTROL PLAN?

An important advantage to having a well documented erosion and sediment control plan is that expectations are clearly articulated well before any erosion problems are encountered. The plan clearly states what drainage and erosion control mechanisms will be implemented. This gives on-site staff an effective tool for reaching the stated objectives of the plan, thus avoiding misunderstandings, conflicts or delays. It also provides a structured mechanism to document successful methods and learn from failed experiences. This type of knowledge can then be passed on to the next challenging situation of a similar type, so that the same mistakes don't continuously get repeated. The implementation of a good ESC plan helps establish a "due diligence" defence.

Good planning and implementation of preventative measures is considered more important, more economic and more effective than conducting remedial measures in response to an unexpected event or possibly undergoing formal investigation for non-compliance under the Forest Practices Code or Federal Fisheries Act. This type of

planning has helped reduce unexpected costs for both the contractors and the project owner (Streed and Skarie 1992).

6.0 WHEN ARE PLANS RECOMMENDED?

Detailed erosion and sediment control plans are not needed for all watersheds and certainly not all stream crossings. Various levels of erosional difficulty and stream sensitivity will require different levels of detail in the preperation of an ESC plan. For simple situations where downstream aquatic values are minimal or non-existent, and erosion potential is low, adherence to environmental guidelines and Forest Practices Guidebook procedures will generally ensure adequate protection of the environment.

However, in watersheds that have been identified as particularly sensitive (i.e. high fish values, fine highly erodible soils, steep terrain, wet climatic conditions, community watersheds) watershed level plans are recommended. Such a plan can benefit both the resource agencies and the licensee because potential problems and available solutions are considered before the problems are encountered. The planning process encourages communication among the plan author, logging supervisors, constructions crews, resource agencies and those monitoring the construction (e.g. environmental monitors).

There exists no formal legislative requirements for producing or submitting an ESC plan before the commencement of logging operations. There is no established review and approval process established by the B.C. Ministry of Forests. However, the production and implementation of an ESC plan may be necessary in many situations to ensure that the operations will "**minimize**" erosion and sedimentation and thus comply with the intent of the legislation cited in Section 2 of these guidelines.

7.0 ENVIRONMENTAL MONITORING

Environmental monitoring is the second part to the approach of erosion drainage and sediment control. Environmental monitors (EMs) are used to monitor and direct the implementation of the ESC plan during particularly erosion prone phases of forestry operations (e.g. stream crossing construction, operations in wet weather). The EM, which can be an erosion control specialists or a trained biologists, forester or crew foreman, is stationed at the work site to interact with regulatory agencies, monitor compliance with erosion control plans and regulations, define areas where regulations are applicable, and review restoration activities. The operations can be either continuously monitored or periodically inspected, depending on site sensitivity or the nature of the construction. Typically EMs have an advisory role during the construction phase, providing on-site recommendations of how to deal with unforeseen circumstances which may cause environmental problems. These recommendations can range from stopping the operations to implementing contingency measures.

The licensee, by having an environmental monitor on site, benefits since this allows the licensee to avoid shutdowns and other costly complications that would otherwise result from preventable environmental violations. It also provides the regulatory agency personnel with a specific individual with whom to discuss erosion and sediment control concerns and issues, thereby increasing communication efficiency. Shut down guidelines are provided in the Forest Practices Code Forest Road Engineering Guidebook (September 1995) under the section entitled "Road works shutdown indicators and procedures".

The main responsibilities of an EM are:

1) to fully understand both the intent and the specifics of the erosion control plans which are to be implemented,
2) to ensure that adequate preventative and mitigative sediment control measures are deployed,
3) to monitor and document the effectiveness of the prevention and control techniques deployed; and
4) to detect at the earliest point in time if the techniques are unsuccessful and recommend appropriate alternative solutions (South Island Forest District, 1997).
5) to work with the contractor and machine operators to achieve the goals of the plan with a minimum of expense and interruptions of construction activities.

9.0 SUGGESTED ELEMENTS OF AN EFFECTIVE WATERSHED LEVEL EROSION AND SEDIMENT CONTROL PLAN

Many of the elements of an ESC plan can be easily obtained from information already gathered as part of the regular forest planning process (i.e. development plans, logging plans, silviculture plans, access management plans, fish, riparian, watershed and slope stability assessments etc.). The ESC plan gathers the relevant information together in one document so that the potential effectiveness, challenges or weaknesses of the plan can be more easily assessed.

The following is a **suggested checklist** of items that have proven to be useful in an effective ESC plan. Depending on the complexity of the situation the plan may be simpler or more complex than what is suggested below. Each situation must be considered individually, and the plan must be adapted to meet the intent of the exercise, i.e. minimize the introduction of sediment into the aquatic ecosystem.

1- Development plans and associated information: A map of the five year development plan with the watershed boundaries outlined on it, a topographical map of the watershed(s), annual rate of harvest for each of the five years of the plan by watershed , kilometres of active roads during each year of the plan (includes both operational and in-block roads) by watershed , number of active stream crossings

during each year of the plan by watershed, all fish bearing streams, all streams that have important downstream resources that may be affected by sediment and sedimentation (e.g. water intakes, recreational sites).

2- Watershed description: Surface erosion potential maps, slope stability maps, FPC stream classifications, monthly precipitation regime and hydrograph if available.

3- Critical road segments and stream crossings: Using the information provided by the development plans and watershed descriptions, identify on the maps sections of roads and stream crossings that will potentially be problematic from a sediment generation and delivery perspective. This may be determined from a combination of factors such as road surface or sideslope gradient, surficial material, proximity to a stream, lake or wetland, natural drainage conditions, type of fish habitat (e.g. spawning, rearing, migration), season of harvest, type and season of road building, timing of hauling, elevation, location of good surfacing material etc.

4- Administration: Administrative measures to ensure satisfactory plan implementation; for example, timing of construction during window of least risk, frequency and schedule of site inspection by EM or other mutually agreed upon inspector, training of workers/contractor, logging contractor input to the plan, schedule of on-site inspections with regulatory agencies, development of specific shutdown guidelines for particular project/watershed.

5- Logging plans/operations: Clearly identifies construction, harvesting and hauling schedules along with the location of all stream crossings and all critical road segments. Describes potential problems and challenges with scheduling and operations on critical sites and the proposed solutions. A solution may be simple and incorporated directly into this plan or it may require a detailed prescription and an individual **site specific plan**. All drainage structures or road segments that require individual sediment control prescriptions (i.e. a site specific plan) are identified on this plan. The location and design of all road drainage structures (e.g. cross drains, fords, ditches, road surface drainage) and channel protection measures (e.g. rock aprons, flumes, culvert approaches, check dams, energy dissipaters) are identified on the logging plans. Although it is impossible to identify all problematic sites in the planning phase, it is the objective of this plan to identify ahead of time as many as possible and make specific prescriptions for each (wherever possible specific prescriptions should consider avoiding the problem altogether). The intent of this plan is that the necessary erosion, drainage and sediment control materials and techniques will be available during the construction and maintenance phases and that the road construction or logging contractor will know ahead of time where the problem sites are likely to occur and what their responsibilities are, i.e. avoid unwanted and unnecessary surprises.

6- Contingency Plans: What processes will be followed if changes are needed (e.g. additional control measures)? What materials and expertise will be available in case

of failure of sediment control measures. Action plans to deal with emergencies (e.g. severe rain, flood flows, culvert blockage, avulsions). The location and access of any stockpiles of erosion and sediment control materials (e.g. silt fences, straw bales, rip-rap, sediment catchment bags, erosion control blankets etc.).

7- Accountability: The names, positions and phone numbers for those responsible for plan implementation and emergency response, along with the agency notification requirements. They should include the on-site construction supervisor, inspector and environmental monitor.

