Handbook For Mineral and Coal Exploration in British Columbia

A WORKING FIELD GUIDE

WORKING DRAFT - March 2006

Association for Mineral Exploration British Columbia

THE MINING ASSOCIATION OF BRITISH COLUMBIA

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Ministry of Energy, Mines and Petroleum Resources

Ministry of Environment

Acknowledgements

This document was developed with the assistance of the Mining Association of British Columbia, the Association for Mineral Exploration British Columbia (AME BC), the Ministry of Energy, Mines and Petroleum Resources and the Ministry of Environment.

Mineral and coal exploration individuals and companies participating in the 2005 review of the draft document are particularly acknowledged for their helpful review comments and contributions.

The project team would like to extend their appreciation to all those who participated in the creation of this Handbook.

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Preface

British Columbia is recognized globally for its exceptional wildlife, diversity of ecosystems, and rich natural resources – including minerals and coal. The Province works to balance sustainable development with the maintenance of these valuable natural assets, which lie at the heart of many recreational and economic activities enjoyed by British Columbians in all regions of the province.

Mineral and coal exploration involves activities intended to locate, identify and inventory these resources, to develop mines and contribute to BC's sustainable economy. Through a variety of sampling techniques, explorationists work to describe and define their resource's extent and potential value. Areas impacted by exploration may be as small as a hand-dug trench or as large as an all-weather access road. Regardless of the scale or duration of impact, exploration activities should be completed in a manner that sustains other resource values.

The intent of this handbook is to provide assistance to the mineral and coal exploration sector to ensure exploration activities are planned and implemented with due regard to worker health and safety and protection of the environment using project and location specific recommended practices.

An Increasing Role for Stewardship

While the Province takes a leading role in the protection of British Columbia's natural resources, species, and habitats, environmental protection and stewardship are ultimately the responsibility of all British Columbians. Active stewardship of our natural resources by all British Columbians is key to maintaining the province's natural diversity and health.

The Province is actively pursuing opportunities for sharing the responsibility of protecting the environment. Partnerships are being established with other governments, First Nations, communities, academic institutions, industries, volunteer organizations, and citizens. The involvement of these partners in the shared stewardship of the province's resources is essential because of their local knowledge, resources and expertise.

Disclaimer

Not withstanding the provision of this handbook, it is the duty of every mine owner, manager and supervisor to comply with all applicable sections of the *Mines Act*, parts of the Health, Safety and Reclamation Code, and other relevant legislation and to ensure every facility required for compliance is provided.

This handbook is a compilation of currently known recommended management practices that, subject to site-specific assessment and adaptation, can be used for activities undertaken during mineral exploration. It is expected that explorationists will not only accept and use these practices but also improve and expand on this guide by utilizing field experience, knowledge and ingenuity.

Use of this guide should complement good planning and the acceptable execution of the work program, subsequent closure and reclamation of an exploration project.

Should anything contained in this guide appear to be in variance with the *Mines Act* and Code, provisions of the *Mines Act* and Code will prevail.

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1 Introduction

A Two-Zone Land Use System for Mineral Exploration and Mining in British Columbia

Numerous land use and zoning designations exist in British Columbia. To clarify the management of mineral sector activities, the province has confirmed in legislation a **two-zone system** for mineral exploration and mining.

The two-zone system ensures mining applications are considered, subject to all applicable laws, **anywhere but in a park, ecological reserve, protected heritage property or an area where mining has been prohibited by an order under the *Environment and Land Use Act.***

The two zones described in the policy are:

Mineral Zone: Land open to mineral and coal exploration, tenure acquisition and mine development, including suitable access required to undertake these activities, subject to appropriate legislation; and

Protected Zone: Crown land closed to mineral development through either legislation or an Order-in-Council, as identified in Section 14(5) (a) through (e) of the *Mineral Tenure Act* and equivalent sections of the *Coal Act*.

This system is consistent with government commitments to provide greater access to Crown land and resources, stimulate mineral and coal exploration in British Columbia and revitalize the economy.

Since the 1960s, mineral and coal explorationists have been involved in the development of reclamation measures to address the environmental impacts of their works. A series of handbooks to guide exploration activities were produced as stewardship responsibilities evolved through the1980s. In 1997, a committee of stakeholders including representatives of the mining industry, labour unions, environmental groups and staff of the Ministry of Energy, Mines and Petroleum Resources (then the Ministry of Energy and Mines), Ministry of Forests and Ministry of Environment set out to develop a code that would contain standards for mineral and coal exploration activities and would revise and streamline the process for permitting these activities. The resulting document was the Mineral Exploration (MX) Code, which forms Part 9 of the larger Health, Safety and Reclamation (HSR) Code for Mines in British Columbia. As part of the HSR Code, the MX Code is enabled under Section 34 of the *Mines Act*.

The purpose of the MX Code is:

(1) to ensure that mineral and coal exploration activities are undertaken in a manner that protects the health and safety of workers on exploration sites and the public who may be affected by exploration activities; and

(2) to manage impacts of exploration activities on other resource values including timber; fish and wildlife and their habitat; water quality and cultural heritage resources.

In September 2002, the Minister of Energy and Mines appointed a new Health, Safety and Reclamation Committee to review the full HSR Code as well as its MX Code component. The intent of the review was to support the development of a results-based approach to mineral and coal exploration activities, consistent with the British Columbia government's stewardship approach.

The revised HSR Code (and its MX Code section) developed by the committee contains specific requirements to protect workers and the environment. In keeping with the government's commitment to balance environmental protection with sustainable development, the MX Code specifies standards that must be achieved during mineral and coal exploration activities and requires regular site inspections to ensure compliance.

1.1 Purpose of This Handbook

The MX Code (provided in Appendix 1) establishes legislated requirements that govern the conduct of mineral exploration in British Columbia. In most cases, these requirements describe what needs to be achieved—the goal or target condition—but typically do not provide guidance on how to achieve it.

This handbook to mineral and coal exploration accompanies the revised MX Code to provide explorationists with practical guidance on how to achieve safety and environmental protection requirements. It should be noted that many of the recommended practices outlined in this handbook have been taken from source documents covering a range of industries. Explorationists are therefore encouraged to tailor these recommended practices to site-specific conditions, providing the underlying requirements of the MX Code and other legislation are met.

This handbook is presented to the MX sector as a working guide and is available as a printed document and as a Web-based portable document format (PDF) file on the websites of the Ministry of Environment and the Ministry of Energy, Mines and Petroleum Resources.

An effectiveness-monitoring program is planned to assess how the handbook and the recommended management practices contained within it are being used by the MX sector. Results of the monitoring program will serve as inputs to the ongoing modification and improvement of this document and the practices it contains. Newly emerging techniques, materials and equipment may better enable mineral explorationists to meet target conditions outlined in the MX Code. Other exploration activities not presently captured by the guide may need environmental protection guidance. Better information resources may be recommended for inclusion. Through the monitoring program, items such as these can be captured and used to improve the overall usefulness and applicability of this "living" document.

1.2 Companion Documents

The Ministry of Energy, Mines and Petroleum Resources is currently working towards developing guidance information regarding the exploration permitting process and the on-line tenuring and permitting system. The Ministry is also developing administrative materials which will provide information and advice to mine and exploration proponents on matters such as First Nations, community consultation, regional administrative boundaries, and regional review agency office locations.

The ministry's website is http://www.em.gov.bc.ca/. Current information on permitting application requirements is available on the Ministry's website at: http://www.em.gov.bc.ca/Mining/MinePer/default.htm.

1.3 Structure of This Guide

This working guide is organized into chapters that follow the major topics addressed in the MX Code, beginning with health and safety. For each MX Code topic, the corresponding chapter of this guide covers:

1) Background—describing the values, issues and impacts associated with that particular topic;

Recommended Additional Resources

Several other companion documents are recommended as additional resources. These include:

Safety Manual: Mineral Exploration in Western Canada. 2005. Association for Mineral Exploration British Columbia (AME BC). www.amebc.ca/healthsafety.htm

Mineral Exploration, Mining and Aboriginal Community Engagement: A Guidebook. 2005. AME BC

2) Objective—summarizing what the MX Code is trying to achieve with respect to the topic;
3) Legislated requirements—outlining the "rules" under the Code, the *Mines Act* and other legislation for the topic;
4) Recommended practices—describing the recommended practices to address the problem and achieve the objective and legislated requirements; and
5) Resources—providing sources of further information.

1.4 Activities Covered by This Guide

The MX Code applies to exploration activities that require an Exploration Activities and Reclamation Permit under Section 10 of the *Mines Act*. These activities are:

- drilling, trenching and excavating using machinery;
- blasting;
- disturbance of the ground by mechanical means;
- construction, modification, deactivation and reclamation of an exploration access;
- induced polarization surveys using exposed electrodes; and
- site reclamation.

