CLIENT **: GUYANA ENVIRONMENTAL CAPACITY DEVELOPMENT PROJECT (GENCAPD)**

PROJECT**: CODE OF PRACTICE FOR MINE EFFLUENTS IN GUYANA'S SMALL AND MEDIUM-SCALE MINING INDUSTRY**

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DISCLAIMER

The primary purpose of this publication is to provide a code of practice for mine effluents in Guyana's mining industry. It expresses the professional opinion of SNC-LAVALIN INC. (SLI) regarding the matters set out herein, based on SLI's professional judgment and reasonable due diligence. It is to be read in the context of the agreement of August 4, 2003 (the Agreement) between SLI and Natural Resources Canada (the Client), and in accordance with the methodology, procedures and techniques that SLI used, the assumptions SLI made, and the circumstances and constraints under which SLI carried out its mandate. This document is meant to be read as a whole, and sections or parts thereof should therefore not be read or relied upon out of context.

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1. INTRODUCTION

1.1 Why a Code of Practice for Effluents?

The proposed amendments to the Guyana Mining Regulations, which strongly focus on the environment, call for the publication or approval by the Guyana Geology and Mines Commission (GGMC) of a number of Codes of Best Practice for Environmental Mining within 18 months of the enactment of these Regulations. Article 224 of these amendments states that the GGMC shall prepare a Code of Practice to provide further guidance for effluent disposal and other practices and that this Code shall form part of the Regulations.

In Guyana, the sluicing of paydirt produces large amounts of suspended material that can be discharged into receiving waters. According to estimates, over 200,000,000 m^3 of tailings, consisting of more than 80% water, are generated each year by dredges in alluvial mines. A large percentage, if not all, of this material flows directly into the receiving environment, causing turbidity plumes in waterways, reduced light penetration, siltation, channel alteration and changes in stream-bottom characteristics along with their dramatic impacts on riverine ecosystems. This situation cannot continue much longer. The Guyana mining sector must join with mining industries in other countries in the shift towards more sustainable practices in order to address public concerns and increasingly stringent regulations.

Greater water recycling provides a solution for some of the problems associated with suspended material. Virtually the only pollution-control measure practised by the placer mining industry is to reduce particulate matter in water discharged into surface watercourses. This is achieved by relying solely on settling ponds, by using a combination of storage areas and settling ponds, or by discharging effluent into large areas of gravel or previous tailings.

2. GLOSSARY OF TERMS

Artisanal mine	A small, medium or even large-scale, informal, legal or illegal mining operation that uses rudimentary processes to extract gold from either primary or secondary ore bodies.
Best Practice	The best way of doing things. Best practices are intended to prevent or (when that is not possible) minimize risks to human health in addition to adverse environmental, social and economic impacts.
Code of Practice	A collection of rules and ethical principles related to a specific field of activity. A Code of Practice describes procedures and sets out standards considered to be best practices in the said field of activity. The Code may be either voluntary or mandatory.
Cut-off trench	Channel or ditch usually excavated around a mining structure in order to collect groundwater.
Effluent	A liquid, solid or gaseous product, frequently waste, that is discharged or emerges from a process.
Freeboard	The difference in elevation between the maximum operating water surface of the impoundment dam and the low point on the upstream edge of the crest.
Guidelines	A non-binding document usually designed to provide the user with information, explanations, guidance and help on a specific topic. Guidelines are a tool commonly used to enforce new regulations. Users can be either the Regulator itself or the industry.
Hydraulicking	The excavating of alluvial or other mineral deposits by means of high-pressure water jets.

Medium-scale mine	A mine for which a mining permit is issued and from which a volume in excess of 200 m^3, but less than 1 000 m^3, of material, including any overburden, is excavated or processed as an aggregate in any continuous 24-hour period.
Non-point source	A source of water (surface or groundwater) pollution that is diffuse and intermittent resulting from land surface disturbing activities, such as mining, grazing, agriculture or forestry practices. A source of pollution that cannot be traced to a specific, identifiable point of entry into a waterway.
Overburden	Loose soil, sand, gravel, etc. lying above the bedrock or above a deposit of useful materials, ores or coal. Also called burden, capping, cover, drift, mantle or surface.
Paydirt	An unconsolidated sediment containing a mineral deposit.
Placer mining	The removal of high-density minerals (such as native gold) from alluvial deposits by washing with water.
Regulations	A type of “delegated legislation” enacted by a state or federal or local government agency given authority to do so by the appropriate legislature. Regulations are generally very specific and are also referred to as rules or simply administrative law. Regulations are official rules and must be followed.
Riparian	Pertaining to or situated on the bank of a body of water, especially of a watercourse such as a river, e.g., riparian land situated along or abutting on a stream bank, or a riparian owner who lives along or has property on a riverbank.
Settling pond	A natural or artificial water body used to contain effluent for the purpose of removing suspended solids before release into receiving waters.

Siltation	The deposition of sediments in a water body as fine suspended particulate matter.
Slurry	A semi-fluid, slushy, murky mass of sediment resulting from treatment of water, sewage or industrial or mining wastes; often appears as local bottom deposits in polluted bodies of water.
Small-scale mine	A mine for which a claim licence is issued and from which a volume in excess of 20 m^3, but less than 200 m^3, of material, including any overburden, is excavated or processed as an aggregate in any continuous 24-hour period.
Stream	Any watercourse, no matter how small or large it is. Includes creeks and rivers.
Stripping	The removal of earth or non-ore rock materials as required to gain access to desired coal, ore or mineral materials; the process of removing overburden or waste material in a surface mining operation.
Sustainable development (SD)	Development that meets present-day needs without compromising the ability of future generations to meet their needs.
Tailings	The gangue and other refuse material resulting from the washing, concentration or treatment of ground ore. Also those portions of washed ore regarded as too poor for further treatment.
Tailings dam	An impoundment to which tailings are transported and in which solids settle to make it possible for liquid to be withdrawn.
Turbidity	The state, condition or quality of opaqueness or reduced clarity of a fluid attributable to the presence of suspended matter.

3. MISSION AND OBJECTIVES

3.1 Mission Statement

The following is the Code's mission statement:

Prevent and minimize water pollution resulting from dredging and placer mining operations.

3.2 Objectives

1) Protect communities and the environment from adverse effects resulting from the discharge into waterways of water containing a high content of suspended material and sediments.

2) Ensure and promote proper effluent management in the Guyana gold and diamond mining industry.

3) Promote the Code's use by small and medium-scale gold and diamond miners.

4) Raise the awareness of and educate all parties as to the importance of sound effluent management practices.

5) Ensure that effluent management practices are flexible and dynamic over time.

6) Ensure that effluent management practices are credible and verifiable.

4. SCOPE

This Code of Practice is a mandatory code that applies to small-scale and medium-scale alluvial gold and diamond mining operations as well as to large artisanal mines (>20 m^3 per day).

This Code of Practice addresses only environmental issues related to effluent management in the Guyana gold mining industry and does not deal with any occupational health and safety (OH&S) issues related to effluent management. Two stages in the life cycle of a mine are covered by this Code: construction and operation. Closures and reclamation will be dealt with in a specific Code of Practice on mine site reclamation.

This Code is subject to the Mining Regulations (currently being amended) of the Mining Act of Guyana (No. 20 of 1989). The Code is intended to complement the regulatory requirements, not to replace them. Compliance with the rules, regulations and statutes is therefore required.

No guarantee is made in connection with the application of the Code to prevent hazards, accidents, incidents or injuries to workers and/or members of the public at any specific mine site where effluent is managed.

5. PRINCIPLES AND STANDARDS OF PRACTICE

(For further details on how the following principles may be implemented, the readers should refer to ***Section 6 Code Implementation***).

5.1 Site Preparation and Construction

Principle: Protect communities and the environment from adverse effects resulting from the discharge of water containing a high content of suspended material and sediments into waterways during site preparation and construction phases.

Standards of practice

5.1.1 Leave a buffer zone of undisturbed riparian vegetation between the area to be worked and an existing stream channel or live body of water.

5.1.2 Limit the amount of vegetation removed in order to reduce and control runoff from unvegetated areas.

5.1.3 Install appropriate runoff control structures.

5.1.4 Design open pits to prevent surface waters from entering the workings.

5.1.5 If diversion structures are needed, obtain permits and approvals prior to proceeding with stream diversion.

5.1.6 Before starting construction, determine the amount of surface to be uncovered in the initial construction phase. This includes the extent of the ore body as well as the best location to set up the plan and build support facilities.