8- Inspection and maintenance: A description of an inspection and maintenance program, with provisions for frequency of inspection, reseeding, repair and reconstruction of damaged structures, cleanout and disposal of trapped sediment, duration of maintenance program, and final disposition of the measures when site work is complete.

9- A watershed erosion and sediment control map for the upcoming 2 years of the plan (scale approx. 1:20,000) . The information on this map may include such items as:

- ⇒ location of all active roads
- ⇒ location of all fish bearing streams
- ⇒ location of all water intakes
- ⇒ location of all stream crossings and types of crossing
- ⇒ location of all critical stream crossings and road segments
- ⇒ location of critical drainage structures
- ⇒ specific erosion control measures for the critical sites if they are minor
- ⇒ location of any major critical sites that require specific erosion control plans, and the references to these plans
- ⇒ road drainage plans

10.0 SUGGESTED ELEMENTS OF AN EFFECTIVE SITE SPECIFIC EROSION AND SEDIMENT CONTROL PLAN

A site specific plan contains many of the same elements as the watershed plan, except this plan is focusing on providing details of erosion control measures for one particular critical crossing or road segment. The site map should be at a scale of about 1:1,000 compared to a watershed map which will be at a scale of about 1:20,000. Not all crossings or road segments within a watershed plan need to have a detailed plan. **Only those sites that provide particularly challenging conditions, relative to erosion and sediment control and downstream risk need a detailed plan.** These sites may be identified by the forest company making the plan, the logging contractor reviewing the plan or a regulatory agency that has identified a significant, specific concern.

1- Project description: Brief description of the project and the plan objectives. This should include items such as reasons for needing this specific plan, specific concerns identified, who identified the concerns, whether it is part of a watershed plan or a stand alone plan.

2- Site conditions: Brief description of existing topography, soils types, site drainage patterns, stream characteristics such as bed material, stream width, stream depth, stream velocity, anticipated erosion and sediment transport and deposition problems.

3- Critical areas: Description of downstream values that could be adversely affected by serious erosion or sediment problems (including the distance from the disturbance site), potential problematic erosion sites and sediment delivery pathways, potential erosion and sediment control sites.

4- Administration: Administrative measures to ensure satisfactory plan implementation; for example, timing of construction during window of least disturbance, in stream work restrictions, licences, agency approvals, frequency and schedule of site inspection by EM or other mutually agreed upon inspector, training of workers/contractor, logging contractor input to the plan, schedule of on-site inspections with regulatory agencies, development of specific shutdown guidelines for the particular project.

5- Construction operations: Description of each construction operation in chronological sequence (i.e. scheduling), pathways of sediment movement, occasions when sediment will enter water, and the measures that will be taken at each step to control erosion and sediment:

- proposed construction time frame and sequence of construction
- pre-disturbance control measures (e.g. silt fences, coffer dams, temporary stream diversions, isolation of flow techniques)
- provisions to limit disturbance, thus keeping erosion problems to a minimum
- clearing and preparation of work areas
- water flow management during construction for:
    - surface water flowing towards creek
    - streamflow management during construction (e.g. stream diversions, pumping etc).
- access to the far shore
- fill placement in floodplain (type, method),
- specific short and long term erosion and sediment control measures (where, when, how, maintenance schedule etc.)
- structural details of each critical erosion and sediment control structure (e.g. sediment basin, dike, silt fence etc.)

6- Contingency Plans: What processes will be followed if revisions are needed? What materials and expertise will be available in case of failure of sediment control measures. Action plans to deal with emergencies (e.g. severe rain, flood flows, culvert blockage, avulsions). Location and access of any stockpiles of erosion and sediment control materials.

7- Accountability: The names, positions and phone numbers for those responsible for plan implementation and emergency response. They should include the on-site construction supervisor, inspector and environmental monitor.

8- Inspection and maintenance: An inspection schedule and expected long and short term maintenance requirements for erosion and sediment control measures.

9- A drawing, sketch or map of the work site showing work phases and mitigation measures (example provided in Section 12, Figure 3). Important elements to include are:

- local topography and drainage directions and patterns
- location and design specifications of all of specific erosion and sediment control structures (both short term and permanent) (see Section 11, Figures 1 and 2).
- location and specifications of drainage control structures (e.g. cross drains, ditches, ditch blocks, etc.)
- location of particular critical areas/ fish habitat values

11.0 TECHNIQUES OF EROSION, DRAINAGE AND SEDIMENT CONTROL

The following is a list of some of the most common control measures used in forestry. Complete descriptions of these control measures can be obtained in numerous publications such as McCullah (1997, 1996), British Columbia. Ministry Forests (1995, 1997), Chilibeck et. al. (1992), Carr (1992), FERIC (1997), Waters (1995), BCIT (1996), and Goldman et. al. (1986).

11.1 Erosion Control

Permanent seeding is used to establish a permanent vegetative grass cover that will prevent soil detachment by raindrop impact or snowmelt, reduce sheet and rill erosion, and stabilize slopes and shallow channels.

Temporary seeding is used to reduce damage from water erosion until permanent stabilisation is accomplished.

Mulching is the application of a protective layer of straw or other suitable material to temporarily stabilize bare and disturbed soils.

Hydraulic planting is the use of hydro-seeders and hydro-mulchers to establish erosion resistant vegetation on disturbed areas and critical slopes.

Erosion control blankets and mats are used to temporarily stabilise and protect disturbed soil from surface erosion by installing a protective mulch blanket or soil stabilisation mat to the prepared soil surface of a steep slope (see Figure 1).

Live Staking involves the insertion and tamping of live, vegetative cuttings into the ground in a matter that allows the stake to take root and grow.

Wattles are live branch cuttings, usually willows, bound together into long, cigar shaped bundles used to stabilise slopes and streambanks (see Figure 2)

Gabions are wire baskets filled with stones used as pervious, semi-flexible building blocks to construct retaining walls and grade control structures.

Inlet Protection includes techniques such as rip-rap or armouring, concrete blocks, channelization, and woven wire gabions (note that gabions should not be installed instream or within flood zone).

Outlet protection includes techniques such as full and half flumes, rock aprons and other energy dissipators.

11.2 Drainage Control

Ditches are the primary tool for water control on forest roads and are used where sidehill drainage is expected or where surfacing material must be drained.

Grass-lined or gravel/rock lined channels or ditches is the establishment of vegetation in a ditch or swale to reduce water velocities and protect the channel from erosion.

Cross drains are used to remove water flowing in roadside ditches, between natural water courses, as collected from sidehill drainage and precipitation on the road surface.

Ditch blocks are used to slowdown or to halt the downslope movement of water in the ditch and to direct the flow of water into the cross drain. Ditch blocks are located downstream of most cross drains.

Insloping puts the inside shoulder of the road lower than the centreline with the intent of directing surface runoff away from the outer shoulder and unstable fill slopes, may need to be accompanied with a short outside berm.

Outsloping puts the outside shoulder of the road lower to direct runoff away from the inner shoulder, ditch and/or cutbank.

Crowning keeps the centreline higher than the shoulder or sides, thus keeping the road surface free of ponding or running water.

Fords can be used where a stream has shown high debris transport and consistently plugs drainage structures, a ford can be considered as a long term self-maintaining structure on high energy streams with no fish.

Broadbased dips or swales are used as failsafes in case of culvert blockages to keep water from running down the road surface (see Figure 1).

Water bars and rolling dips are ridges or channels constructed diagonally across a sloping road to disperse water from road running surfaces into ditches or non-erodible surfaces.

Cattle guards can be used as "permanent waterbars" in places where swales cannot be built.

11.3 Sediment Control

Most of the controls mentioned below require a substantial amount of maintenance for them to perform adequately. If they are not cleaned out regularly and large amounts of sediment are allowed to accumulate in critical areas, then this can create a greater sediment hazard than existed in the first place. Consequently, effective sediment control can be an expensive long term endeavour, more so than effective erosion or drainage control.