The MX Code does **not** apply to, nor is a permit required for, exploration activities that generally do not involve mechanical disturbance of the surface. These exploration activities include:

- prospecting using hand-held tools;
- geological and geochemical surveying;
- airborne geophysical surveying;
- ground geophysical surveying without the use of exposed, energized electrodes;
- hand trenching without the use of explosives; and
- establishment of grid lines that does not require the felling of trees unless permitted under the definition.

Exploration and mining activities related to placer mining are administered under other areas of the *Mines Act* and the Code and are not specifically addressed within this working guide.

Given these qualifications, this guide covers all activities from the application stage to closure and reclamation of MX sites. However, it does **not** cover extraction of bulk samples.

1.5 Resources

The MX Code is available as an appendix to this document and also on the Ministry of Energy, Mines and Petroleum Resources' website: http://www.em.gov.bc.ca/Mining/Healsafe/mxready/mxcode01.htm

The Health, Safety and Reclamation Code is available on the Ministry's website at: http://www.em.gov.bc.ca/Mining/Healsafe/mxready/mxcode01.htm

2 Health and Safety

2.1 Background

There are few occupations that expose individuals to such a variety of hazards as mineral exploration. Several characteristics are somewhat unique to the industry and affect safety considerations and monitoring. The "workplace" encompasses wilderness areas ranging from alpine to near desert and arctic to temperate environments. The unwary could succumb to any one of many potentially fatal hazards, including falls in crevasses or on precipitous ground, avalanches or falling rock, hypothermia, hyperthermia, asphyxiation, exposure, drowning, lightning strikes, tree falls, animal attacks, insect stings, and injuries resulting from aircraft, vehicle, and boat travel[1].

Additional health and safety hazards, which some may consider more conventional, may also be encountered in the workplace and must be addressed. These hazards can include noise, ergonomics, working in confined spaces, working around heavy industrial machinery, working in and around excavations, and working at heights requiring fall protection.

Mining and mineral exploration activities in BC are regulated under the *Mines Act* by the Health, Safety and Reclamation (HSR) Code for Mines in British Columbia. Employers have the responsibility to comply with the HSR Code, thus ensuring workers' health and safety are protected. Specific occupational health and safety information, as it relates to mineral exploration alone, is found in the MX Code – Part 9 of the HSR Code.

2.2 Objectives

The objectives of the "Health and Safety" portion of the MX Code are to ensure that:

- exploration sites are equipped with appropriate first aid kits, attendants and access to emergency communication;
- all persons employed at an exploration site are trained in safe working practices specific to site conditions;
- any pits, trenches and excavations are made safe;
- exposure to uranium and thorium is limited;
- people are protected from electrical hazards, such as those potentially posed by the use of Induced Polarization Geophysical Survey Systems; and
- explosives are used and stored safely.

[1] Adapted from BC and Yukon Chamber of Mines Safety Committee, 15th Annual Report

2.3 What's Required under Legislation

In the province of BC, WorkSafe BC (the Workers Compensation Board of BC) is the body largely responsible for providing guidance to employers and employees regarding workplace safety. In the case of mining related activities, however, health and safety guidance for field-based activities is provided through the HSR Code. The direction within this code is specifically targeted towards mining and mineral exploration activities, while WorkSafe BC's Occupational Health and Safety (OHS) Regulation is more general in nature. For office-based mineral exploration activities not specifically covered in the HSR Code or for additional safe work practices for activities, explorationists are referred to WorkSafe BC's OHS Regulation.

Under the HSR Code, and specifically through Part 9 (the MX Code), explorationists are required to ensure worksite health and safety through the provision of first aid, appropriate health and safety training, and hazard management.

Table 2.1: Code Health and Safety Topics

Topic
First Aid
Training
Personal Protective Equipment
Uranium and Thorium
Induced Polarization Geophysical Survey Systems
Use of Explosives
Safety Around Excavations

While the MX Code itself contains explicit requirements for health and safety related to mineral exploration, it is important to note that the parent HSR Code also contains health and safety requirements which may apply to your works. Accident/Incident reporting and use of the Workplace Hazardous Materials Information System (WHMIS) are two examples of commonly overlooked health and safety requirements.

2.4 Recommended Practices

The section of the MX Code addressing health and safety for mineral explorationists details the health and safety practices required under the MX Code. Consideration should also be given to the use of additional practices to reduce health and safety risks associated with hazards such as those listed in the introduction to this chapter. Examples of such practices include, but are not limited to:

- additional personal safety equipment for field staff (e.g., handheld radio, bear spray, fire starter, emergency flares, personal first aid kit, and suitable clothing or raingear),
- working practices that have field crews working in pairs or within 200m of another crew member,
- communications protocols that involve scheduled radio 'check-ins' with crews throughout the day and daily satellite phone calls out from camps, and
- wildlife protection measures, including the use of electric bear fencing around camps.

AME BC's Health and Safety Manual

The updated AME BC *Safety Manual: Mineral Exploration in Western Canada* can be obtained from AME BC (www.amebc.ca/healthsafety.htm).

The Association for Mineral Exploration British Columbia (AME BC) has recently (2002) updated their health and safety document, *Safety Manual: Mineral Exploration in Western Canada.* This document provides detailed information on recommended health and safety practices and can be obtained from AME BC (www.amebc.ca/healthsafety.htm).

2.4.1 First Aid

- Comply with the emergency preparedness provisions of Part 3 of the HSR Code.
- Equip active exploration sites of mechanical disturbance with a minimum Level-2 first aid kit, a stretcher and an epinephrine auto injector, and make provisions for continuous and consistent emergency communication.
- Ensure at least two members of the exploration drill crew shall have a valid WorkSafe BC Level 1 or equivalent first aid certificate at exploration drill sites, unless the work site is accessible in all weather conditions and within 5 minutes of a facility where there is a qualified first aid attendant.

2.4.2 Training

Managers must ensure that workers are adequately trained to perform their job or are working under the guidance of someone who has competency both in the job and in giving instruction

- All workers must receive orientation and basic instructions on safe work procedures. All workers on site must receive health and safety training, including:
  - basic survival skills;
  - safety with respect to wildlife;
  - wearing of appropriate clothing;
  - use of personal protective equipment;
  - need for and use of suitable equipment to avoid becoming lost;
  - safety procedures to be adopted for vehicle and boat handling operations;

- safe practices when working in or around aircraft, including effective communication; and
- handling and storage of controlled products through the Workplace Hazardous Materials Information System (WHMIS).

- Managers must maintain records of all training workers and supervisors have received.

2.4.3 Pits, Trenches & Excavations

Section 12 – Pits, Trenches & Excavations

Recommended practices for aspects of pits, trenches & excavations other than those specifically related to safety are addressed in Section 12 of this document.

- Do not enter or permit anyone to enter any excavation over 1.2 meters in depth unless:
  - the sides of the excavation are sloped to a safe angle down to 1.2 metres from the bottom of the trench; or
  - the sides have been supported according to the requirements of Part 4 of the HSR Code.
- Keep excavated material back a minimum distance of 1 metre from the edge of any trench excavation, and 1.5 meters from any other excavation.
- Have a qualified person inspect an excavation immediately before any person is allowed to enter.
- Make any hazard safe before persons are allowed to conduct other work in the excavation.
- Consider using sloping of excavation sides instead of shoring only where the protection afforded to workers is equivalent to that provided by shoring.
- If excavation walls are sloped as a substitute for shoring, slope walls at angles, dependent upon soil or rock conditions, which will provide stable faces. Do not create a slope steeper than a ratio of one horizontal to one vertical.
- Use safe work procedures to protect workers when installing and removing shoring.

2.4.4 Uranium & Thorium

- Unless the chief inspector permits otherwise, where standard assay results show, or are expected to show uranium mineralization in a grade of 0.05% by weight or greater or thorium mineralization in a grade of 0.15% by weight or greater, ensure that:
  - all drill holes are completely sealed with concrete on completion of exploration;
  - all practicable precautions are taken to ensure no drilling fluid, water or drill cuttings contaminate any drinking water supply, irrigation water supply, or surface water;
  - all persons working at the exploration site are provided with a gamma radiation dosimeter of an approved type; and

- no person is exposed to a whole body dose of more than 5 millisieverts in a 12 month period.

2.4.5 Induced Polarization Geophysical Survey Systems

- Where an induced polarization geophysical system is being operated, ensure that:
  - energized wires are sufficiently insulated to prevent electric shock;
  - induced polarization electrodes have visible warning stickers stating "Danger - High Voltage;"
  - signs are posted to warn other persons who may enter the area;
  - electronic communication is provided to every member of the crew whose movements are out of sight and sound of the other crew members; and
  - all signs are removed on completion of the survey and no wires used during the survey shall be left on the site after the survey is completed.
- Coordinate electric blasting activities with active induced polarization and active electromagnetic survey work.

2.4.6 Use & Storage of Explosives

- Use and store explosives pursuant to the provisions of Part 8 of the HSR Code.
- Ensure that blasters have a valid blasting certificate granted pursuant to Part 8 of the HSR Code.