5.1.7 Determine the size and location of settling pond(s).

5.1.8 The Regulatory body should determine, through appropriate soil evaluation or analysis, how long water must be retained in the ponds in order for sediments to settle out and to decide how many ponds are necessary.

5.1.9 Build one or more settling pond(s).

5.1.10 Segregate and stockpile overburden and topsoil for use in reclamation.

5.1.11 When designing the mine plan, consider how the site will be reclaimed.

5.2 Mining Operations

Principle: Protect communities and the environment from adverse effects resulting from the discharge of water containing a high content of suspended material and sediments into waterways during mining operations.

Standards of practice

5.2.1 Limit the amount of vegetation removed in order to reduce and control runoff from unvegetated areas.

5.2.2 Install appropriate runoff control structures.

5.2.3 Segregate and stockpile topsoil and overburden for use in reclamation.

5.2.4 Prevent wind and water erosion of topsoil stockpiles.

5.2.5 Inspect and clean sediment control structures to maintain their efficiency.

5.2.6 Monitor water quality prior to discharge into the environment.

5.2.7 Dredging operations tailings should be piled up onto the shore and not discharged directly into the watercourse.

6. CODE IMPLEMENTATION

6.1 Site Preparation and Construction

Suggested Runoff Collection Methods (see Appendix A)

6.1.1 Diversion Dike/Ditch: Diversion dikes/ditches should be used whenever it is necessary to dispose of concentrated surface water without causing erosion. They can be used to divert creeks or streams away from mining areas. Diversions should be used in conjunction with a silt fence or sediment ponds.

6.1.2 Interceptor Trench: An interceptor trench should be used to divert surface runoff around mining structures, such as stockpiles, waste dumps, pits, settling ponds and tailings impoundments. Can be used to interrupt long slope faces on gentle slopes (less than 3:1).

6.1.3 Open Top Box Culverts: An open top box culvert should be used to convey surface runoff and flow from inside ditches across the roadway onto the downhill slope of a road.

6.1.4 Siltation Berm: A siltation berm should be placed around a disturbed site to capture and contain surface runoff so that sediment can be filtered prior to discharge of the water.

6.1.5 Waterbars: A waterbar should be constructed across the roadway to divert storm runoff away from unpaved surfaces or other disturbed areas.

6.1.6 Corrugated Metal Culverts: Corrugated metal culverts can be used instead of open top box culverts to remove water from roadways. They are permanent water conveyance systems.

6.1.7 Drain Fields: Drain fields can be used to discharge infiltrating water and/or groundwater away from a site.

6.1.8 Stream alteration: Stream alteration, which consists of diverting a stream into a new channel, pipe or culvert, should be considered when streams flow through economically minable areas or when it is necessary to divert live water from a pit, quarry, pond or adjacent impacted area. Often, this is a delicate operation that requires technical know-how and expertise for it to be carried out in an environmentally friendly and safe manner.

6.1.9 Road sloping: Road sloping can be used to divert surface water off the entire road surface so that water does not concentrate in any specific location.

Location criteria for settling ponds

6.1.10 Ponds should be located in a geologically stable area, at least 20 meters away from the low water mark of a riverbank except for access of dredges from the river.

6.1.11 Ponds should be located so that all surface water may be diverted around them. This may necessitate diverting streams and other surface water away from the site.

6.1.12 Ponds should be located so that groundwater seepage into the pond is kept to a minimum. Should excess seepage occur, line the pond with bentonite clay or other impermeable liners, or by installing cut-off trenches around the pond to decrease groundwater infiltration.

Design criteria for settling ponds

6.1.13 Settling ponds should be designed in accordance with current engineering practices.

6.1.14 Several settling ponds in a series are often preferable to one large pond. Water can be retained for a longer period in multiple ponds, thus allowing sediments more time to settle out before water is discharged. One pond in the series might be the principle sediment trap, while another could be used to hold clarified water that can be recirculated through a processing plant.

6.1.15 To reduce the velocity of water flowing through the pond, settling ponds should be designed so that their length is greater than their width. Reduced velocity enhances the settlement of solids and increases the stability of the embankments.

6.1.16 Design the pond so that it is large enough to contain all sediment-laden process water as well as seepage, surface runoff and precipitation from the design storm event. The pond should be large enough to provide a minimum freeboard of 0.60 m (2 feet) at all times.

6.1.17 Process water ponds should be designed using current engineering practices. Process water ponds must work as a closed system, meaning there is no discharge.

Construction criteria for settling ponds

6.1.18 If the pond cannot be built below ground level, build the pond embankment on clean, stable foundation material. This will help prevent seepage between the embankment and the foundation material. Ponds requiring large dams should be designed and built by a qualified specialist.

6.1.19 Construct the containment embankment with well-compacted, competent soil free of organic debris.

6.1.20 Settling ponds can also be excavated below ground level with a compacted embankment placed above the ground surface as an additional safety factor. If ponds are excavated below ground level, the foundation should be constructed so that water cannot seep out of the pond into adjacent streams or other surface waters.

6.1.21 A spillway may have to be installed for a discharging settling pond so that sediment-free water can be decanted. An emergency spillway must also be installed. Spillways must be riprapped with coarse material to prevent erosion of the toe of the dam. Anti-seep collars must be placed around spillways to prevent seepage and possible washout of the spillway.

6.1.22 The settling pond must be completed, ready for use, and all surface flows should be diverted around the pond before general mining activities commence.

6.2 Mining Operations

Control of wind and water erosion of topsoil stockpiles (see Appendix B)

6.2.1 Level spreaders: Runoff velocities can be reduced by using level spreaders. Reduced velocities lessen erosion, allow sediment to settle out of runoff water and enhance infiltration.

6.2.2 Benched Slopes: Benched slopes can be constructed to enhance stability on steep slopes, reduce slope lengths and facilitate revegetative efforts.

Operating parameters of settling ponds

6.2.3 When operating a settling pond, do not fill the pond with solid sediments exceeding 60% of the designed storage volume. If this limit is reached, some of the sediments should be removed and deposited elsewhere or used for reclamation.

6.2.4 Always maintain at least 0.60 m of freeboard in the ponds. This is especially important during periods of high precipitation, and for non-discharging ponds.

6.2.5 Chemical flocculants such as alum or lime can be added to settling ponds to reduce the length of time needed to settle out solids.

Sediment control structures (see Appendix C)

6.2.6 Straw Barrier: Straw, fibrous tree roots or plaited cocorite leaves can be used where temporary diversions or berms are required. The straw, roots or leaves allow water to filter through and retains the sediment. Frequent inspection is necessary.

6.2.7 Sediment Traps or Catch Basins: Small temporary structures should be used to catch runoff containing sediment from temporary roads and construction sites. Larger permanent basins should be constructed to catch periodic sediment-laden runoff from permanent erosion control structures, such as culverts and waterbars.

6.2.8 Vegetated Buffer Strip: A strip of vegetated ground can be established at many locations between the source of sediment and live water sources. Vegetation catches and holds sediment from runoff water flowing across it.

6.2.9 Silt Fence/Filter Fence: Silt fences should be used on small intermittent drainages where surface water collects or leaves a mine site. They are made of filter fabric, wire and steel or wooden posts and used to filter sediment out of runoff water before it is discharged.

6.2.10 Brush Sediment Barrier: Brush sediment traps can be an effective permanent or temporary erosion control structure and are used below any surface disturbance.

6.2.11 Sediment/Settling Ponds: Sediment/settling ponds can serve as effective sediment traps, holding and storing sediment-laden water for long periods of time. They can be designed with a spillway so that sediment-free water can be allowed to decant off during periods of peak flow.

6.2.12 Log and Brush Check Dams: Log and brush check dams can be used to prevent or reduce erosion of banks and bottoms of channels, streams, and drainage-ways by reducing gradients and flow velocities.

Water quality monitoring

6.2.13 Monitoring of water quality at the effluent (point of discharge) should be carried out at the frequency required by regulations. Samples should be taken and sent to a certified lab to test for turbidity, content in heavy metals (mercury) and other parameters to be specified.

7. REFERENCES

Australia Environment Protection Agency, *Water Management.* Best Practice Environmental Management in Mining, 34 p., 1999.

GENCAPD Mining, *Workshop on Producing Environmental Codes of Practice for the Mining Industry of Guyana. Summary Report.* September 30, 2003.