Temporary sediment basin is a pond created by excavation and designed to retain or detain runoff sufficiently to allow excess sediment to settle.

Silt Fence is a temporary sediment barrier consisting of filter fabric placed on slope contours, small swales or short, low volume ditchlines to pond water and allow sediment to settle out. Silt fences that are not maintained, or cleaned out can cause a very serious sediment hazard when they blow out. (see Figure 1).

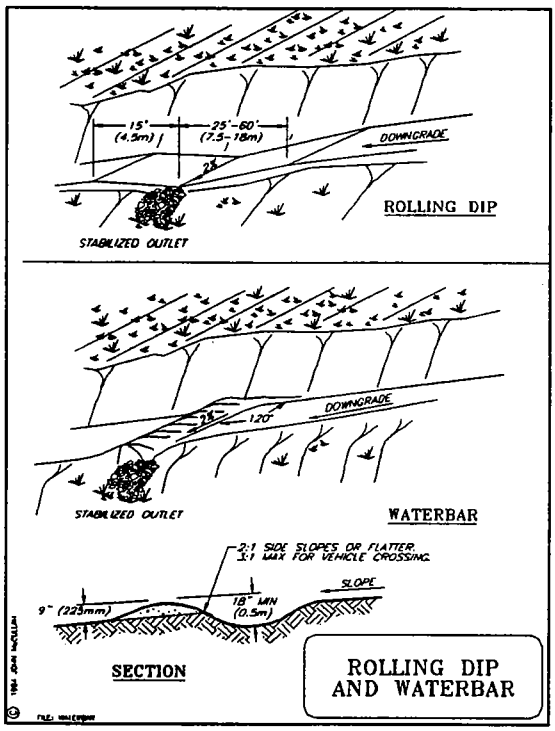
Silt dike is a temporary barrier consisting of straw bales or other appropriate materials (e.g. urethane foam wrapped in geotextile fabric) installed across a slope, at the toe of a slope and/or around the perimeter of a construction site (see Figure1).

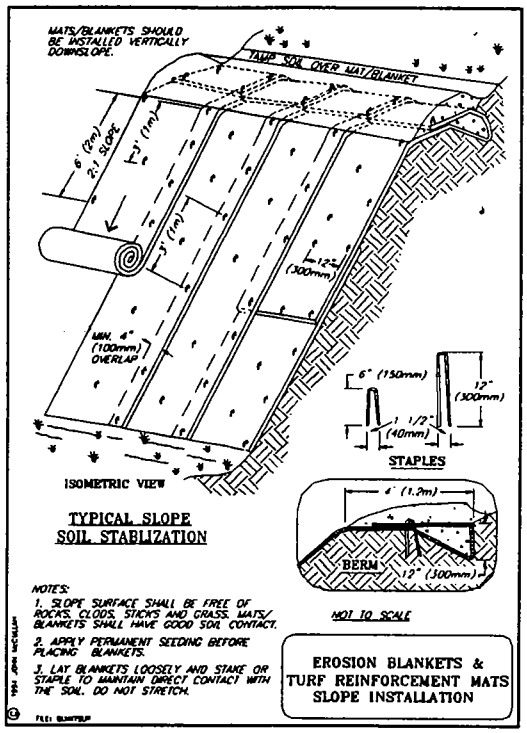
Straw bale sediment barrier (semi-pervious) is a temporary barrier consisting of straw bales and a rock spillway placed across small drainages or gently sloping swales. These are intented to intercept and detain small amounts of sediment while allowing runoff to flow through and over the barrier (see Figure 2).

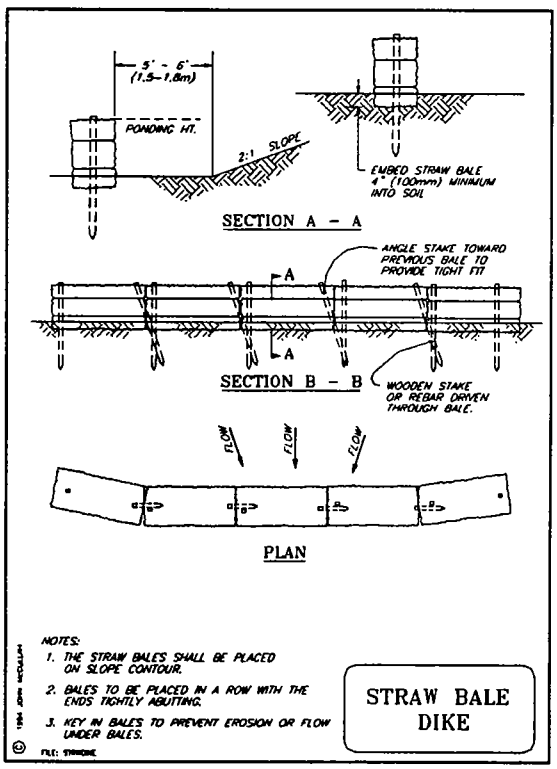
Check dams are small temporary dams constructed across a swale, gully or ditch to reduce water velocity and erosion and to trap and store larger sized sediment Check dams can be built out of small boulders, straw bales or wooden strcutures (see Figure 2).

Sediment catchment bags are large geotextile bags installed on the outlet ends of culverts to collect sediment before it is delivered to the stream.

Continuous berm is a temporary diversion dike or sediment barrier constructed with infill material encased within geotextile fabric. It is used to divert and intercept sheet type runoff and also to detain and pond sediment laden stormwater.







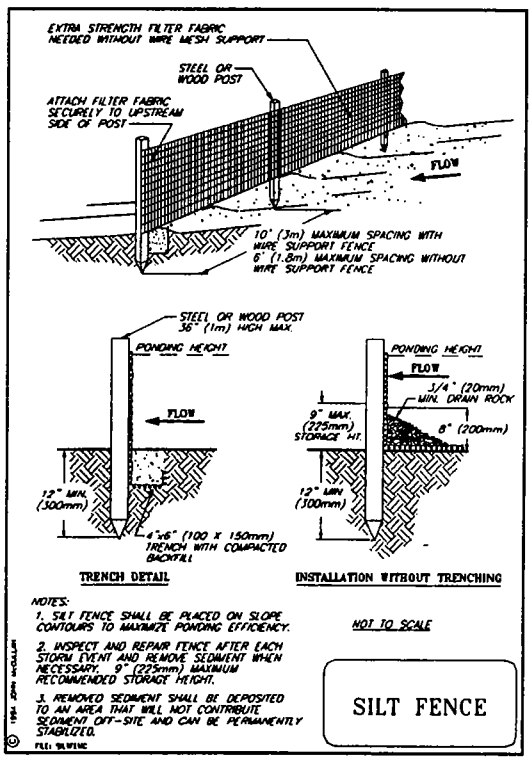


Figure 1: Typical drawings for popular erosion and sediment control practices in forestry