2.4.7 Working In and Around Fixed Wing and Rotary Aircraft

- Ensure that all passengers and personnel follow the directions of the pilot. The pilot is responsible for compliance with numerous aviation safety requirements and will direct activities in and around the aircraft. These may include:
  - delivery of safety briefings;
  - filing of proposed flight plans, either as a plot on a map or by written description;
  - management of loading and landing zones;
  - directing exit or entry procedures; and
  - controlling loading.
- Take extra care to act safely around helicopters. Some basic points to remember include:
  - stay well back from the landing zone prior to landing and loading;
  - control loose items - hold tools low, and secure hats and loose clothing;
  - face away from the helicopter when the rotor is in motion during landing and take-off; and

- avoid the main and tail rotors by approaching or leaving the helicopter as directed by the pilot. This will usually be on the down slope in a crouched position, towards the front or side of the helicopter. Stay in the pilot's field of vision and away from the rear tail rotor.

- If directed to assist in a helicopter slinging operation, obtain clear instructions from pilot as to loading and operational parameters before proceeding.
- Become familiar with helicopter hand signals for ground-to-air and air-to-ground communication if required to provide communications during slinging operations
- If requested, give the pilot a clearance to take-off after ensuring that the sling is free from possible obstructions or snagging and that all personnel are at a safe distance from the helicopter and not in or below its flight path.

Checklist: Health and Safety

The heath and safety of mineral explorationists is of paramount importance, and both the HSR and MX Code outline measures to ensure worker health and safety are adequately protected. Refer to the Codes for specific information, but use this list as a quick reminder.

Have you:

- ❑ Conducted any occupational health and safety orientation training for workers?
- ❑ Equipped workers with the appropriate first aid training and supplies?
- ❑ Properly trained workers in safe work procedures as it relates to their duties and equipment?
- ❑ Developed and implemented an Emergency Preparedness Plan?
- ❑ Developed a system to identify, assess and control various workplace hazards?
- ❑ Safely planned and carried out any excavation activities?
- ❑ Trained workers to safely work with vehicles, boats and aircrafts?
- ❑ Coordinated health and safety efforts with any sub-contractors?
- ❑ Provided any necessary personal protective equipment?

2.5 Resources

Association for Mineral Exploration British Columbia (AME BC). 2005. Safety Manual: Mineral Exploration in Western Canada. www.amebc.ca/healthsafety.htm .

3 Community Watersheds & Drinking Water Sources

3.1 Background

British Columbia is a unique province in that most of the population derives its water from surface sources. Over 80% of the population uses surface water as its drinking supply, with small and medium-sized streams comprising the most common source of water for communities[2].

Community watersheds are areas people depend on for drinking water - drainage catchments upstream of a point of water withdrawal for human consumption. They are unevenly distributed, as is the provincial population, with most concentrated in the southern third of the province and relatively few in the north. The province classifies over 450 watersheds as community watersheds based on three criteria:

- the water source is from a stream where the water is used for human consumption;
- the stream is licensed under the *Water Act* for a waterworks purpose or a domestic purpose controlled by a water users' community; and/or
- the drainage area is not more than 500 km^2.

Community watersheds are listed by name, map sheet, forest district and a variety of other characteristics at http://srmwww.gov.bc.ca/wat/cws/query/cws.htm.

Other watersheds that do not meet these criteria can also become community watersheds through a process described in Section 2 of the *Community Watershed Guidebook* published by the Ministry of Forests (see Section 3.5: Resources).

In addition to community watersheds, domestic water systems and drinking water sources may also include groundwater wells. Information on water wells and water resources other than community watersheds can be found at the Ministry of Environment's Water Resource Information website: http://www.env.gov.bc.ca/wat/

[2] From the *Community Watershed Guidebook*, Ministry of Forests

3.2 Objectives

The objectives of the "Community Watershed" portion of the MX Code are to:

- ensure that exploration activities do not unduly impact water quality, water quantity, timing of flow and channel stability such that water quality objectives cannot be met;
- avoid harmful or cumulative hydrological effects and reasonably ensure that they can be mitigated if they do occur;
- ensure that exploration activities do not impair the ability of a water purveyor (the person or entity responsible for a community water supply) to provide potable water and reasonably assure that any impairment can be and is mitigated; and
- ensure affected stakeholders are notified of proposed activities.

3.3 What's Required under Legislation

Under the MX Code, explorationists are required to maintain natural drainage patterns and water quality in community watersheds, and notify water licence holders or water purveyors of their activities. Explorationists are also required to have a contingency plan and take remedial action if any exploration activities adversely affect a community water supply.

3.4 Recommended Practices

3.4.1 Notification to Other Water Users

- The water licence holder of record or the representative of record within a community watershed must be notified at least 48 hours prior to the start date of activities within the watershed. Under the MX Code, this must be done by an owner, agent or manager responsible for exploration activities. The notification and its receipt should be documented to protect all parties.

3.4.2 Target Water Conditions

- Natural drainage patterns and water quality should be maintained. Avoid impacts to water quality and quantity of flow. Target conditions for water quality are outlined in the *Community Watershed Guidebook* (MoF, 1996) and reproduced in Table 3.1).

Table 3.1: Target Conditions for Water Quality in Community Watersheds

Attribute	Target Condition
Stream flow	No change in the timing, duration or magnitude of peak flows No change in the magnitude or duration of low flows
Turbidity and suspended sediments	Within the range and duration of the natural variability of the undisturbed watershed
Coliforms	No detectable increase in faecal coliforms
Temperature	Within the range and duration of the natural variability of the undisturbed watershed
Nitrate-N	Less than 10 mg/L at the intake
Pesticides	Not detectable at the intake
Algae	Less than 2 µg/L chlorophyll-a in lakes, less than 50 mg/m^3 chlorophyll-a in streams

Source: *Community Watershed Guidebook,* Section 5

- Works should be planned to avoid or limit impacts to these and other water quality parameters.
- Water quality target conditions should be monitored to assess potential impacts.

3.4.3 Exploration Accesses

- Take particular care when constructing an exploration access in a community watershed or in the area of any drinking water source.
- Boundaries of community watersheds and the locations of intake structures or other drinking water supply infrastructure should be identified.
- Where practicable roads, stream crossings, and other works should be located below (i.e., downstream of) water intakes. If an access must be located above a water intake, locate it at least 100m upslope unless otherwise authorized and ensure the access does not interfere with known subsurface water flow paths.

Potential ARD?

Review the "Metal Leaching and Acid Rock Drainage" section of this document

- Rock from formations known to generate acid should not be used in the construction or modification of exploration access in a community watershed.
  - If an acid-generating formation is encountered in the course of access construction or modification, notify the district inspector. The work may be permitted to continue by the district inspector, provided you demonstrate that the use of the material with acid-generation potential is minimized.

3.4.4 Water Supply Contingency Planning

- Check to determine if a contingency plan already exists for a given community watershed or domestic water source. The Drinking Water Protection Act requires all purveyors of domestic water systems to have an emergency response plan. Check with the local water licence holder/purveyor or the local Health Authority's Medical Health Officers and Environmental Health Officers.
- If your area is without a contingency plan, you should develop a site-specific plan that provides for supplying emergency water and rehabilitating the water system should damage occur as a result of exploration activities. The contingency plan should be based on the principle of immediate response to water supply problems and should include the following items:
  - immediate cessation of exploration activity if an event occurs that would impact potable water quality;
  - identification of names, addresses and phone numbers of the initial contacts to ensure proper action. Figure 3.1 outlines an example of a flow chart detailing emergency response;
  - establishment of procedures for providing alternative water supplies for the community watershed users; for example, the use of water tankers, wells or pre-constructed pipelines from adjacent drainages; and
  - establishment of procedures to mitigate or rehabilitate potential water supply problems; e.g., constructing settling ponds, laying bypass pipe and constructing a filter system to clarify water.