GGMC, *Conceptual Review of Tailings Management for the Small-Scale Industry.* Georgetown, Guyana, 2002.

Government of Guyana, *Regulations made under the Mining Act (No. 20 of 1989). Proposed amendments, 2002.*

Idaho Department of Lands, Best Management Practices for Mining in Idaho. Idaho Department of Lands, 112 p.

Ripley, E.A., Redman, R.E. and Crowder, A. (1996), *Environmental Effects of Mining.* St. Lucie Press, 1996, 356 p.

Web sites

http://xmlwords.infomine.com/xmlwords.htm (on-line dictionary of mining terms)

http://www.northstar.k12.ak.us/schools/upk/gold/facts/dredge/dredge.html (How a gold dredge works)

http://www.nalms.org/bclss/mining.html (Best management practices for water quality)

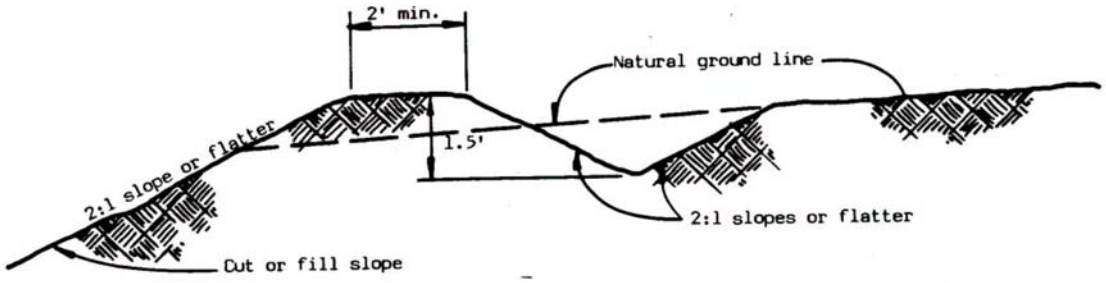
http://www.nalms.org/bclss/runoff.html

http://www.nalms.org/bclss/aquatichabitat.html

APPENDIX A

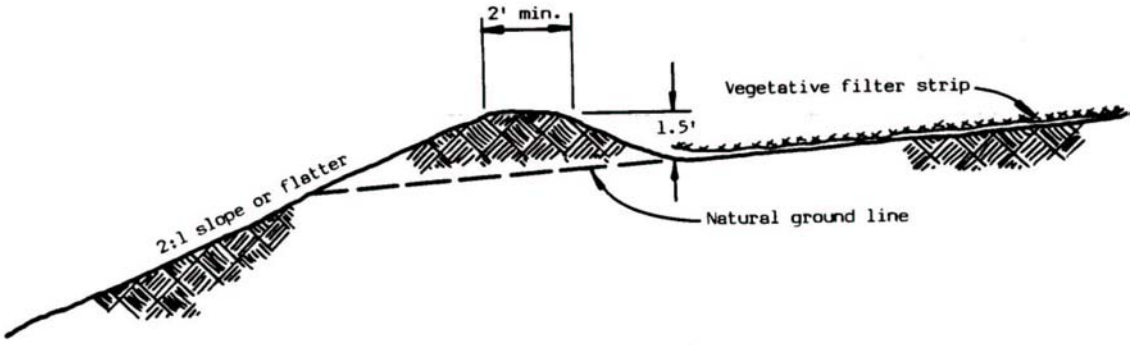
Runoff Collection Structures

Diversion Dike/Ditch



NOTE: Bed of dike to be riprapped.

SECTION

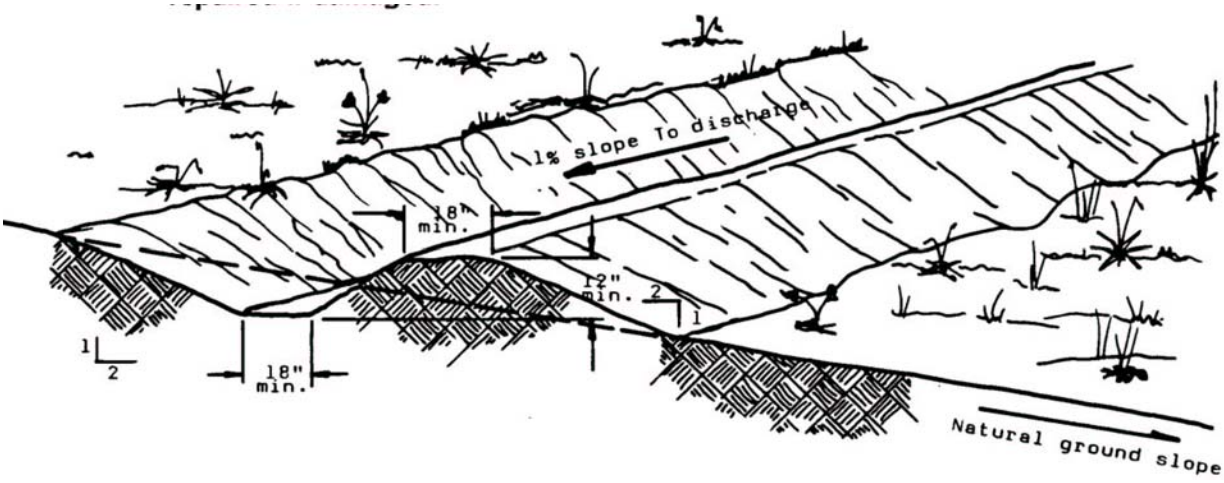


NOTES: 1) Dike constructed by dozer moving soil upslope and dumping at top of slope.
2) Outlet to stabilized vegetated soil.

SECTION

After Idaho Department of Lands, 1992

Interceptor Trench



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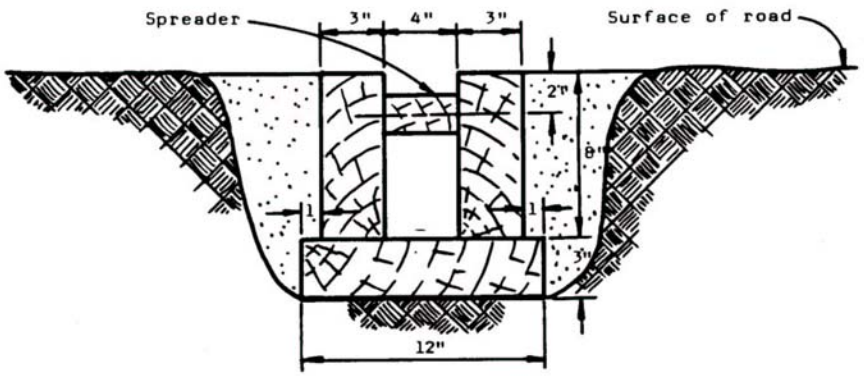
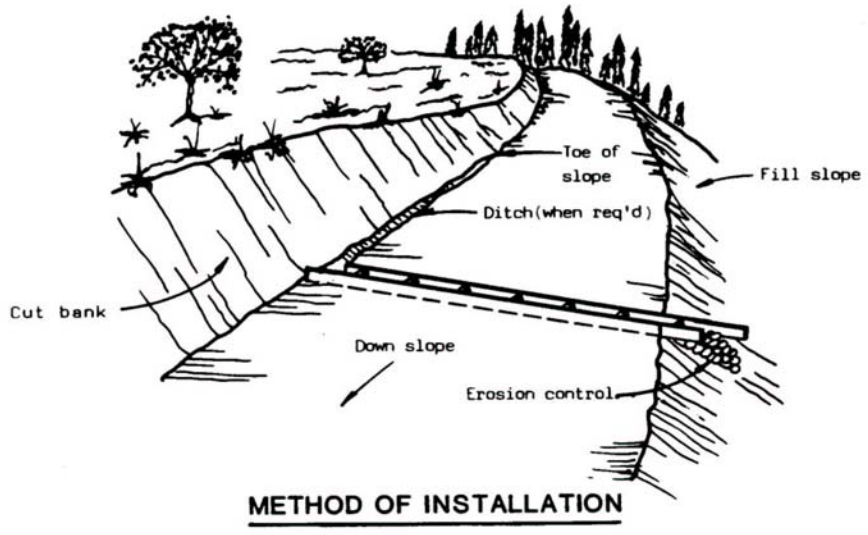
Open Top Box Culvert