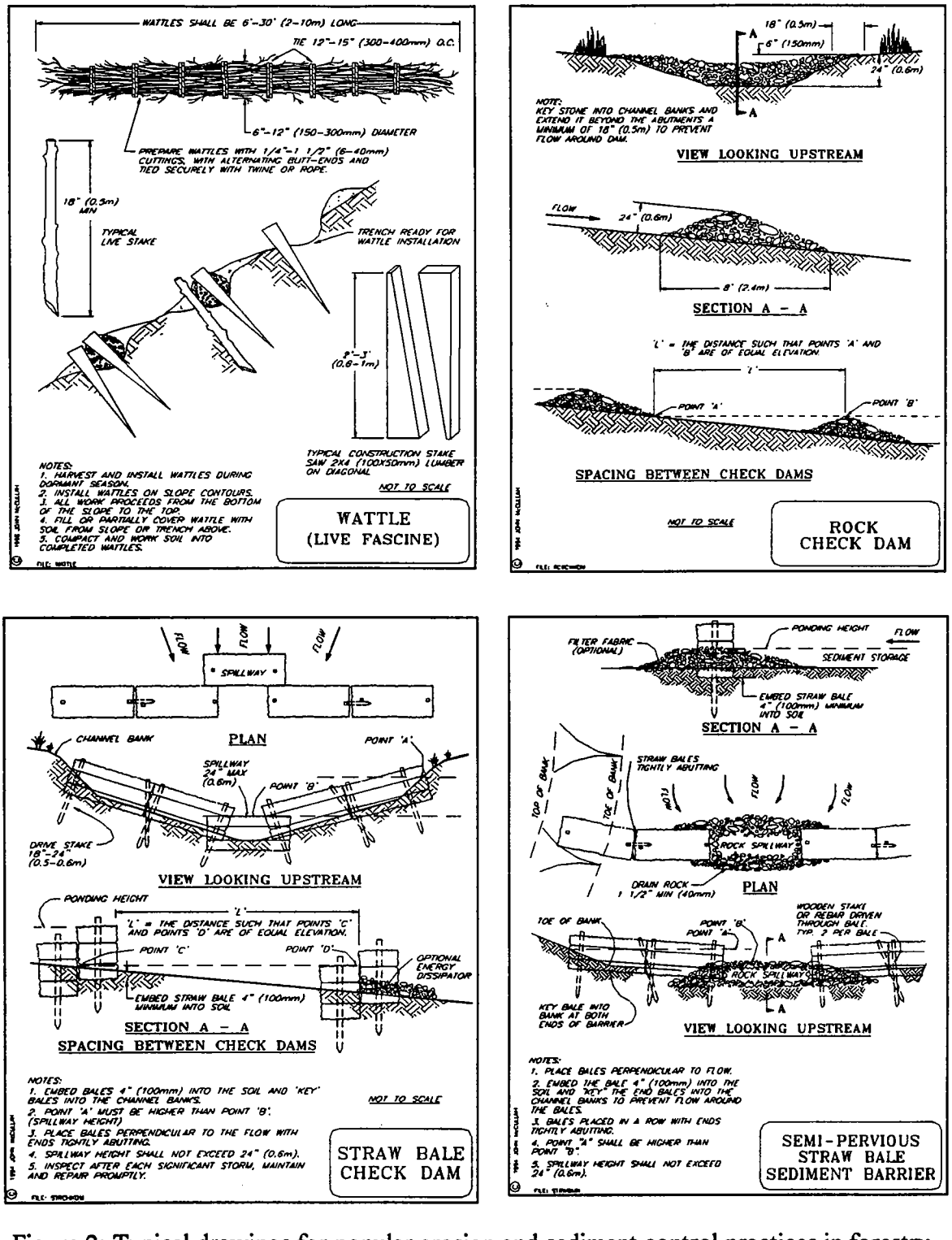


Figure 2: Typical drawings for popular erosion and sediment control practices in forestry.

12.0 EXAMPLE OF A SITE SPECIFIC EROSION AND SEDIMENT CONTROL PLAN

The following erosion and sediment control plan (ESCP) was developed by the Ontario Ministry of Natural Resources (OMNR) for a stream crossing on a Ministry road (i.e. the equivalent of a Forest Service Road). Since this crossing was on a stream that contained important stocks of sports fish including walleye and brook trout, it was decided that a sediment control plan would be helpful to deal with potential problems in advance of construction. This sediment control plan was included in the specifications provided to bidders and the cost of implementing the SCP was to be included in the tendered price. The culvert was installed by the contractor building the forest access road, and he had the opportunity to provide ideas and amend the plan to make construction as efficient as possible. **Design specifications for the erosion and sediment control techniques to be implemented were very clearly specified and they were included with the bid package. The contractor liked the ESCP approach because requirements and expectations were clearly set out at the time of bidding.**

Example Sediment Control Plan . Trout Creek Culvert

This plan has been adapted with permission from Bruce Adamson - Ontario Ministry of Natural Resources (06/01/97), to better reflect practices and regulations in British Columbia.

1.0 Plan Objectives

The objective of this plan is to install the culvert water crossing, yet keep the short term introduction of sediment into the creek to the lowest levels practically achievable. The site will be stabilized on completion to ensure no sediment enters the water in the long term. The erosion and sediment control measures described in this plan are being implemented to comply with Sections 8, 9, 12, 13 and 18 of the Forest Road Regulations of the Forest Practices Code.

2.0 Project Description

Trout Creek is located at Station **50+00,** (kilometre 5) of the North Road. Trout Creek is a direct tributary to the Harra River which supports very important populations of Chinook Salmon. Juvenile Chinook use Trout Creek as off channel habitat and refuge from the high water spring flows of the Harra River. It is possible that some of the juveniles use Trout Creek all summer and into early Fall as an early rearing environment. Trout Creek is also used by Bull and Rainbow Trout as spawning and rearing habitat. The culvert crossing is located near the mouth of Trout Creek, only 50 m upstream with the confluence of the Harra River. This situation makes Trout Creeks a very sensitive fisheries stream, and therefore merits a well developed Erosion and Sediment Control Plan to minimize potential impacts from the installation of the culvert.

The Forest Service Road is being constructed by a Forest Licensee to access wood in the Harra watershed. The single 3000 mm diameter culvert is designed to pass the 100-year flood flow. Construction of the crossing will take place in July or August 1998. Work will be done by a Contractor working for the Forest Licensee, with the engineered designs being reviewed by a Forest

Service engineer A full-time on site inspector reporting to the Forest Licensee will be monitoring construction.

The 24 m culvert length will support a 7.3 m wide road and the 4 m high **fill** with 2H: 1V side slopes. For 100m on each side of the creek an Area of Concern (AOC) has been defined where the construction techniques and mitigation measures set out in this plan will be used to control erosion and reduce sediment.

3.0 Existing Site Conditions

Water depth in the creek during a dry spell was 15 cm deep and 6 m wide. Flow velocity is slow. Streambed is composed of cobbles, gravels and sand. The east bank is about 2 m high and slopes gently upwards from the creek. The west bank is 1.2 m high and from there the ground rises quite steeply, about 5 m in 61 m. Beyond this point, the ground flattens out. Both banks contain silty sand material, considered highly erodible.

Right of way clearing was completed last winter. The cleared width through the AOC was kept as narrow as possible and no greater than 20 m. No grubbing has occurred near the crossing.

4.0 Critical Areas

Downstream of the North Road, Trout Creek flows into the Harra River about 50 m away. Fish species in the creek include important stocks of Chinook salmon, Rainbow and Bull trout. The soil texture around the stream crossing is a fine glacio-lacustrine deposit. The climate is wet with deep winter snowpacks and frequent long duration rainfall events, especially during the Fall. Without appropriate erosion control measures, large quantities of sediment could easily make it into Trout Creek, negatively affecting the fish and their habitat for both Trout Creek and the Harra River.

5.0 Construction Operations and Sediment- Control Measures

The following construction operations are expected to occur on the project. Erosion and sediment control measures are described for each operation. Erosion and sediment delivery to the stream channel will be kept to a minimum by adherence to this ESCP and specific requirements of the Forest Road Regulations of the Forest Practices Code. Refer to the Drawing of sediment control measures at the crossing (Figure 3).

5.1 General

Because the culvert is greater than 2000 mm, the culvert crossing will be designed by a qualified Engineer, as set out by the Forest Practices Code. The Forest Road Regulations will be adhered to and guidance will be obtained from both the Forest Road Engineering Guidebook and the Stream Crossing Guidebook For Fish Streams. To control sediment and to ensure the best foundation conditions, a creek diversion channel will be built alongside the existing stream channel. The water from the existing channel will be temporarily routed in the diversion ditch, this will allow construction in the "dry", away from flowing water. A well constructed cofferdam or an aquadam will be installed in the stream channel to divert the water flows into the temporary diversion ditch. This diversion dam must be built in such a way as to not create a source of sediment, either during installation or removal.