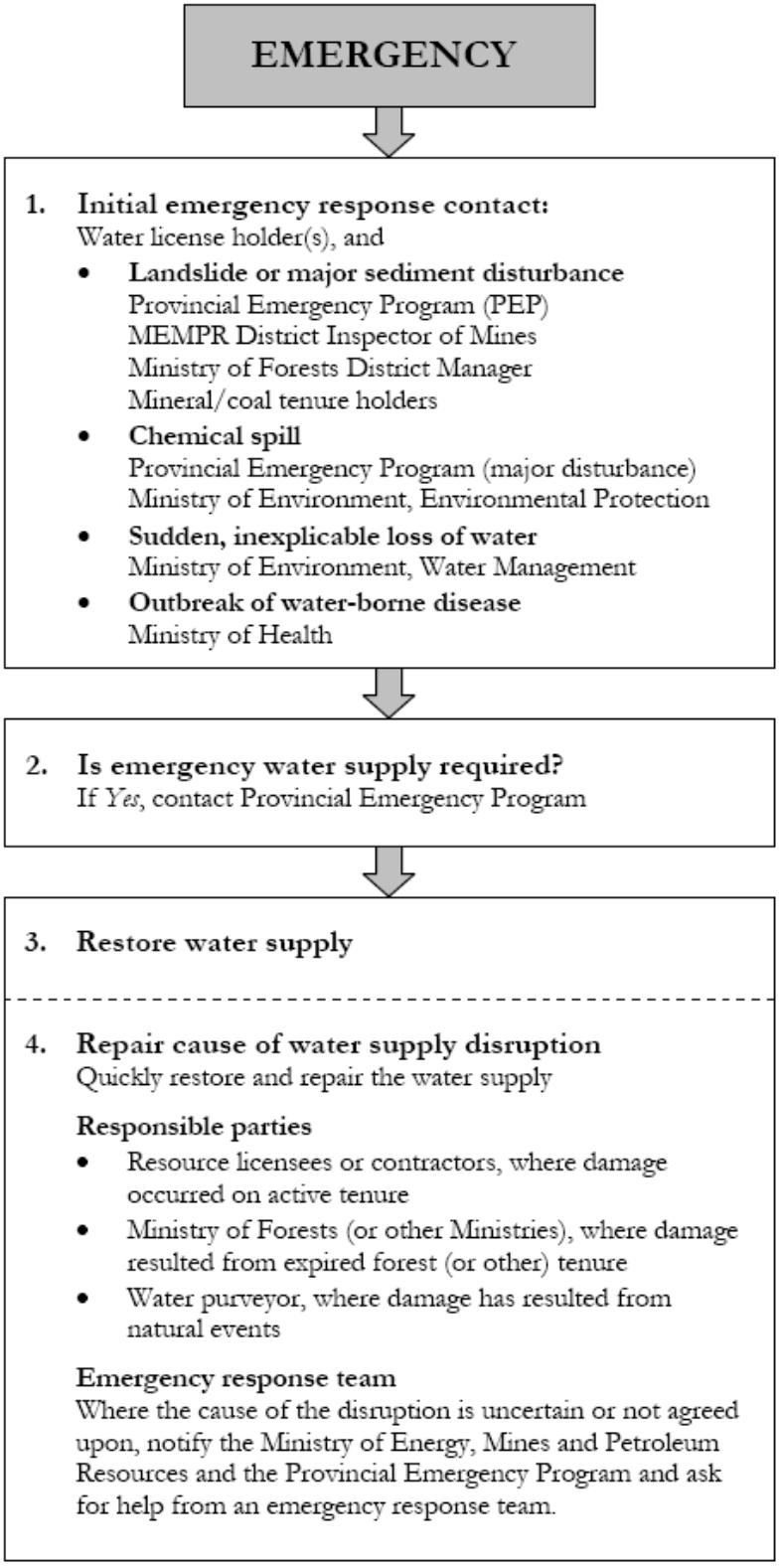


Figure 3.1: Example Emergency Response Flow Chart, (adapted from *Community Watershed Guidebook,* MoF)

Checklist: Community Watersheds

The MX Code requires that exploration activities occurring within community watersheds take steps to ensure the protection of water quality and supply.

- ❑ If your exploration activities occur within a community watershed have you:
  - ❑ Planned exploration access within the community watershed to avoid impacts to:
    - ❑ Water quality;
    - ❑ Water quantity;
    - ❑ Timing of flow; and
    - ❑ Channel stability?
  - ❑ Obtained or created a water supply contingency plan to address potential impacts to local water supplies?
  - ❑ Notified, at least 48 hours prior to the start date of activities, the water licence holder of record or the representative of record within the community watershed?
  - ❑ Maintained the watershed's target water quality conditions (Table 3.1) during exploration activities?

3.5 Resources

Ministry of Forests. 1996. Community Watershed Guidebook. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook.
http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/WATRSHED/Watertoc.htm

Ministry of Sustainable Resource Management—Community Watershed homepage
http://srmwww.gov.bc.ca/wat/cws/cwshome.htm

4 Riparian Management

4.1 Background

Riparian areas are the lands that occur adjacent to rivers, lakes, and wetlands (Fig. 4.1). They are distinctly different from surrounding areas because of unique soil and vegetation characteristics that are strongly influenced by the presence of water. Riparian areas comprise a very small percentage of the land base but are among the most productive and valuable natural resources. In some parts of BC, they can be major habitat providers for threatened and endangered species. They are, however, perhaps best known for their value in providing fish habitat.

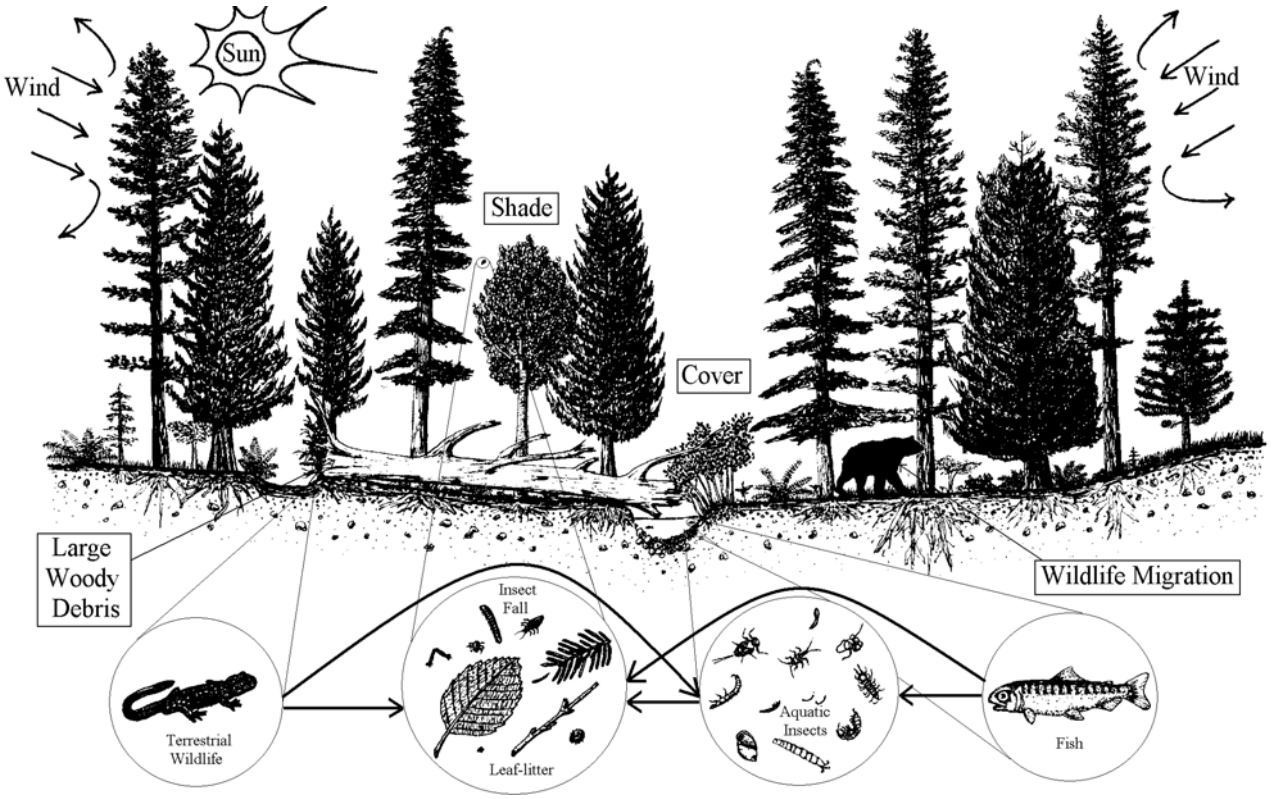


Figure 4.1: Functions of Riparian Areas (Source: MoE, Lower Mainland Region)

Riparian area functions and values can include:

- Controlling non-point source pollution by holding and using nutrients and sediment;

- Supplying food, cover, and water for a diverse collection of animals and serving as migration routes and habitat for a variety of wildlife; and

- Providing riparian vegetation that stabilizes stream banks, and reduces downstream flooding by checking floodwater velocity.

The functions and values of riparian areas can be significantly degraded if care is not taken while conducting work in and around these areas.

4.2 Objectives

The objectives of the "Riparian Management" portion of the MX Code are to:

- avoid harmful impacts of exploration activities on stream channels, water quality, aquatic ecosystems, and riparian habitat and vegetation; and
- manage any permitted activities within riparian areas to maintain the integrity of the stream, lake or wetland; prevent the introduction of deleterious substances into a stream, lake or wetland; and minimize the disturbance caused by the activity.

4.3 What's Required under Legislation

The federal *Fisheries Act*, administered by the Department of Fisheries and Oceans (DFO), is the key piece of regulation over fish and fish habitat in Canada. Section 35 prohibits any "harmful alteration, disruption or destruction of fish habitat" (a HADD) that is not authorized by DFO. The definition of fish habitat under the Act extends to riparian areas that provide habitat on which "fish depend directly or indirectly in order to carry out their life processes." Depositing sediment or other "deleterious substance" into streams that support fish or fish habitat is also prohibited under the *Fisheries Act,* and any party doing so is therefore liable under the Act.