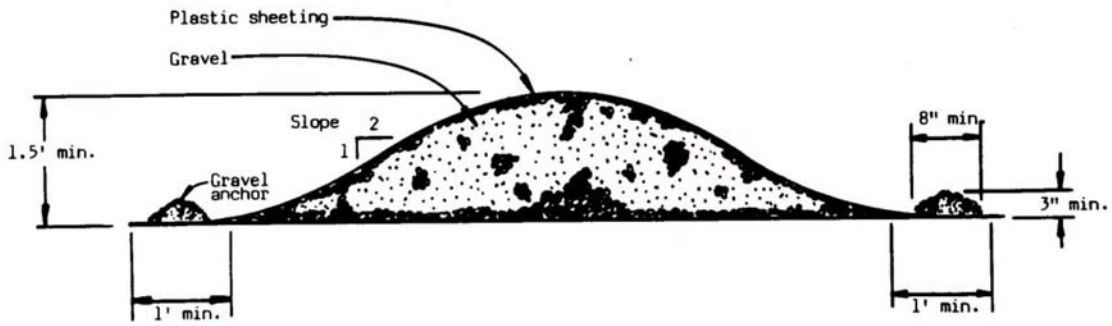
END VIEW



METHOD OF INSTALLATION

After Idaho Department of Lands, 1992

Siltation Berm



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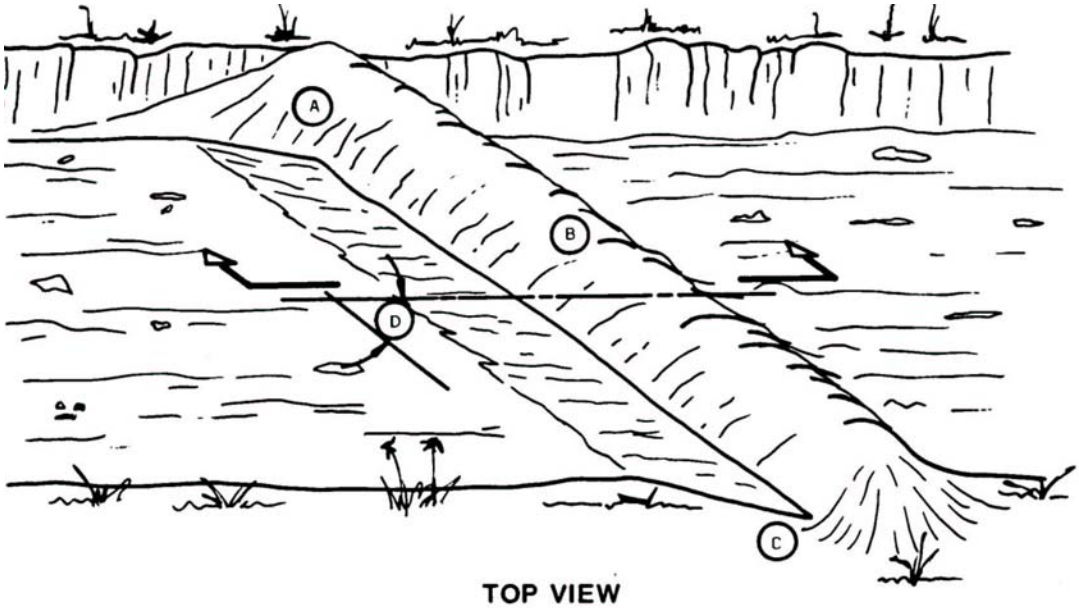
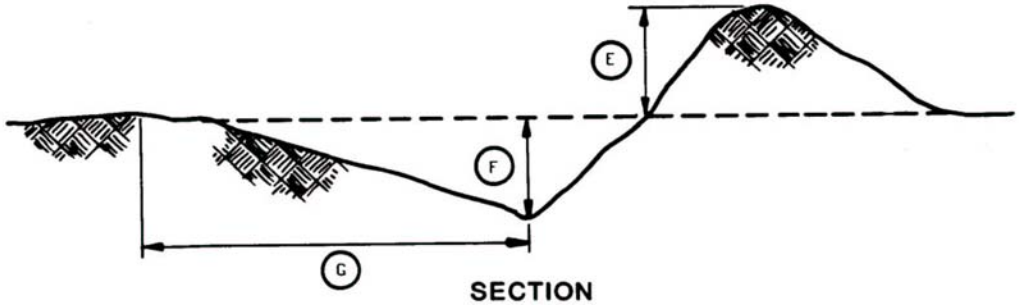
Waterbars



TOP VIEW

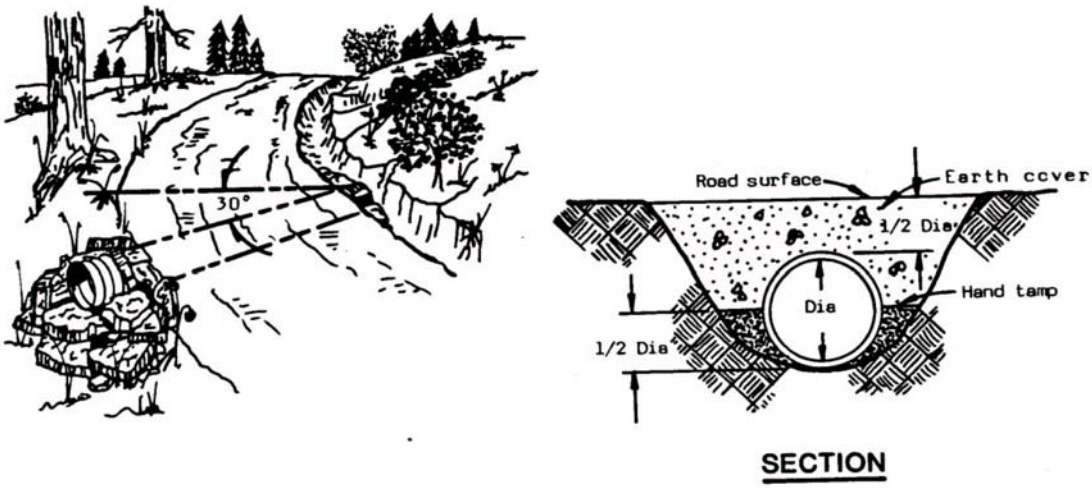


SECTION

WATERBAR (CROSSDITCH). Construction for unpaved forest roads with limited or restricted traffic. Specifications are average and may be adjusted to gradient and other conditions. A, bank tie-in point cut 6 to 12 in. into roadbed; B, cross drain berm height 12 to 24 in. above roadbed; C, drain outlet cut 8 to 16 in. into roadbed; D, angle drain 30 to 40 degrees downward with road centerline; E, height up to 24 in; F, depth to 18 in; G, 36-48 in.

After Idaho Department of Lands, 1992

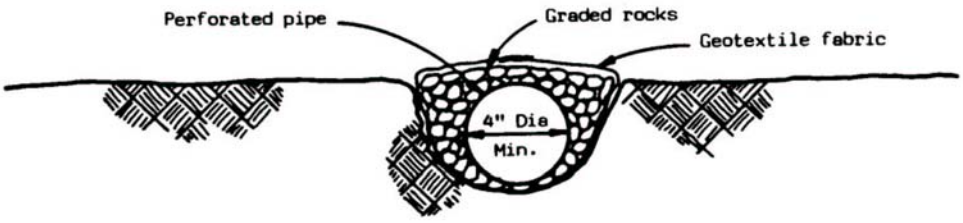
Culvert Installation



After Idaho Department of Lands, 1992

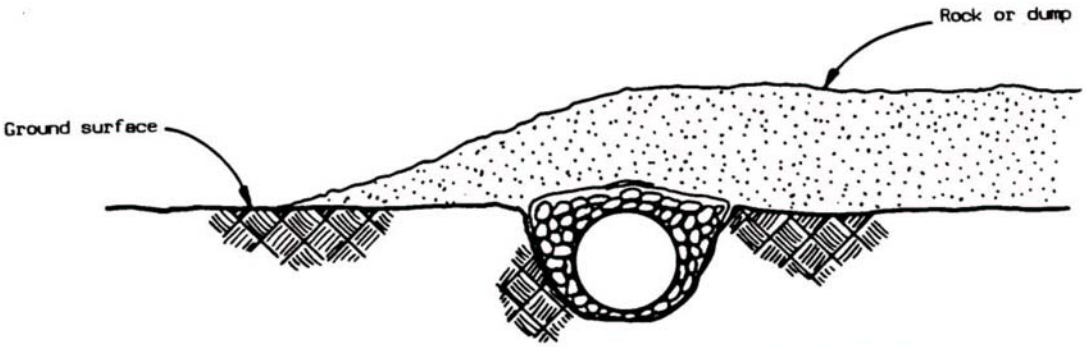
Drain Fields

DRAIN FIELD TRENCH LINED WITH GRADED ROCKS



NOTE: Diameter of pipe to be based on the amount of water to be drained.