After the culvert is installed, the cofferdam will be carefully removed and the flow will be re-routed back to its original channel and allowed to flow through the culvert. The length of creek diversion will be about 30m.

5.2 Preventive Measures

Construction on the water crossing will take place during the Chinook and trout work window which is between June 15 and July 15 for Trout Creek.

Construction operations will be discussed at a meeting between the Contractor, the Inspector and all equipment operators so everyone understands the sediment control measures. Conspicuous flagging tape will be placed at the beginning and end of the AOC so operators know when they are working in the sensitive zone.

5.3 Introduction of water into diversion ditch

Careful planning of this operation is important so downstream sediment is minimized. Prior to diverting the flow, the diversion ditch will be lined with suitable geotextile cloth and adequately weighed down to the bottom and sides of the ditch with rip-rap. A settling pond shall be located at the bottom end of the diversion ditch, immediately upstream of where the water re-enters the original channel. The outflow of the settling pond shall also be lined with appropriate geotextile cloth. The ultimate objective is to prevent erosion and generation of sediment by the diversion ditch when flows are directed into it.

5.4 Clearing and Grubbing

Clearing of trees will be kept to the minimum necessary to access the work area and construct stable fill slopes. The Contractor and Inspector will jointly mark each tree that must be removed within the AOC. Cut trees are to be de-limbed and piled nearby at a location to be marked by the Inspector.

5.5 Access

Since the location of the diversion ditch is to the west of the existing creek, temporary access across the creek is not necessary. Construction operations will be scheduled by the Contractor so the culvert will be installed before any road work on the opposite side. The Contractor will ensure there is no fording of the creek.

Access to both sides of the culvert will be available around one end of the pipe. Due to the limited working area, it may be necessary to open flow through the culvert before backfilling is complete to prevent backfill from blocking the diversion channel. Backfill material can be placed over the pipe to the far side by an excavator.

5.6 Culvert Placement and Channel Excavation

The culvert will be installed according to the Engineered design specifications, which will ensure fish passage.

5.7 Introduction of Water Flow to New Culvert

Careful planning of this operation is also important so downstream sediment is minimized. The culvert backfill and erosion protection must be in place to above water level, before water flows through the pipe. Complete backfill of the culvert is not necessary at this stage, however it must be 3/4 up the pipe.

Gravel fill material and rip rap should be **readily** available in sufficient quantities to complete the operation.

6.0 Control of Surface Water Runoff

Details of surface runoff control are shown on the plan. The ground topography is favourable for controlling the flow and preventing erosion.

On the west side of the creek, the ground slopes to the north at a gradient of 5%. A diversion berm and cross culvert will be installed at Station 49+70, or closer to the creek, to divert water from the south side of the road to the north. A rock apron energy dissipator will be installed at the outlet of the cross drain to prevent erosion. The sediment laiden ditch water, that has been carried through the cross ditch, will then be filtered through the forest floor before it eventually reaches Haggen creek as groundwater. A settling pond will be built immediately adjacent to Trout creek to settle out sediment that was carried by the ditch water between the cross drain and Trout creek.

On the east side of Trout creek the road slopes quite steeply towards the creek for a distance of 60 m. Steep cut slopes on either side of the road prevent the usage of a cross drain to divert sediment laiden waters into the forest. A series of straw bale check dams will be installed in the ditches on both sides of the road approaching the creek (see technical drawing; Figure 5). This will minimize ditch erosion and facilitate sediment deposit. Small, temporary sediment ponds will be built immediately before the ditch waters enter Trout creek. The outlet of all of the sediment settling ponds will be lined with geotextile cloth to prevent erosion of the pond embankment.

Beyond Station 50 +60 water will be diverted to the east and north, away from Trout Creek by ditching and a cross culvert at Station 51+20. A rock apron energy dissipator (see technical drawing, Figure 6) will be installed at the outlet of the cross culvert.

7.0 Permanent Erosion Control Measures

All slopes are to be trimmed to a stable angle no steeper than 2H: 1V. Both cut slopes, located between 50+00 and 50+70 will be treated with an erosion blanket. The slope surface shall be free of rocks, clods, sticks and grass. Mats/blankets shall have good soil contact. Permanent seeding shall be applied before placing blankets. The blankets will be lain loosely and staked or stapled to maintain direct contact with the soil (see technical drawing, Figure 5).

The straw bale check dams and the sediment ponds shall be maintained and cleaned out regularly until the ditch lines have stabilized and the seeded vegetation has taken hold.

All areas within the cleared right-of-way, excluding the road surface, are to have an application of seed and fertilizer to re-establish vegetation on disturbed soils. Spreading will be done with a hand broadcast seeder.

8.0 Technical Specifications

Details of the mitigation techniques are explained in the Forest Practices Code "Forest Road Engineering Guidebook" , the "Stream Crossing Guidebook" and "Land Development Guidelines for the Protection of Aquatic Habitat" published by DFO and MoE.

Gravel Fill

Gravel fill used in the AOC will be well graded coarse granular material approved by the Inspector.

RipRap

All rip rap for erosion protection on the slopes and channel bottom will come from the stockpile of cobbles at Km 0.35 right.

9.0 Inspection and Maintenance

Construction operations will be under the direction of John Brown (contract foreman) and inspected on a daily basis by Tom Smith representing the licensee to ensure compliance with this Sediment Control Plan and the Contract. Any problems or concerns will be resolved on-site between Tom Smith and John Brown.

Cut slopes and sediment control areas will be monitored by the Licensee for two years after construction and repaired if necessary to ensure their effectiveness. Areas treated with seed and fertilizer will be inspected and any bare areas will be re-seeded by the Licensee with a second application.

10.0 Revisions to Plan

Revisions to this plan can be made on-site by mutual agreement between the Licensee and the Contractor. All changes will be recorded and a copy provided to the Regional Engineer. Every revision must result in an improvement to the sediment control plan.

9.0 Accountability

The following individuals are responsible for preparation and implementation of this sediment control plan and will, to the best of their ability, ensure it is followed during construction of this project.