Deleterious Substance - MX Code Definition

"*any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water*".

To meet the requirements of the *Fisheries Act*, the MX Code specifically addresses the management of MX activities within riparian areas. It defines a number of terms related to riparian management and establishes "riparian setbacks" on streams, wetlands and lakes. MX activities are permitted in these areas, but any works within a riparian setback must meet the MX Code objectives and be addressed in a management plan included in the Notice of Work.

The width of the riparian protected area, reserve or setback that should be left around watercourses and water bodies is outlined in the following table, excerpted from the MX Code. Appropriate riparian setback widths depend greatly on site conditions, including the type of exploration activity and the size of the watercourse or water body.

Table 4.2: Riparian Setback Widths

Riparian Type		Riparian Setback (metres, measured from the top of bank) required for:	
		Drilling	**Exploration Access**
Streams (width)	> 20 m	50	70
	> 5 and ≤ 20 m	30	50
	≥1.5 and ≤ 5 m	20	40
	< 1.5 m	5	30
	< 0.5 m in alpine areas above timberline	5	15
Wetlands (area)	> 5 ha	10	30
	> 1.0 ha and < 5.0 ha	10	20
	>0.25 ha and < 1.0 ha	10	10
Lakes		10	30

Source: MX Code, Table 9.1

The riparian setbacks listed above use as a reference point the watercourse's "top-of-bank". Top-of-bank is a term that can be variously interpreted, but is commonly defined as the slope change closest to the natural boundary (or peak high water mark) of a watercourse. The natural boundary of a watercourse is the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself (from the *BC Land Act*). The riparian setbacks extend from the top-of-bank or natural boundary to the required slope distance.

The following activities are permitted within the riparian setbacks described above:

- construction, maintenance, deactivation and reclamation of stream crossings (see Chapter 10 for recommended practices for stream crossings);
- access from water landings for the purpose of servicing exploration camps and equipment;
- access to set up and service water supply pumps; and
- access to service drill sites when no other practicable option exists.

Other exploration activities may occur within these setback areas when no other practical option exists, and risks to health, safety or the environment

can be reduced. In these cases, a management plan shall be prepared that shows how the proposed activities will:

- maintain the integrity of the stream, wetland or lake;
- prevent the introduction of deleterious substances into the stream, wetland or lake; and
- minimize the disturbance to the riparian area caused by the activity.

Include the management plan in your Notice of Work, and ensure it is approved by the inspector and authorized in your permit.

4.4 Recommended Practices

When carrying out activities in or near streams, lakes and wetlands, mineral and coal explorationists should plan and carry out these activities in a manner that minimizes both short and long-term impacts. The following section outlines recommended practices for works in riparian areas.

4.4.1 General Recommended Practices

- Prior to any activity, the boundaries of the riparian setback should be flagged as a machine exclusion zone and those areas where exploration activities are permitted within the riparian setback should be clearly defined. Check with local logging companies for potential conflicts with their riparian flagging and use distinctive flagging to minimize confusion with other flagging present.
- Trees to be cleared in areas near riparian setbacks should be fallen and yarded away from riparian setback areas, not into them.
- Introducing sediment and debris into setback areas should be avoided.
- Restrictions to natural water patterns into and out of setback areas should be avoided.
- Any fuel or lubricant leaks should be captured and contained.

4.4.2 Working in Watercourses

- Streams, wetlands and lakes should generally not be entered.
- If instream activity is unavoidable and work may affect fish streams, downstream fish habitat, or water quality, plan the work for periods of low stream flow and times of the year that are not critical to fish survival. Refer to Fisheries and Oceans Canada's series of Operational Statements for further information.
- Timing windows during which instream work is permitted vary by watercourse or region depending on the fish species present. Fisheries

and Oceans Canada offices, regional MoE offices, or local Ministry of Forests and Range offices are recommended sources of information. .

4.4.3 Access Roads

Routing Roads Through Riparian Setbacks

The need to route roads through a riparian setback must be identified and justified in your permit application.

- Whenever practicable, access roads and trails should be routed outside the setback area rather than parallel to a watercourse within a riparian setback. Minimize crossings, but where they are necessary, cross the riparian area and the stream at right angles to minimize the area of disturbance (Figure 4.3).
- Look for narrow stable stream crossing sites and, where practicable, avoid sites with fine or unstable bank materials.
- Where roads must be routed within riparian setbacks, minimize the width of the right of way and roadbed to reduce the amount of disturbance to the riparian area.

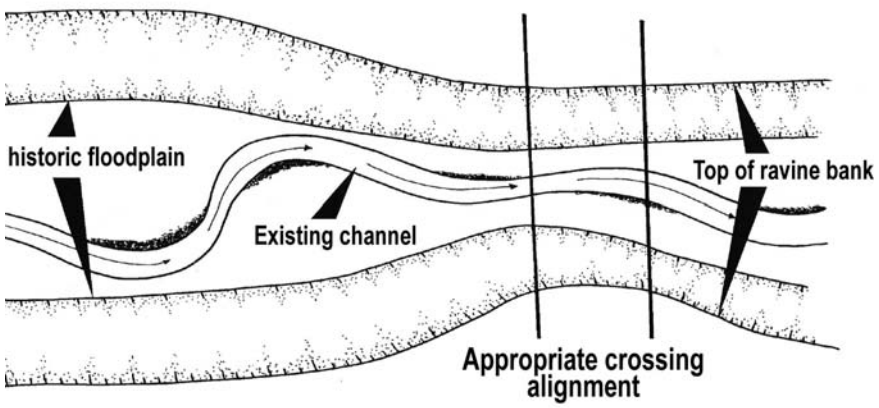


Figure 4.3: Access Road Location

4.4.4 Fill Deposit and Removal

- Gravel or fill should not be removed or deposited within the riparian setback other than for the purposes of constructing a stream crossing or a structure specified in your Notice of Work and authorized in the permit.
- Fill heights for crossings and any other structures should be minimized and the fill protected from erosion. Fill placement or access construction that parallels the stream should be avoided.

4.4.5 Operating Equipment

- Operation or transportation of mechanized equipment within the riparian setback should be avoided with the exception of water pumps authorized under a permit, unless there are no practicable alternative

Streamside water supply pump - the pump and motor are seated in a containment tray and the ground is buffered by a tire.

routes and operating the machinery outside the setback will create a higher risk of sediment delivery to the watercourse. The need to operate within the setback should be identified in your Notice of Work application and authorized in the permit.

- Keep machinery surfaces free of grease and oil.
- Equipment servicing or fuelling should not occur within riparian setbacks other than pumps and machinery that are:
  - hand held;
  - required for fire fighting;
  - broken down and require fuel or services in order to be moved; or
  - authorized in your permit to be fuelled or serviced in the area.

4.4.6 Water Withdrawal

- Access points for water withdrawal for drilling purposes or for camp use should be planned to minimize disruption of riparian vegetation where practicable:
  - use an existing access instead of constructing a new one;
  - situate accesses on rocky banks or shores that can withstand mechanical disturbance better than soft edges or erodible banks; and
  - minimize the number of routes to access a source of water, where practicable.
- Water withdrawal rates should be selected to ensure that the flows required for instream resources (i.e., fish, amphibians, other aquatic species) are maintained.
- Pumps set up near stream banks should be placed on a flat area with a minimum amount of digging and soil disturbance to reduce the risk of bank erosion and sediment introduction to the watercourse.
- Drip trays should be placed under water supply pumps and associated machinery to contain all fuel or oil leaks and minor servicing spills. Fuels and lubricants should not be stored with the pump; rather, they should be safely stored away from the watercourse.
- When installing water supply pumps in fish streams or other fish-bearing waters, pump intakes should be equipped with screens to prevent fish from being drawn into pumps. DFO has a guidance document, the *Freshwater Intake End-of-Pipe Fish Screen Guideline* (http://www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/guidelines-conseils/guides/pipe/index_e.asp), which contains helpful information on appropriate screen sizing and construction.

4.4.7 Removal of Structures

- All temporary structures should be removed once operations are completed. If stream bank disturbance is evident and erosion is likely to

occur after the structure is removed, bank stability should be re-established through application of appropriately designed erosion protection measures (e.g., armouring with native rock, or replacement of streamside vegetation).