TRENCH LINED WITH GEOTEXTILE FABRIC,
GRADED ROCK AND PERFORATED PIPE



SURFACE WASTE OR DUMP TO BE PLACED
OVER UNDERDRAIN AFTER CONSTRUCTION

After Idaho Department of Lands, 1992

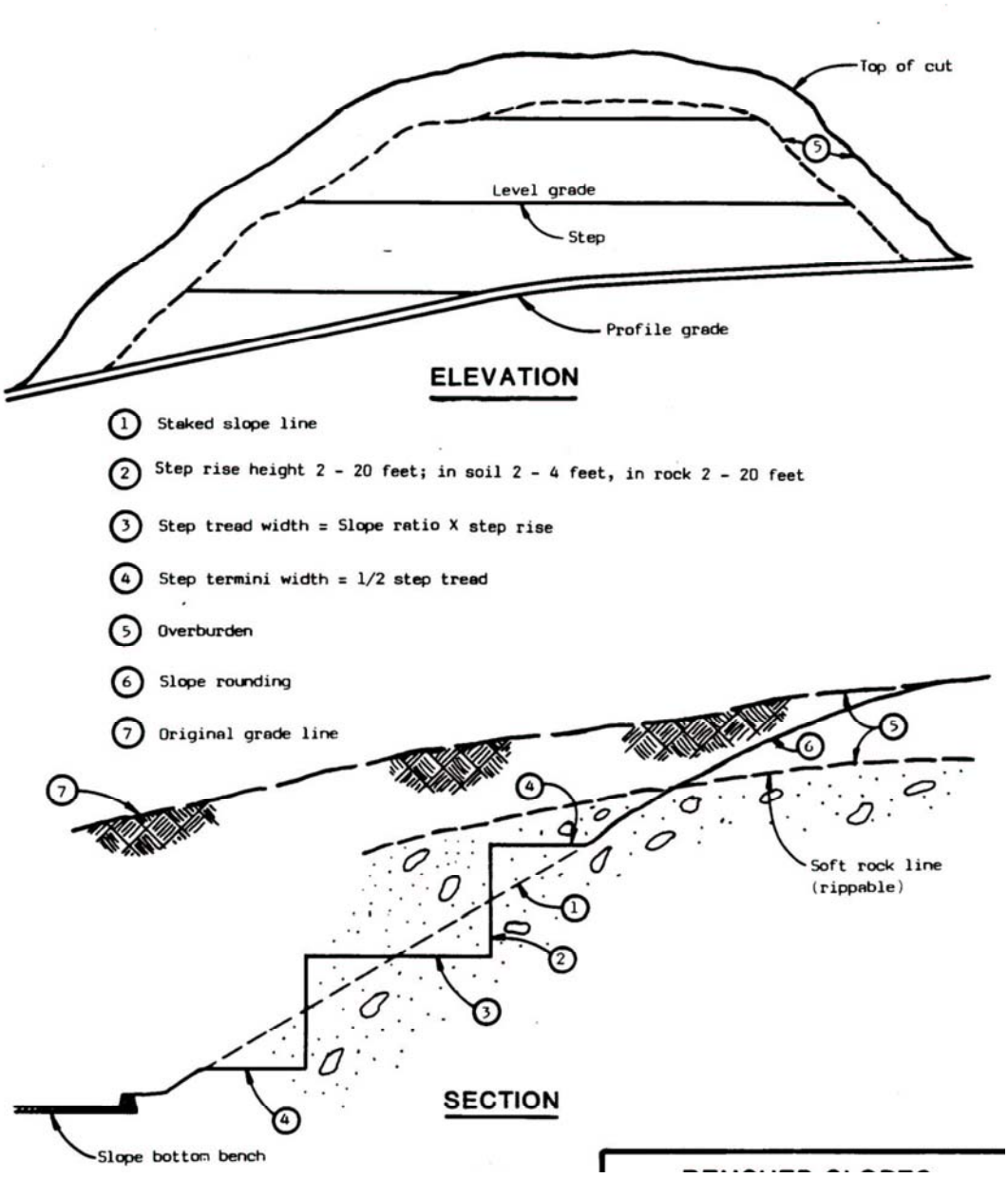
Road Sloping

After Idaho Department of Lands, 1992

APPENDIX B

Runoff Dispersion Structures

Benched Slopes



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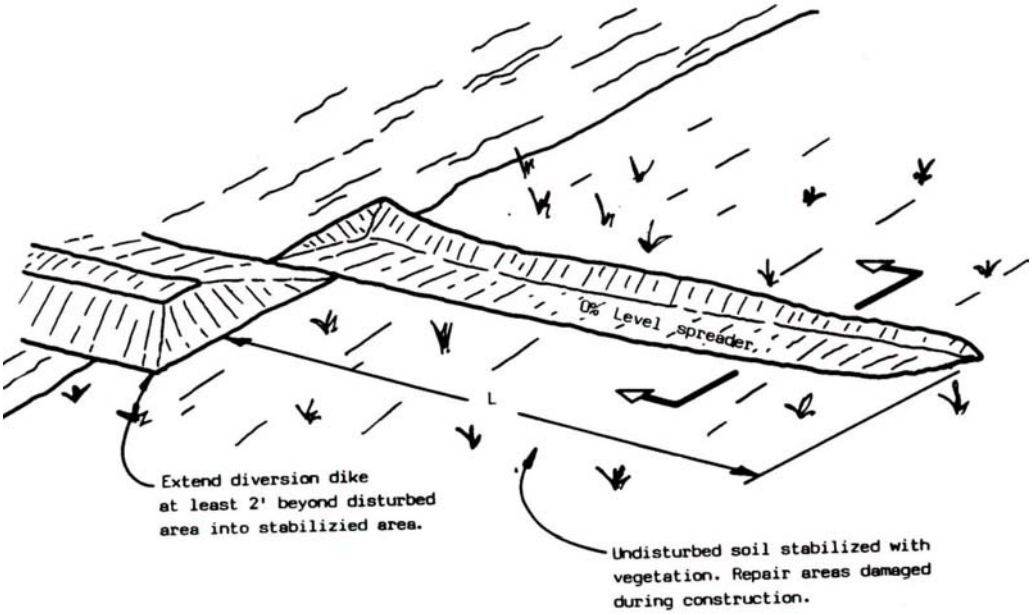
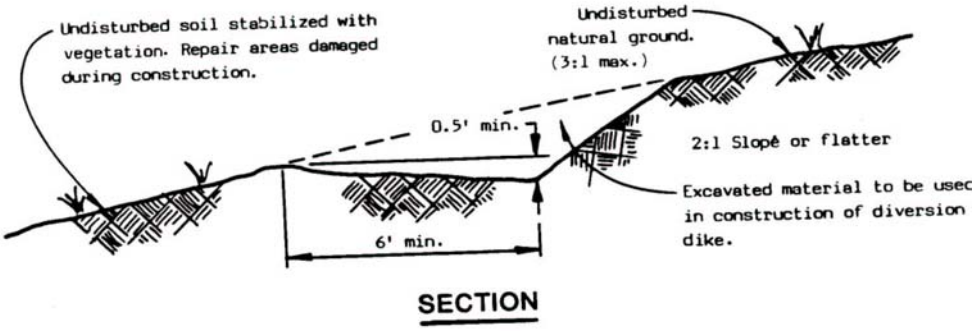
Level Spreader