Plan prepared by,

Tom Smith, P.Eng
Forest Engineer
The Big Tree Lumber Co
(250) 296-2476

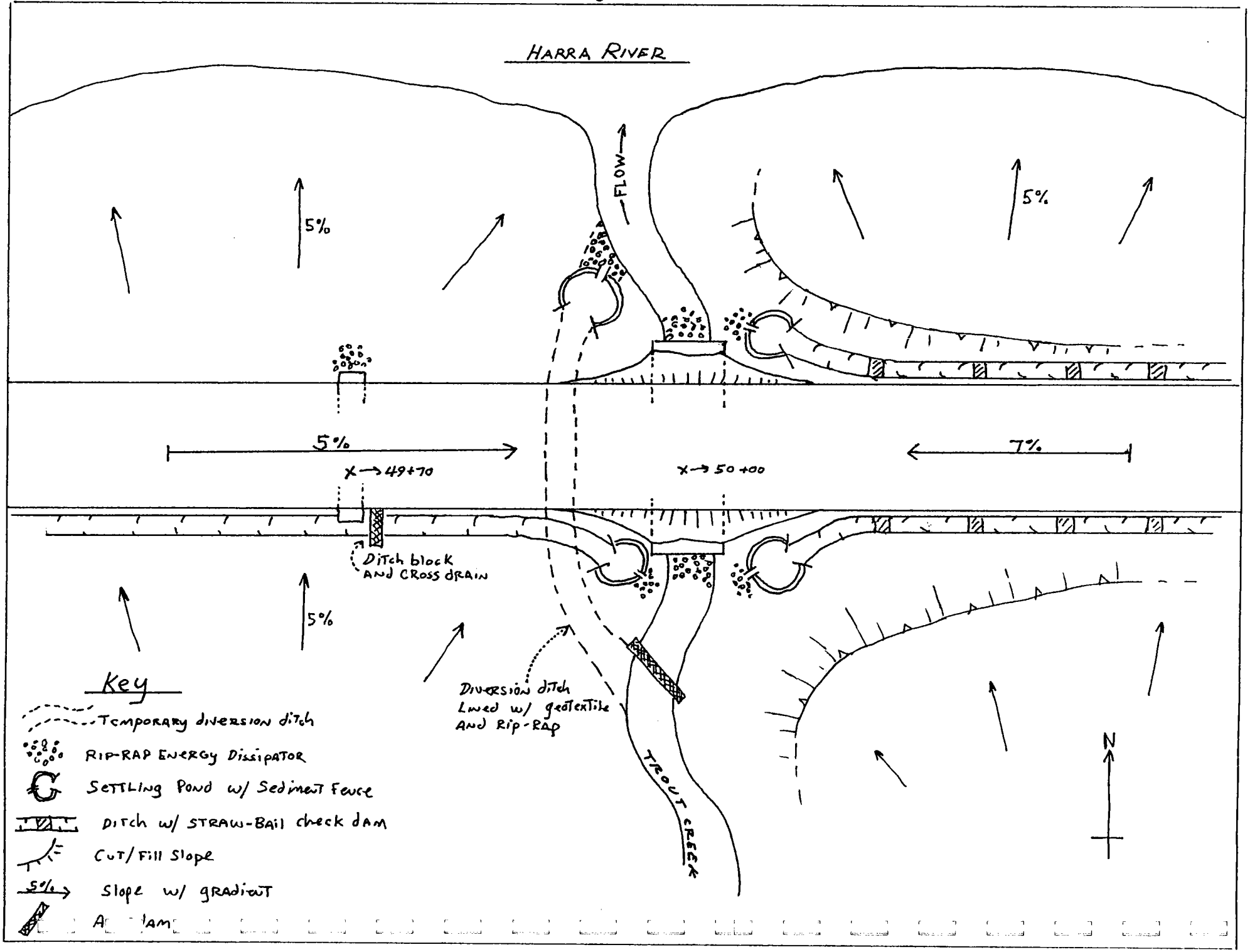
Plan will be implemented by,

John Brown,
Construction Supervisor
The Big Construction Company
(250) 276-8437

Plan will be inspected by,

T.J. Black, P.Eng.
A.B.C. Engineering
(250) 278-5294

Figure 3.


HARRA RIVER
FLOW
5%
5%
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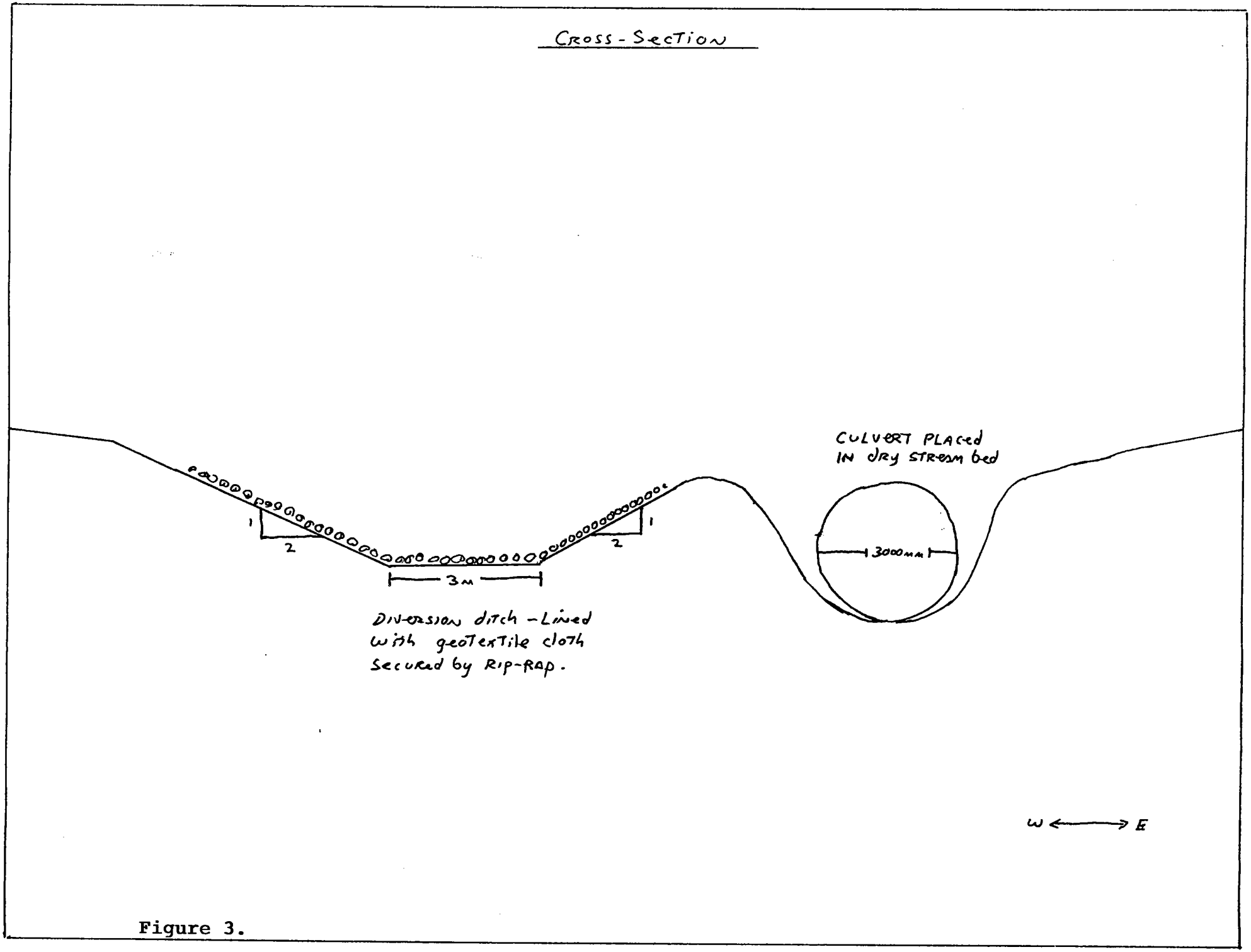
X → 49+70
X → 50+00
Ditch block
AND CROSS DRAIN
Key
Temporary diversion ditch
RIP-RAP ENERGY DISSIPATOR
SETTLING POND w/ Sediment Fence
DITCH w/ STRAW-BAIL check dam
CUT/FILL Slope
5% → Slope w/ gradient
DIVERSION ditch
LINED w/ geotextile
AND RIP-RAP
TROUT CREEK
N


Cross-Section
CULVERT PLACED
IN DRY STREAM bed
1
2
1
2
3M
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DIVERSION DITCH - LINED
WITH GEOTEXTILE CLOTH
SECURED BY RIP-RAP.
W
E

Figure 3.