4.4.8 Wildlife Trees

- Wildlife trees located within riparian setbacks should not be removed unless recommended by a wildlife tree hazard assessment. Some wildlife trees within the setback may pose a risk to workers operating in or near setbacks. These include standing dead trees that are vertical or lean towards the work area, as well as some live trees with large dead branches or tops.
- If a hazardous wildlife tree is identified for removal, complete a wildlife tree assessment to determine the habitat value of the tree. Unsafe trees deemed to be of low wildlife value may be removed, but trees felled in a setback area should be left as coarse woody debris. Unsafe trees of high wildlife value (e.g., nest tree for eagles, osprey or great blue heron) should be marked as wildlife trees and left in place. Establish a no-work zone around the tree – zone size will vary by tree and site, but generally will be one or two tree lengths.
- More information on wildlife trees and hazard tree assessment training can be found at the Ministry of Forests and Range Wildlife Tree Committee website: http://www.for.gov.bc.ca/hfp/values/wildlife/WLT/

4.4.9 Species at Risk

- British Columbia is home to tens of thousands of plant and animal species living in a rich diversity of habitats. Many of these species and their habitats are at considered to be at risk or in danger of becoming extinct or lost from the wild. Explorationists should consider the potential presence of species at risk in their areas of work and particularly in riparian areas where many species at risk or critical habitats may be found.
- Several pieces of legislation, including the federal *Species At Risk Act* (SARA), exist to protect these species by preventing their killing, harming, capture, as well as the destruction of their residence or critical habitat. Further information on the federal Species at Risk Act, BC's species at risk approach, and information on species occurrences can be located on the following websites:

  http://www.speciesatrisk.gc.ca/default_e.cfm

  http://srmwww.gov.bc.ca/cdc/

  http://www.env.gov.bc.ca/wld/serisk.htm

Wildlife Trees

A wildlife tree is a standing live or dead tree with special characteristics that provide valuable habitat for wildlife, whether it be nesting, feeding or roosting. Wildlife trees also provide a source of large woody debris for maintaining stream channel characteristics.

High quality wildlife trees are frequently present in riparian areas and are used by a variety of species. The proximity of these trees to the edge of streams, wetlands, lakes and marine-sensitive zones increases their value for wildlife.

Note:
Protection of wildlife trees is an obligation under the BC *Wildlife Act*

4.4.10 Marine-Sensitive Zones (MSZs)

- Operations should be timed so as to minimize effects on MSZs. Information on work timing windows in MSZs can be obtained from local Fisheries and Oceans Canada (DFO) staff or at the following website: http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/timing_marine_e.htm
- A machine exclusion zone should be identified and flagged 5 m from the high water mark along all shorelines; trees, shrubs and herbaceous vegetation within this 5-m zone should be retained.
- Trees should be fallen and yarded away from MSZs, not into them.
- Sediment introduction to MSZs should be prevented.
- Any fuel or lubricant leaks should be captured and contained. Machinery surfaces should be kept free of grease and oil.
- Debris should be contained so that it does not enter the marine environment. Should any debris enter the marine environment, remove it and dispose of it in a manner that prevents its re-entry and contamination of the aquatic environment. Periodic sweeps of the water surface should be conducted to capture floating debris before it sinks.

Marine-sensitive zones (MSZs)

MSZs are intertidal and subtidal areas that are highly productive and include estuaries, herring spawning areas, shellfish beds, eelgrass beds and other areas of marine vegetation, marsh areas and aquaculture sites.

Checklist: Riparian Management

Maintaining the integrity of riparian areas is key to protecting the physical, chemical and biological components of fish and wildlife values in and near streams, rivers, wetlands and lakes.

- ❑ Do your proposed exploration activities occur within the riparian setbacks listed in this chapter? If they do, have you:
  - ❑ Prepared and submitted a management plan with your works application?
  - ❑ Planned your works to minimize riparian disturbance by:
    - ❑ Considering alternative access locations and routing roads outside of riparian areas;
    - ❑ Using existing access routes when available;
    - ❑ Clearly marking setback areas and permitted work zones;
    - ❑ Preventing the introduction of sediment, debris, fallen timber or other materials into the riparian setback area;
    - ❑ Locating stationary equipment (e.g., pumps) in drip trays and storing fuels and lubricants in a manner that prevents their accidental release to a watercourse (e.g., outside of setbacks);
    - ❑ Preventing the alteration of natural drainage patterns within the setback area;
    - ❑ Avoiding and limiting work in watercourses;
    - ❑ Working instream only during instream work timing windows;
    - ❑ Operating and servicing machinery and equipment outside of riparian setbacks unless work within the setback has been specifically permitted;
    - ❑ Removing all temporary structures in a manner that leaves the area stable and revegetated once exploration activities are completed; and
    - ❑ Retaining wildlife trees within setbacks unless removal is recommended by a wildlife tree hazard assessment?
- ❑ Do your proposed exploration activities occur within intertidal and subtidal areas of a Marine Sensitive Zone (MSZ)? If they do, have you:
  - ❑ Prepared and submitted a management plan with your works application?
  - ❑ Planned your works to minimize disturbance to the MSZ by:
    - ❑ Establishing a machine exclusion zone 5 m from the high-water mark and retaining vegetation within this area;
    - ❑ Preventing the introduction of sediment, debris, fallen timber or other materials into the MSZ;
    - ❑ Containing fuels and lubricants outside of the MSZ; and
    - ❑ Containing and collecting debris to prevent it from entering the marine environment?

4.5 Resources

B.C. Ministry of Forests. 1995. Riparian Management Area Guidebook. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/Rip-toc.htm

B.C. Ministry of Sustainable Resource Management—B.C. Fisheries. "Fisheries Inventory Summary System (FISS)." Provides spatially represented summary-level fish and fish habitat data for water bodies throughout British Columbia and the Yukon. The information is in database format and can be displayed on the 1:50 000 Watershed Atlas. http://www.bcfisheries.gov.bc.ca/fishinv/fiss.html.

B.C. Ministry of Sustainable Resource Management—B.C. Fisheries and Fisheries and Oceans Canada. "Fish Wizard." Contains the most recent information about British Columbia lakes and streams and the fish in them, including salmon escapements, fish stocking records and depth maps for over 2500 lakes. http://pisces.env.gov.bc.ca/.

B.C. Ministry of Water, Land and Air Protection. 2004. *Standards and Best Practices for Instream Works.* 174 pp. http://wlapwww.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

Land and Water British Columbia Inc. 2005. "A User's Guide to Working in and around Water - Regulation under B.C.'s *Water Act*." http://www.lwbc.bc.ca/03water/licencing/docs/working_around_water.pdf

Fisheries and Oceans Canada. 2005. Pacific Region Operational Statements series. http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/operational_statements_e.htm

5 Soil Conservation

5.1 Background

An example of soil conservation—salvaged topsoil temporarily stockpiled.

In many cases, advanced exploration activities require some level of disturbance of natural ground cover to expose bedrock. Soils that may be impacted by these activities provide the foundations for productive plant growth and so the salvage of natural soils for subsequent use in reclamation is an integral part of any mining or MX program. To provide for self-sustaining vegetation cover on exploration sites, soils to support this cover need to be available for use after the exploration work is completed.

Soils that have developed naturally onsite are far better for restoration than no soil or soils brought in from elsewhere. Soil biota or soil microorganisms found in native material are known to thrive under the climatic conditions of the site, while soil biota in transported soils may be poorly suited. Salvaging soils utilizes native seeds and plant parts to assist in revegetation. Even in northern and alpine sites, there is usually sufficient soil to be salvaged for future restoration treatments—unless activities are occurring on bare rock.

The level of effort you invest in the conservation of soils should be commensurate with the level of your impact and will be directed by a number of specific site factors, such as:

- area of soil disturbance;
- capability of the site to naturally recover; and
- erosive potential of soils.

Explorations should strive to minimize the amount of surface disturbance in order to reduce both the potential for environmental impact and the costs required for salvage, storage and reclamation efforts at exploration sites.

This chapter provides information on the conservation of soils for reclamation. Additional information about protecting soil from loss through erosion is provided in Chapter 7, while further information about the use of soils in reclamation can be found in Chapter 14.

5.2 Objectives

Objectives of the "Soil Conservation" portion of the MX Code are to:

- prevent the destructive loss of soil and soil productivity;
- provide for the orderly reclamation of sites disturbed by MX; and
- prevent the destruction of other environmental values (fish and wildlife habitats) through the erosion of soils associated with MX.

5.3 What's Required under Legislation

The MX Code requires exploration activities to be carried out in a manner that minimizes the loss of any soil that can be reasonably reclaimed to support appropriate self-sustaining vegetation.

5.4 Recommended Practices

The following steps are important for the conservation of soils during MX:

- control of erosion and sediment generation through revegetation;
- salvage of soils prior to site use; and
- replacement of soils following MX.

Recommended practices related to erosion and sediment control are discussed in Chapter 7: Water Management. This section concentrates on soil salvage and replacement before, during and after exploration activities.

5.4.1 Soil Salvage for Reclamation

Revegetated trail—natural regeneration after one year in sub-alpine balsam forest.