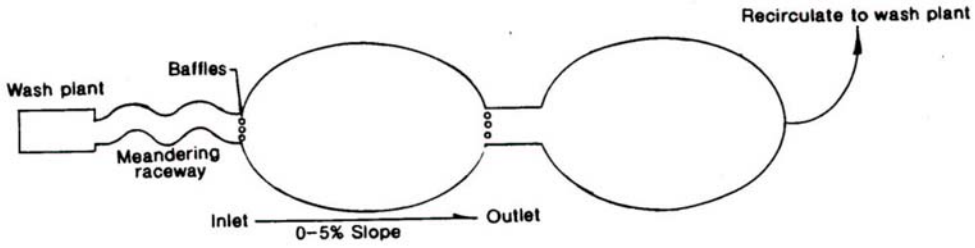


After Idaho Department of Lands, 1992

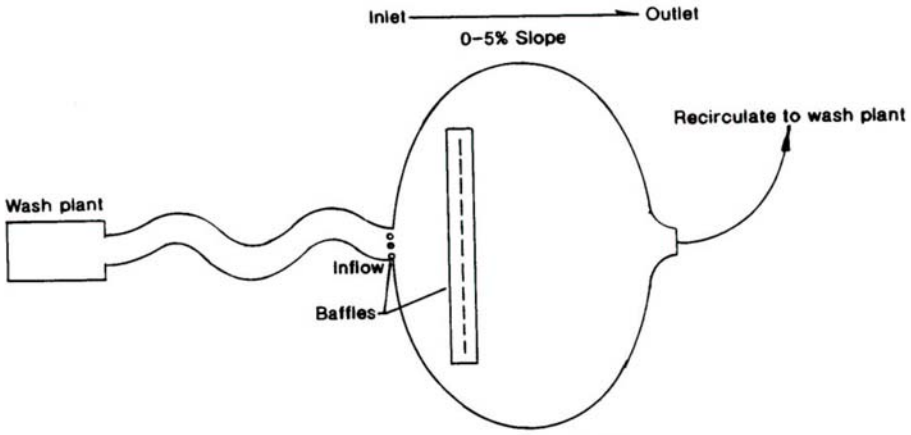
APPENDIX C

Sediment Collection Structures

Diagram of Settling Ponds for Placer Mining



STANDARD SETTLING PONDS IN SERIES



SETTLING POND WITH BAFFLES

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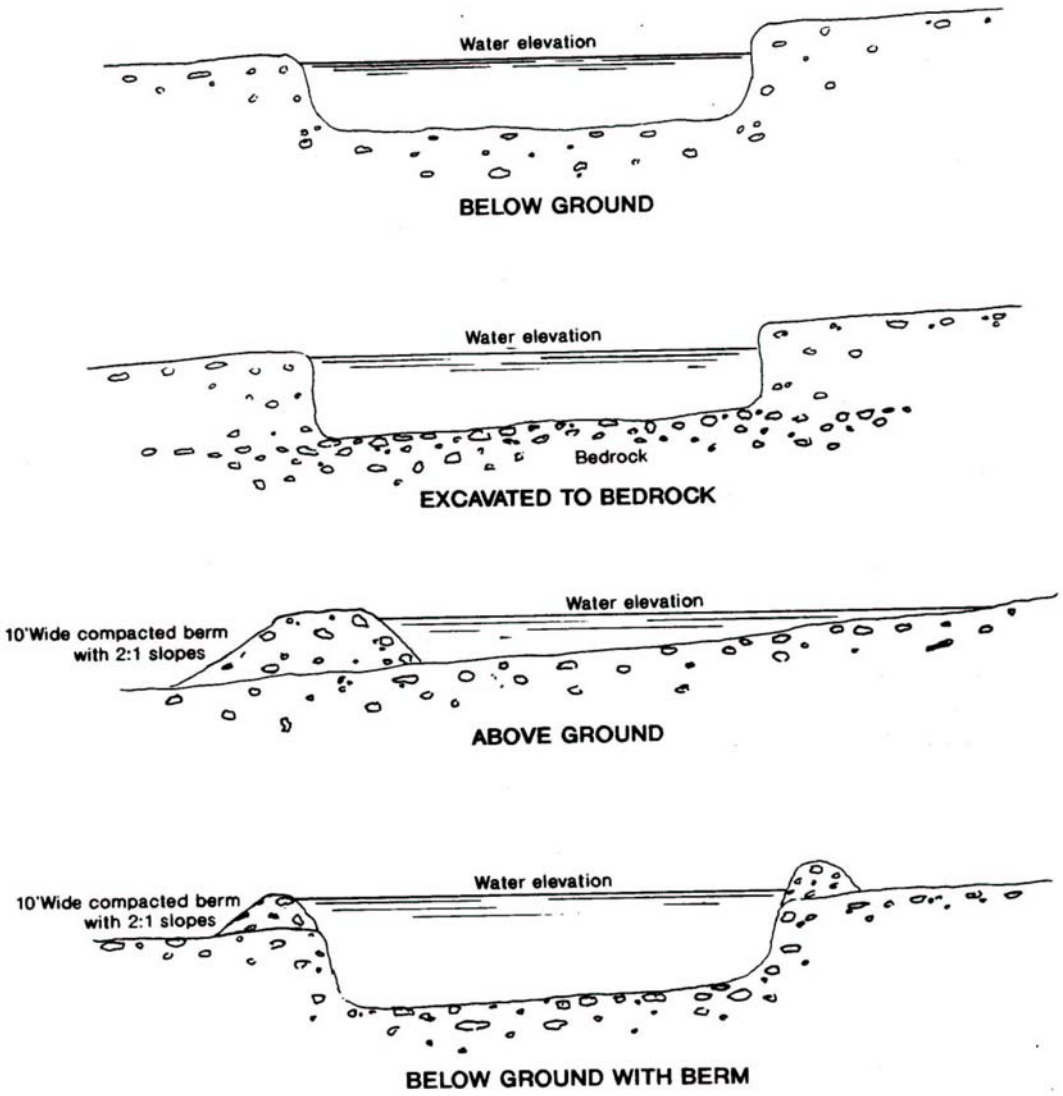
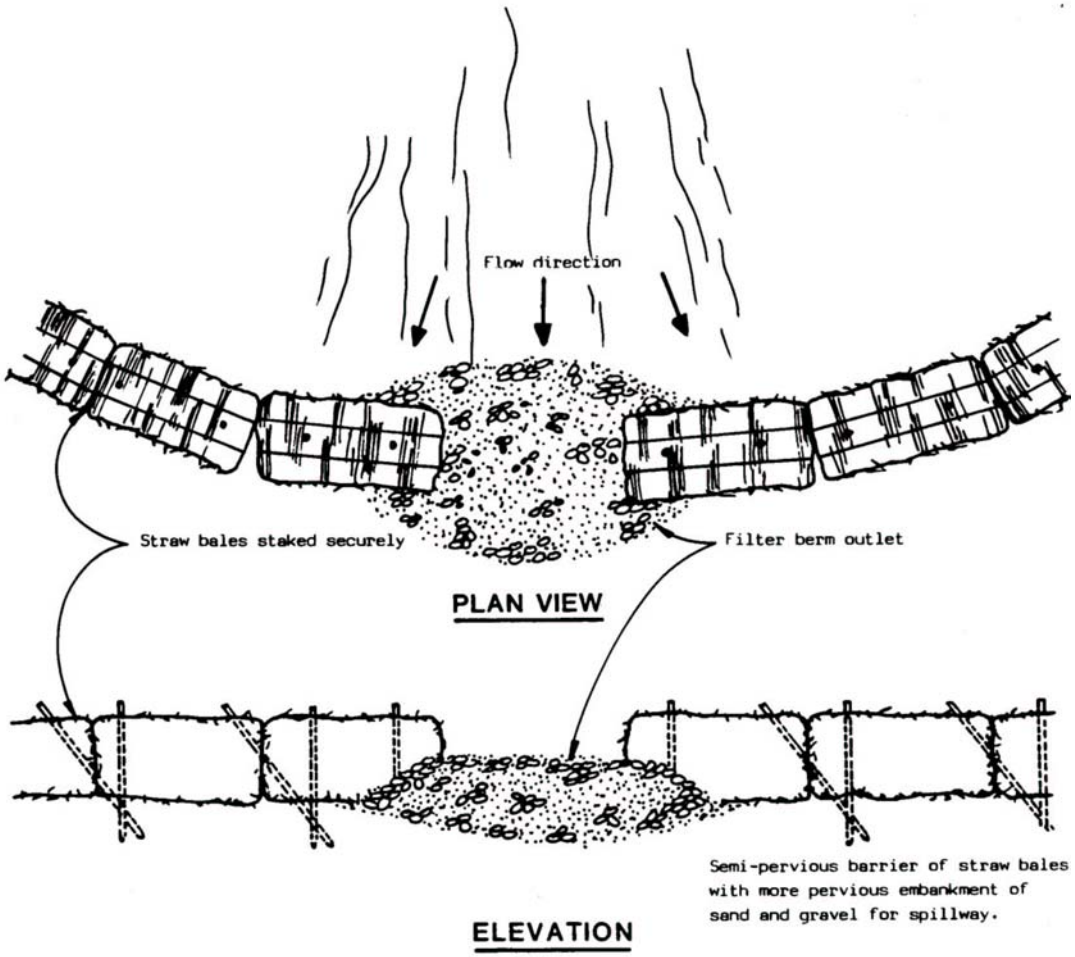
Settling Pond Construction Options