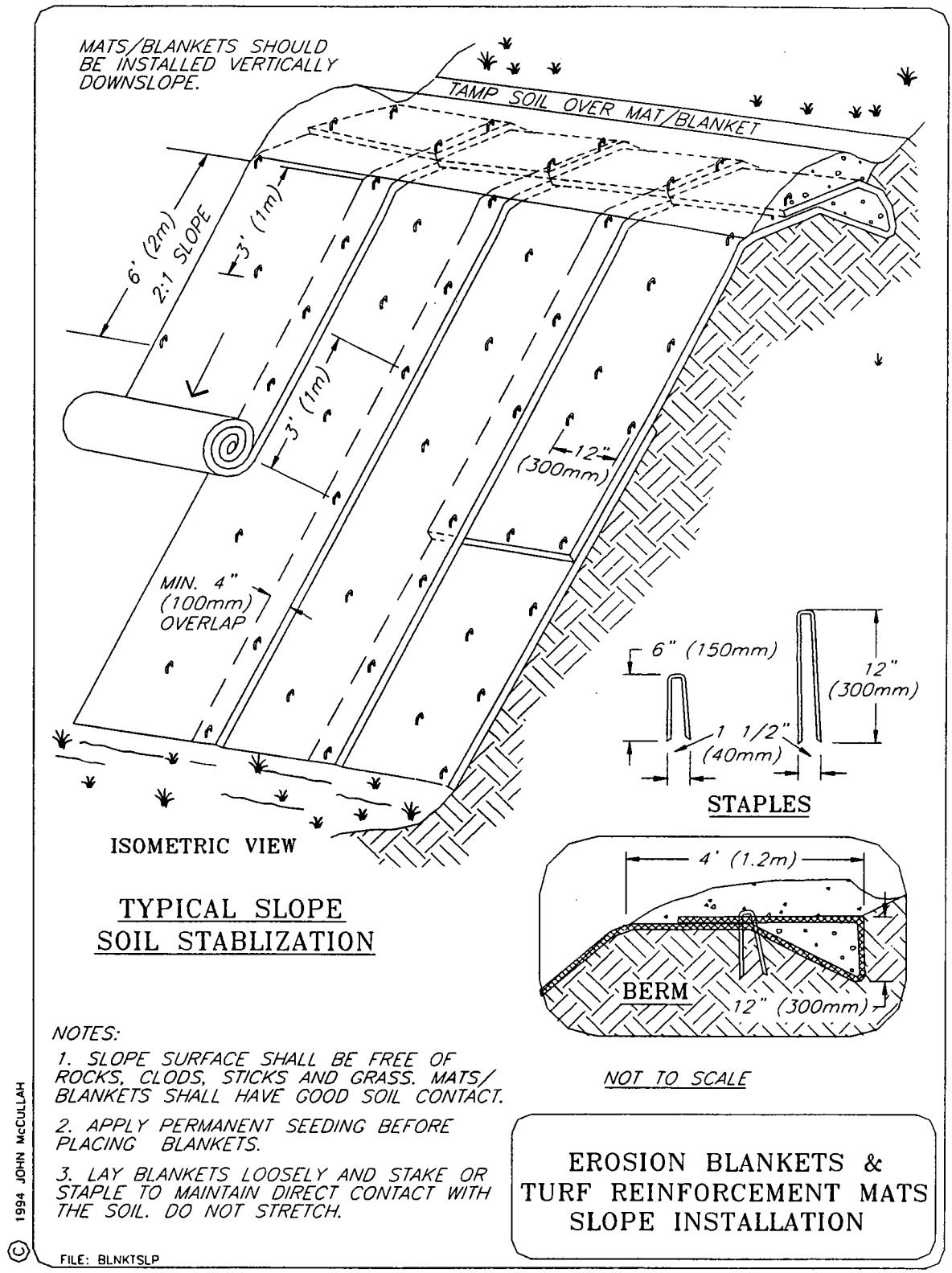

Figure 4: Technical specifications for erosion blanket

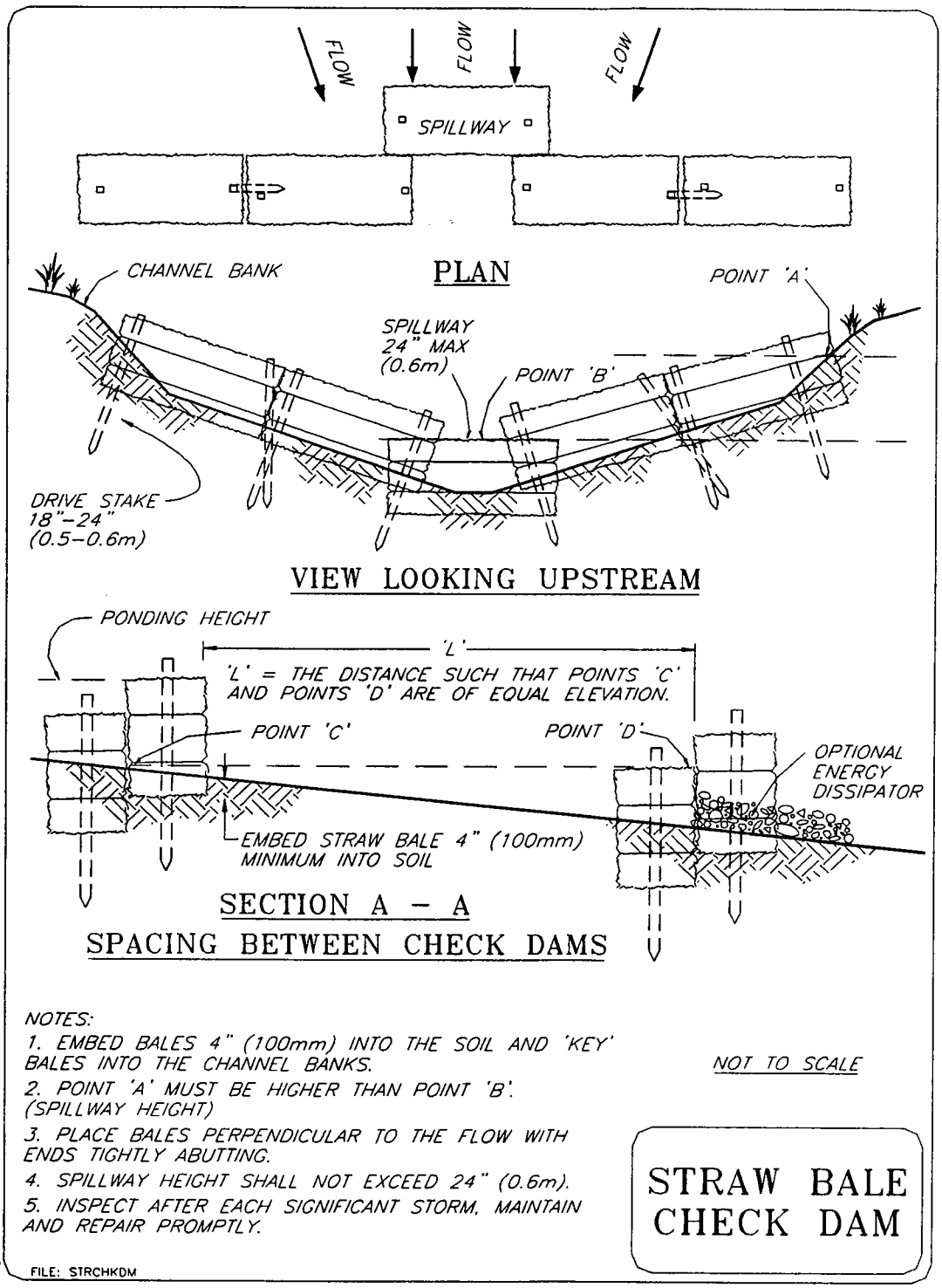

Figure 5: Technical specifications for straw bale check dam.