Reclaimed trail—organics were pulled back, grass was seeded, and trees were planted

- Collection of soils for reclamation should include roots, small woody debris and plant fragments. In some cases, plant roots, living plant fragments and seeds contained in the soil's "seed bank" will regenerate once the soils are applied to the reclamation site and assist with revegetation. Stumps and other small woody debris included with the salvaged soil will also create substrate diversity. This, in turn, encourages the maintenance of biological diversity in the salvaged soils.
- When large areas of soil are to be disturbed, you should plan how soils are going to be stripped, stockpiled and subsequently used in site reclamation prior to any work on the site to avoid the need to move stockpiles and the risk of contaminating soils.
  - Where practicable, consider removing soil from one area and reapplying it to another site immediately to limit the need to stockpile soils.
  - Where stockpiling of salvaged soils is unavoidable, stockpiles should be located in a convenient spot easily accessible for reclamation.
  - The surface area of stockpiles should be maximized to maintain higher levels of biological activity. Build a windrow of salvaged soils around the edge of the exploration site that will serve as a barrier to run off and a convenient configuration for storage of soil materials.
  - Temporary vegetation covers should be used on soil stockpiles that are going to be in place for two or more months. Use an annual cover crop such as fall rye for short-term stockpiles (up to one year) and a mixed cover of annuals and perennial grasses and legumes for soils that are to be stored for two or more years.

- Reasonable precautions should be taken to minimize the potential for soil stockpiles to become sites of invasive plant infestation, as any invasive plants on stockpiles may then be spread on the reclamation site.

- Excavators rather than bulldozers should be used for road building where practicable. This will allow selective stripping of surface soils and the placement of material in a location where it will be available for reclamation once use of the road is complete.

5.4.2 Soil Contamination

- Protecting natural soils from contamination with petroleum products, drilling mud, and other non-natural materials, will avoid expensive soil remediation measures during the reclamation of project sites.

- Potential contaminants should be contained in non-porous ponds or specially constructed tanks. Special care should be taken with drilling fluids that may contain environmentally toxic materials. Chapter 9 provides details on the safe storage and handling of fuel and lubricants.

5.4.3 Wind Erosion

- Dry, powdery soils prone to wind erosion should be protected with vegetation or with some material, such as gravel, that will not be picked up by the wind.

- The use of snow fencing should be considered to modify wind patterns and reduce wind erosion in trouble spots.

Invasive Plant Strategy for British Columbia

Invasive plant species – also known as noxious weeds – are taking over large tracks of land throughout the province. Annual economic losses from invasive plants in BC are in the tens of millions of dollars each year. Without natural enemies to control their populations, these weeds have a competitive advantage over local native plants that makes them very difficult to control. Invasive plants adversely affect crop yields, reduce range productivity (as many weeds are non-palatable or injurious to domestic livestock), reduce wildlife forage and the land's recreational values, impact conifer regeneration efforts and even impact personal health. More information may be obtained at: http://www.fraserbasin.bc.ca/publications/fbc_reports.html

Checklist: Soil Conservation

Salvage of natural soils for subsequent use in reclamation is an integral part of any mining or MX program.

- ❑ Have you planned your exploration activities to:
  - ❑ Minimize the disruption of soils?
  - ❑ Salvage native soils prior to site use by using soil stockpiles that:
    - ❑ Are carefully stripped;
    - ❑ Include plant material and woody debris;
    - ❑ Are only in place for a short duration;
    - ❑ Maximize surface area;
    - ❑ Are located to avoid relocation and contamination; and
    - ❑ Are close to the reclamation site;
  - ❑ Control erosion and sediment generation by protecting disturbed and stockpiled soils with temporary covers and windbreaks;
  - ❑ Avoid introducing invasive plant species;
  - ❑ Avoid the potential contamination (and resulting cost of remediation) of conserved soils; and
  - ❑ Replace soils following your mineral exploration activities?

5.5 Resources

B.C. Ministry of Forests. 1997. Tools and Techniques *in* Soil Rehabilitation Guidebook. For. Prac. Br., Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/soilreha/REHABTOC.HTM

B.C. Ministry of Forests. 2001. Soil Conservation Guidebook. 2nd ed. For. Prac. Br., Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/soil/soil-toc.htm

B.C. Ministry of Forests. 1999. Hazard assessment keys for evaluating site sensitivity to soil degrading processes guidebook. 2nd ed., Version 2.1. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/HAZARD/HazardAssessKeys-web.pdf.

6 Terrain

6.1 Background

Qualified Person Defintion

The *Mines Act* defines a "qualified person" as a person who, in the opinion of the manager, is a) qualified because of the person's knowledge, training and experience to design, organize, supervise and perform the duties for which the person is appointed, b) familiar with the provisions of this Act, the code and the regulations that apply to the duties for which the person is appointed, and c) capable of identifying any potential or actual danger to health or safety in the workplace.

Terrain stability is an essential issue to be identified and managed when carrying out MX programs. This chapter explains the terrain considerations of the MX Code and provides guidance on what to do if terrain stability issues arise.

Terrain stability problems may take many forms, from simple erosion as discussed in Chapter 7 to massive landslides, debris flows or other mass movement events. Unstable terrain and slope failures may cause significant property damage and even loss of life. For this reason, the advice of a "qualified person" or appropriate qualified geotechnical professional should be sought if there are any indications of potential terrain instability.

6.2 Objectives

The objectives of the "Terrain" portion of the MX Code are to:

- minimize the risk of landslides and other ground instabilities; and
- protect human life and property in the event of a landslide or other ground instability.

6.3 What's Required under Legislation

Tension cracks on steep slope.

The MX Code specifies that exploration activities shall be designed and implemented by a qualified person to minimize the risk of activities causing landslides, channelized debris, mud or debris flows, gully bank destabilization, debris fan, snow avalanche or destabilization of an alluvial fan. It also lays out steps to be taken should any of these events occur.

6.4 Recommended Practices

Recommended practices associated with terrain concerns focus on two key elements:

- identification and avoidance of hazardous situations; and
- treatment of instabilities that arise.

The following sections outline recommended practices for dealing with terrain concerns. More details can be obtained from guidebooks and terrain stability mapping published by the former Ministry of Sustainable Resource Management and the Ministry of Forests and Range (see Section 6.5: Resources).

6.4.1 Assessing Potential for Instability

Identifying areas of potential instability and their probability of causing problems is by far the easiest and most effective means of avoiding terrain problems (see Table 6.1).

Harp-shaped tree stems indicative of slope instability.

Table 6.1: Indicators of Slope Instability

Field Indicators	Potential Landslide Type
• recent landslide scars • revegetated landslide scars	High likelihood of landslides of the same type and size
• partially revegetated strips (may also be snow avalanche tracks) • jack-strawed trees (trees tilted in various directions) • linear strips of even-aged timber • landslide debris piled on lower slopes • soil and rocks piled on the upslope side of trees • curved or sweeping trees (may also indicate snow creep) • mixed or buried soil profiles • poorly developed soils relative to other comparable slopes • tension fractures • poorly drained or gullied, fine-textured materials <3 m deep on slopes >50% • poorly drained or gullied coarse-textured materials on slopes >50% • wet site vegetation on slopes >50% • shallow, linear depressions • shallow, wet, organic soils on slopes >40%	Debris avalanches Debris flows Debris slides
• recently scoured gullies • exposed soil on gully sides • debris piles at the mouths of gullies • vegetation in gully much younger than the adjacent forest • poorly developed soils on gully sides relative to adjacent slopes (repeated shallow failures continually remove the developed soil profile)	Debris flows Debris slides
• tension fractures • curved depressions • numerous springs at toe of slope, sag ponds • step-like benches or small scarps • bulges in road • displaced stream channels • jack-strawed trees (trees tilted in various directions), split trees • poorly drained medium- to fine-textured materials (e.g., till, lacustrine, marine and some glaciofluvial deposits) >3 m deep • mixed or buried soil profiles • ridged marine deposits	Slumps
• talus or scattered boulders at base of slope • steeply dipping, bedrock discontinuities (bedding planes, joints or fracture surfaces, faults) that parallel the slope • bedrock joint or fracture surface intersections that dip steeply out of the slope	Rock slides or rock fall (can be induced by excavation and blasting for roads)

Source: Modified from Chatwin *et al.* 1994

Terrain mapping is a very useful tool in determining the potential for instabilities. Three levels of terrain mapping are identified in the *Mapping and Assessing Terrain Stability Guidebook* (see Section 6.5: Resources):

- reconnaissance terrain stability maps identify unstable or potentially unstable land areas from a broad perspective. They help identify areas

where more concentrated analysis is required such as detailed terrain and terrain stability mapping and terrain stability field assessments;

- detailed terrain stability maps provide a more comprehensive assessment of terrain stability hazards. They help to more narrowly define where terrain stability field assessments are required; and
- terrain stability field assessments focus on specific areas of concern for a proposed road or drill pad location.

A terrain stability map is required as part of a Notice of Work when exploration activities are proposed on potentially unstable lands. The map should show the location of activities relative to all areas that fall into terrain stability Class 5, and to areas within a community watershed that are fall into terrain stability Classes 4 and 5 (Table 6.2).