After Idaho Department of Lands, 1992

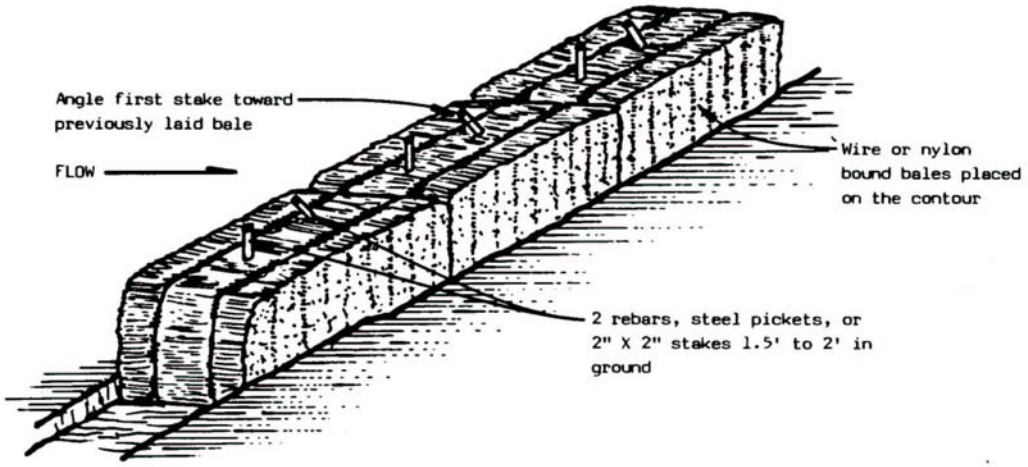
Straw Bale Sediment Barrier



After Idaho Department of Lands, 1992

Straw Bale Sediment Barrier *(cont'd)*

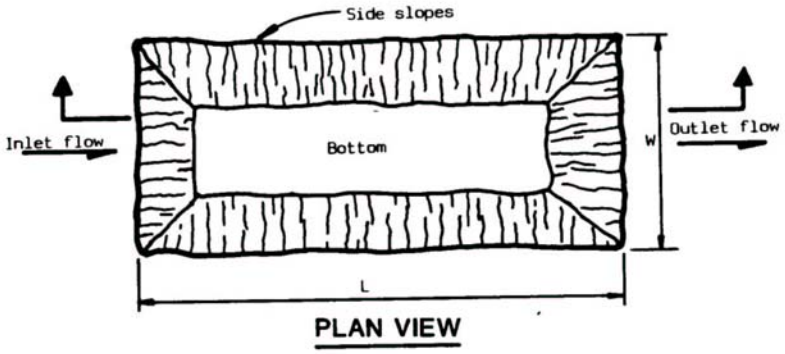
EMBEDDING DETAIL



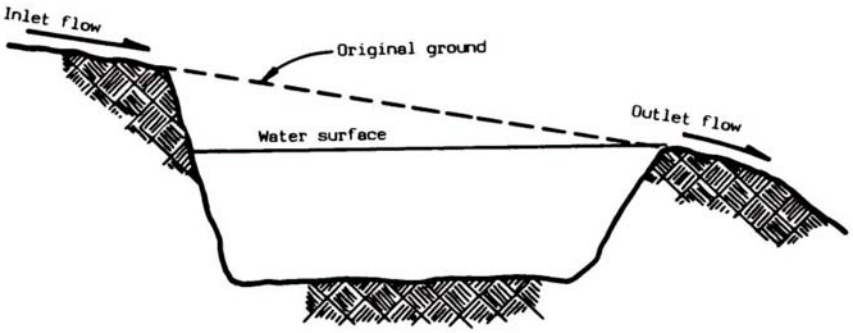
ANCHORING DETAIL

After Idaho Department of Lands, 1992

Sediment Traps or Catch Basins



PLAN VIEW

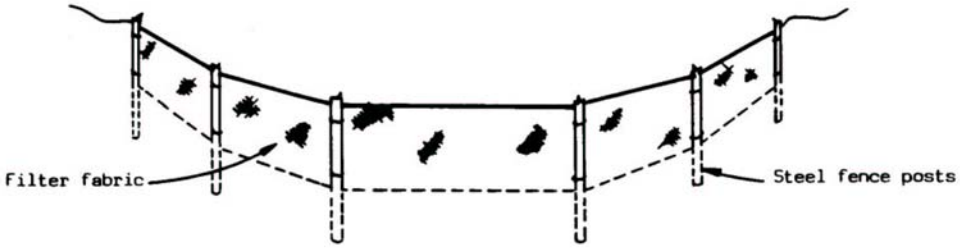


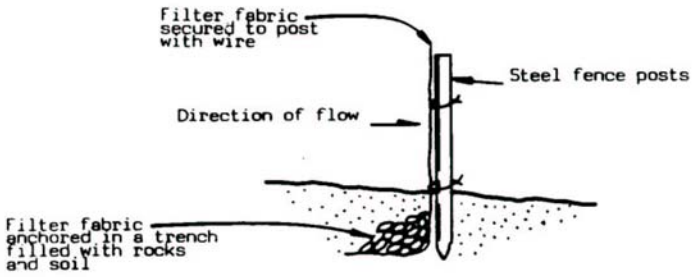
SECTION

After Idaho Department of Lands, 1992

Silt Fence/Filter Fence