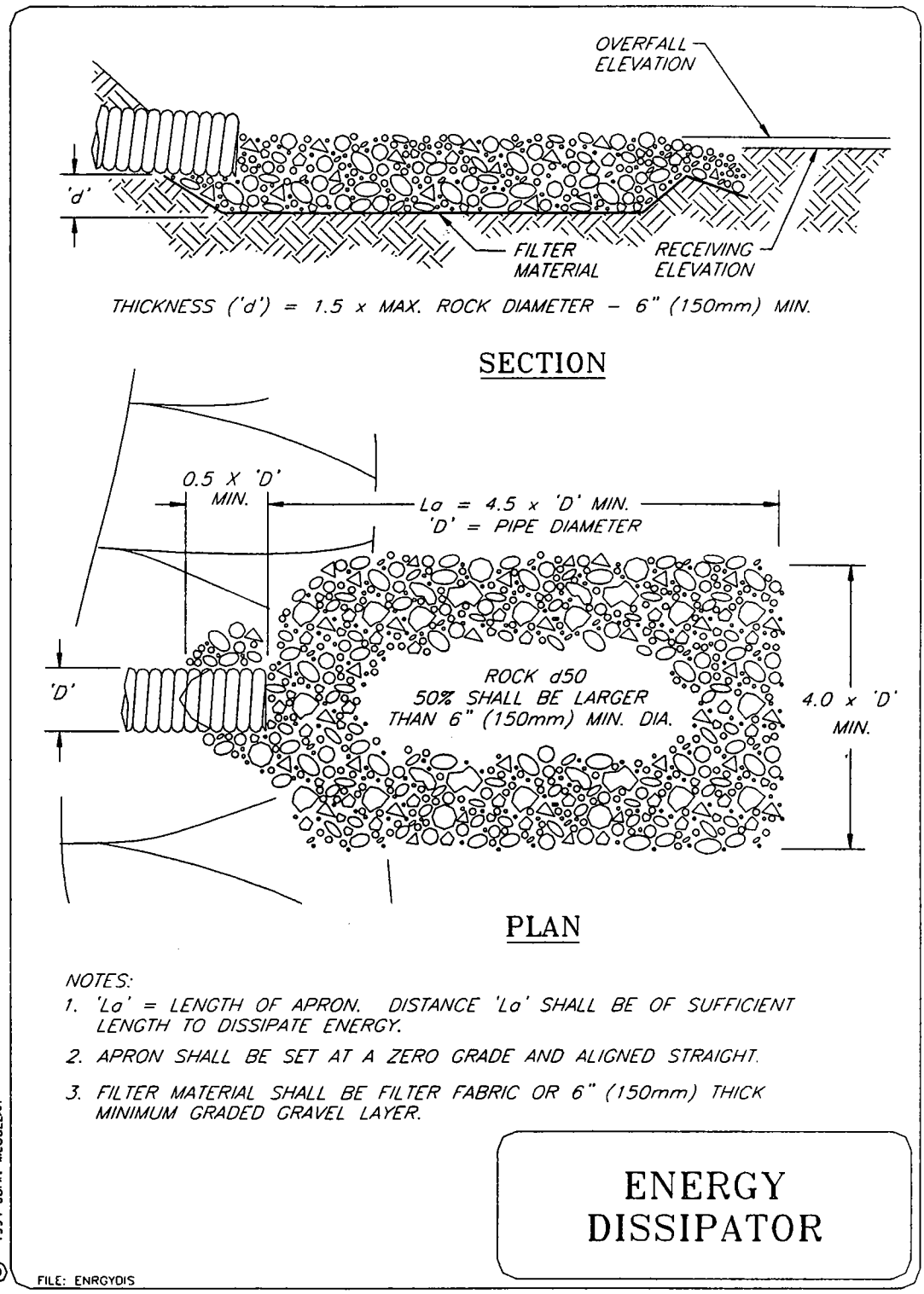

Figure 6: Technical specification for rock apron energy dissipator

13.0 ACKNOWLEDGEMENTS

The information provided in this document is based heavily of the work of Bruce Adamson, Regional Engineer for the Ontario Ministry of Natural Resources (Adamson 1992, 1997). Mr. Adamson was contacted by phone in January of 1998 at which time he approved the use of his materials. He was enthusiastic and encouraging of the project and he also agreed to provide additional sediment control plans and teaching materials he uses in his extension work. A second important source of material was the work done by McCullah (1996, 1997). His erosion control manual and his commercial product called Erosion Draw 2.0 (which we have purchased) provided much of the information in the section on specific techniques of erosion and sediment control. I would also like to acknowledge the following people who completed editorial reviews and provided very useful comments towards the improvement of this document: Chris Ritchie (MoELP), Don Cadden (MoELP), Peter Jordan (MoF), Pat Teti (MoF), Steve Chatwin (MoF), Ken Hodges (MoF), Jeff Burrows (MoF), Nick Leone (DFO), Jason Quigely (DFO), Jason Hwang (DFO), Paul Sanborn (MoF), Carl Erickson (MoF), Tom Deevy (MoF), Dwight Hickey (EDI), Kevin Kansky (MoF).

14.0 REFERENCES

Adamson Bruce, 1997. Erosion and sediment control practices for construction activities at water crossings. International Erosion Control Association.

Adamson B. and A. Harris, 1992. Sediment Control Plans: Reducing sediment concerns at water crossings. Technical Note # 20. Northwestern Ontario Forest Technology Development Unit. Ontario Ministry of Natural Resources.

B.C.I.T. 1996. Road construction practices and procedures. Course notes for RRET 0310/0311. British Columbia Institute of Technology, Burnaby, B.C.

Bilby, R.E. 1985. Contributions of road surface sediment to a western Washington stream. Forest Science. 31(4):827-838.

Bilby, R.E., K. Sullivan and S.H. Duncan, 1989. The generation and fate of road-surface sediment in forested watersheds in southwestern Washington. Forest Science. 35(2):453-468.

British Columbia. Ministry of Forests, 1995. Forest Practices Code forest road engineering guidebook. Province of British Columbia.

British Columbia. Ministry of Forests, 1997. Forest Practices Code stream crossing guidebook for fish streams. Province of British Columbia.

Carr W.W. and I Wright, 1992. A soil and erosion and sediment control planning system for managed forest land: A case study at Shomar Creek, Queen Charlotte Islands. Ministry of Forests Land Management Report number 69. Minitry of Forests Forest Science Research Branch, Victoria, B.C.

Chilibeck, B., G. Chislett, and G. Norris, 1992. Land development guidelines for the protection of aquatic habitat. Department of Fisheries and Oceans Canada and the B.C. Ministry of Environment, Lands and Parks.

Cook, G. 1996. The disparity between erosion control plans and field practice: closing the gap. Proceedings of the 27th International Erosion Control Association Conference.

Duijsings J.J.H.M., 1986. The sediment supply by streambank erosion in a forested catchment. Z. Geomorph. N.Z. Suppl. Bd.60: 233-244.

Goldman, S.J., K. Jackson, and T.A. Bursztynsky, 1986. Erosion and sediment control handbook. McGraw-Hill, Inc. New York.

Everest, F.H., R.L. Beschta, J.C. Scrivner, K.V. Koski, J.R. Sedell, and C.J. Cederholm 1987. Fine sediment and Salmonid production: A paradox. *In:*Streamside Management Forestry and Fisheries Interactions. E.O. Salo and T.W Cundy eds. University of Washington, Institute of Forest Resources, Contribution No. 57, Seattle Washington.

FERIC 1997. Compendium of watershed restoration activities, techniques and trials (SR-119). Forest Engineering Research Institute of Canada, Western Division, Vancouver, B.C.

McCullah John, 1996. Erosion Draw 2.0 - Erosion and sediment control manual with typical drawing files for computer aided drafting. Salix Applied Earthcare, Redding California.

McCullah John, 1997. How to put the BEST back into your Best Management Practices (BMP's). International Erosion Control Association, professional development training course, November 25, 1997 - Vancouver, B.C.

Reid, L.M. and T Dunne, 1984. Sediment Production from road surfaces. Water Resources Research 20(11):1753-1761.

Saunders, J.W. 1965. Changes in stream population of trout associated with silt. J.Fish. Res. Bd. Can. 22:395-404.