Wood may replace steel for fence posts

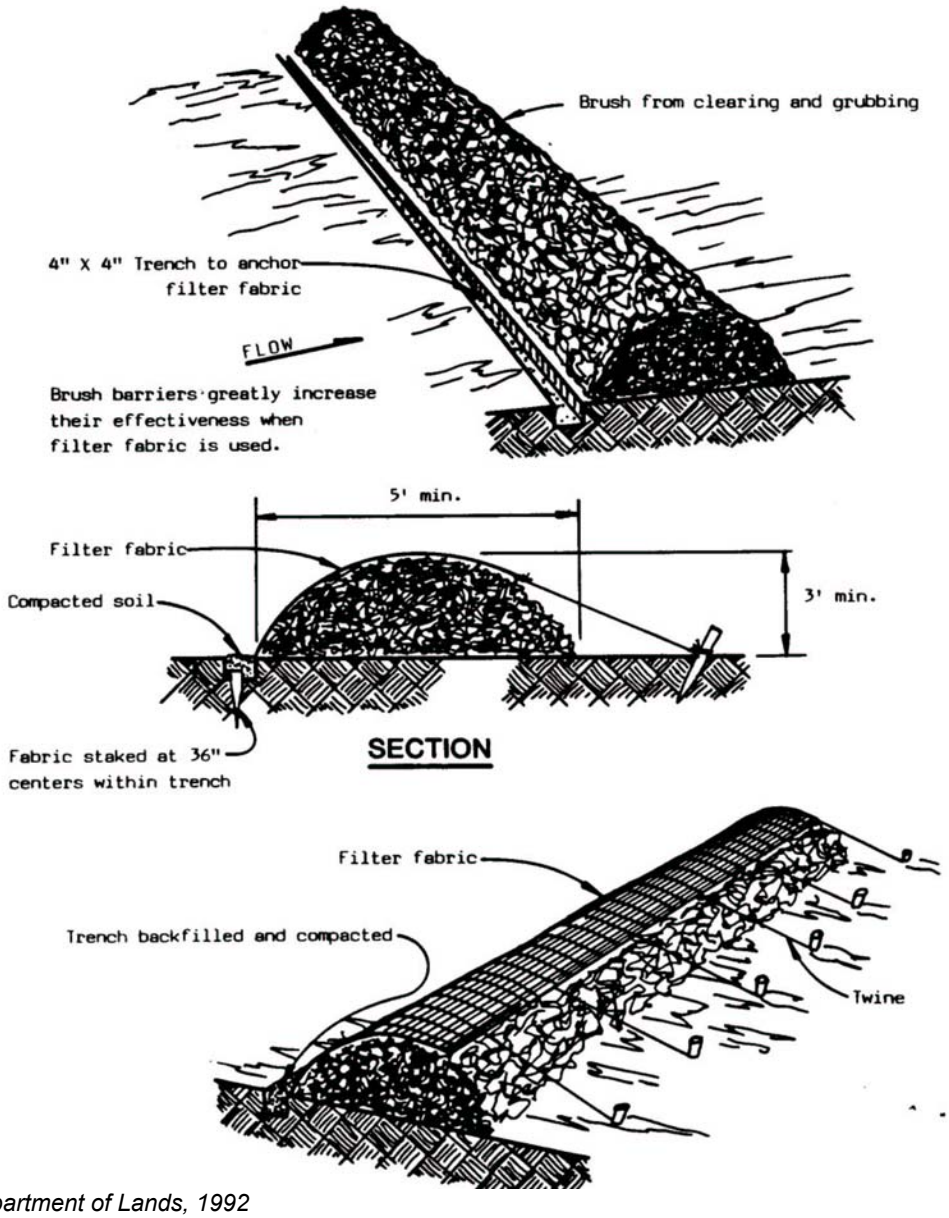




SECTION

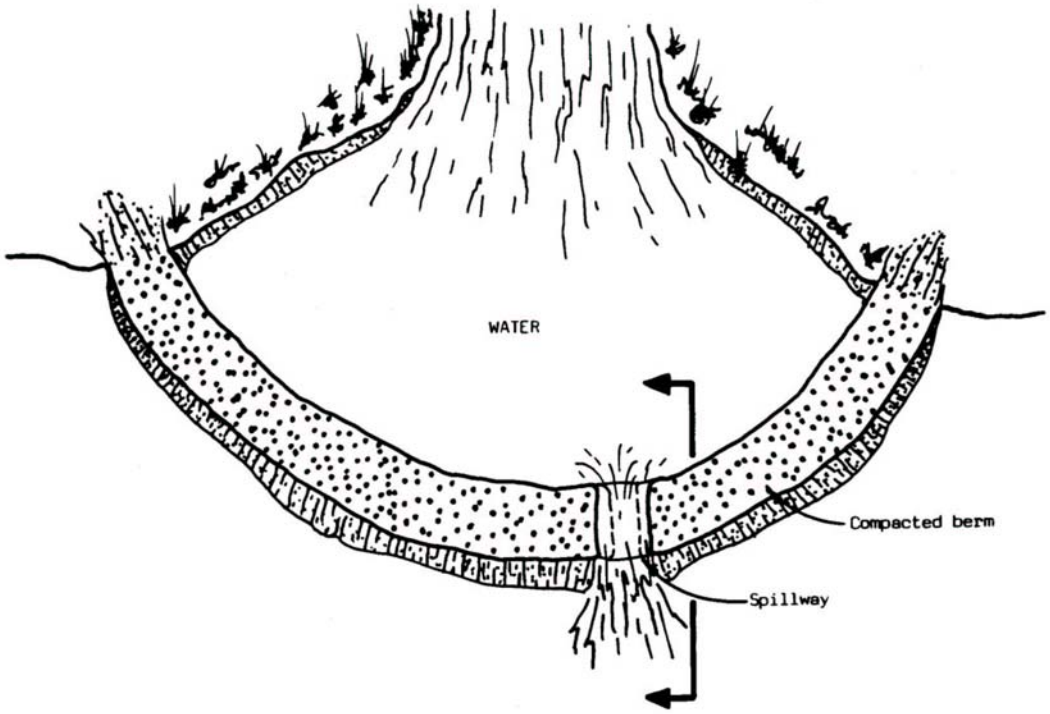
After Idaho Department of Lands, 1992

Brush Sediment Barrier

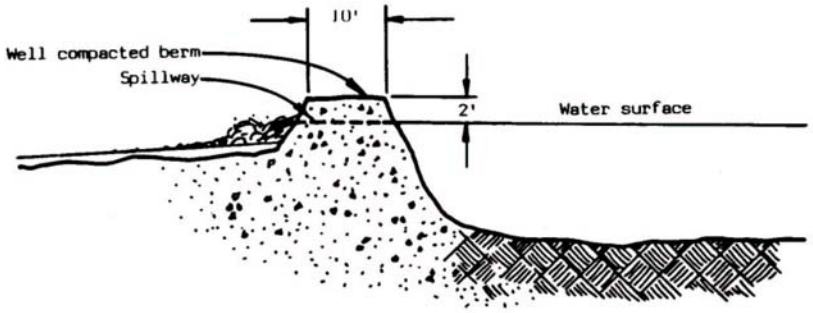


After Idaho Department of Lands, 1992

Sediment/Settling Pond



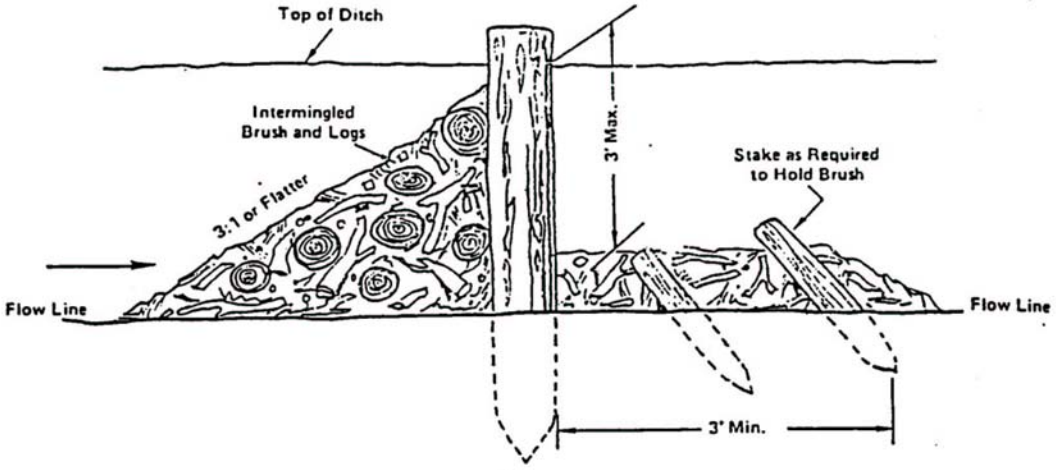
PLAN VIEW



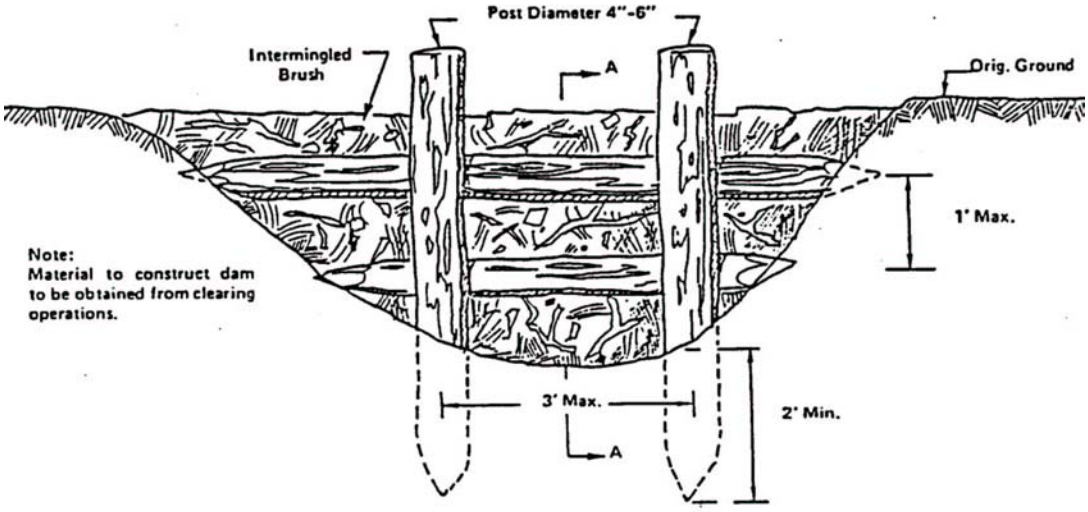
CROSS SECTION

After Idaho Department of Lands, 1992

Log and Brush Check Dam



SECTION A-A



ELEVATION VIEW

After Idaho Department of Lands, 1992