Table 6.2: Terrain Stability Classification

Terrain Class	Slope Class	Features	MX Program Specifics	Survey Mine Plan Preparation
I	0 – 20%	• Flood plains and wide valley bottoms. Well-drained deposits.	• Generally there should be minimal terrain issues. • Stream crossings and proximity to fish bearing streams and community watershed intakes are the primary concern.	• An engineered design will usually not be required, unless the crossing of a major stream or construction of a bridge is required. • A survey is not usually required unless operations will be adjacent to or on private property or critical infrastructure right of ways.
II	20 – 40%	• Mostly gently sloping, poorly to well drained landforms. • Moderately sloping, well to rapidly drained deposits	• Terrain related issues begin to be a concern especially in areas of adverse or wet soil conditions, previous failures. • Stream crossings and proximity to fish bearing streams and community watershed intakes are a concern.	• An engineered design may be required, depending on the site specifics. However the absence of adverse soil types and subsurface water must be demonstrated. • A survey may be required, along with drawings in plan and section based on the survey, depending on engineering requirements. • A detailed terrain stability assessment would usually not be required.
II to III	40 – 60%	• Level to gently sloping imperfectly or poorly drained marine clays or lacustrine deposits. • Moderately sloping, imperfectly to poorly drained deposits that are not marine or lacustrine. • Moderately sloping, deeply gullied surficial deposits that are not lacustrine or marine.	• Access to the deposit and exploration development methods must be planned and executed in consideration of site-specific terrain issues. • Stream crossings and proximity to fish bearing streams and community watershed intakes are a concern. • Site stability, drainage and erosion controls need consideration. • Routes should avoid channels or gullies that may carry intermittent flows, unless diversion works can be constructed.	• An engineered design based on a detailed geotechnical site assessment by a qualified person may be required. • A survey may be required to provide detailed topographical information. • An exploration program carried out under the supervision of the design engineer may be required depending on site and program specifics.
IV	60 – 70%	• Steeply sloping, well drained, deeply gullied deposits • Steeply sloping, poorly drained deposits • Moderately sloping, deeply gullied or imperfectly to poorly drained lacustrine or marine deposits.	• Access to the deposit should only consider exploration development methods that would not be expected to increase the risk of geotechnical instability. • Stream crossings and proximity to fish bearing streams and community watershed intakes are a concern. • Site stability, drainage and erosion control must be carefully considered and implemented. • Avoidance of channels or gullies that may carry intermittent flows of water should be practiced. • Overall long-term slope stability and erosion control will be a requirement and must be a prominent feature of the exploration project plan.	• An engineered design based on an appropriate topographic survey and a detailed geotechnical site assessment would be necessary to assure due diligence. • A detailed topographical survey may be necessary. • A permit pursuant to the *Mines Act* would be required.

Terrain Class	Slope Class	Features	MX Program Specifics	Survey Mine Plan Preparation
V	>70%	• Any area where natural landslide scars are visible on air photographs or in the field. • Very steeply sloping, imperfectly to poorly drained, deeply gullied deposits.	• Exploration development proposals in this type of terrain will require careful planning and execution. • The district inspector may exercise a certain level of discretion and deny approval or a permit for certain activities, if in his or her opinion they cannot be done safely. • Only exploration development methods that would not be expected to increase the risk of geotechnical instability should be considered. • Site stability, drainage and erosion control must be carefully considered and implemented. • Avoidance of channels or gullies that may carry intermittent flows of water should be practiced. • Overall long-term slope stability and erosion control will be a requirement and must be a prominent feature of the exploration project plan.	• An engineered design based on an appropriate topographic survey and a detailed geotechnical site assessment would be necessary to assure due diligence and to obtain a permit. • A detailed topographical survey would likely be necessary. • A significant project will cause environmental degradation. A cost/benefit analysis may be necessary to justify such a work program. • Exploration development would be expected to follow in a logical sequence of events. For example, it is expected that basic prospecting, sampling and mapping may be a first step, followed by geo-chemical/geo-physical surveys, then helicopter drilling followed by more intensive methods if the nature of the deposit warrants it. • A permit pursuant to the *Mines Act* would be required.

Source: BC Ministry of Energy Mines and Petroleum Resources

Terrain stability maps (TSM) for the province are under development; paper copies may be obtained by emailing bcsoils@pop.bc.ca. Local forest licensees may also have TSM maps available. However, TSM coverage of the province is not complete, and you may need to have terrain stability assessed by a qualified person.

Air photo interpretation can also show hidden instabilities such as old slump scarps and ancient mass flow events.

6.4.2 Qualified Design

Mechanical soil disturbing activity on Class 4 or 5 lands could result in the initiation of landslides.

- If reconnaissance terrain stability mapping indicates that such lands exist in the area of intended MX, then the design for roads, drill pads or other surface disturbing features must be developed by a qualified person (i.e., a suitably qualified licensed professional).

6.4.3 Preventing Unstable Situations

The angle at which slopes may become unstable depends on the material and the conditions of the site. Signs such as tension cracking are indicators that the slope is unstable and some remedial measures should be introduced before it fails. As moisture plays a major role in the stability of slopes, care in the handling of water will help to avoid slope stability problems.

- Safety is the first priority. At all times, and particularly during periods of heavy rainfall or spring melt, keep personnel and equipment away from unstable slopes and gully areas where debris avalanches and torrents might occur.
- Avoid over-steepening slopes on road and trench cuts and fills.
- Full bench cuts and end-hauling are the preferred methods for constructing accesses on steep slopes (slopes in excess of a 1.5:1 ratio, or greater than 67%).
- Loose or broken over-steepened rock slopes encountered or caused during site or road construction should be bolted or otherwise supported
- Waste material disposal sites should be located on stable terrain and all organic soils from the foundations of the site should be removed for subsequent reclamation use.
- Waste rock from exploration adits and other excavations should not be placed on steep slopes.
- Runoff water should be diverted away from loose fills and stockpiled materials.
- Logs and debris should not be used to support road fills if these are to be in place for more than one or two seasons.
- Culverts placed at all gully crossings and swales should be suitably sized. Water bars and cross ditches should be spaced along roads to convey water away from the road cut and reduce the risk of eroding the cutslope toe.

Terrain Stability and Road Construction

Refer to the Ministry of Forest's *Forest Road Engineering Guidebook* (http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm) for more information on road construction techniques in areas of differing terrain stability.

6.4.4 Instability Event—What to Do

Figure 6.1 outlines the steps to be taken in the event of a slide resulting from MX activities.

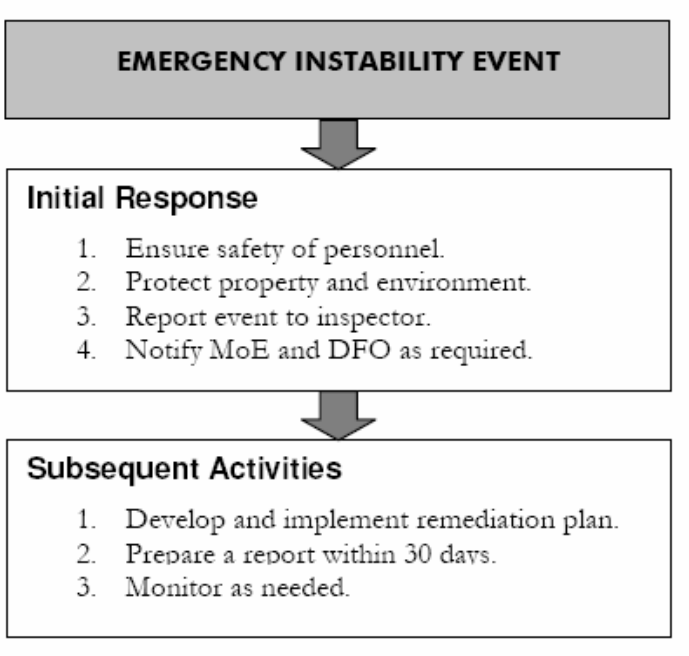


Figure 6.1: Emergency Event Flow Chart (based on MX Code emergency response requirements)

Put Human Safety First

- In the event of a slide or other instability occurring, the first response must be to ensure the safety of all personnel. Do not place yourself or others in danger of any further slides that may occur.

Protect Property and Environment

- Where there is a danger to property or the environment, measures should be taken to protect these elements. This may require that mobile equipment be moved or that protective berms be constructed.
- All instability events should be reported as soon as practicable to an inspector, who will assist on further actions and contact.
- Where environmental damage occurs, contact the mine inspector, the Ministry of Environment and, if a fish stream is involved, the Department of Fisheries and Oceans. Contacting environmental regulatory personnel immediately will show "due diligence" and help to avoid or minimize potential charges.

Plan for Remediation

- Ensure that remediation considers stabilization of the site, as well as revegetation and restoration of areas damaged by a slide or other event. Consultation with a qualified person is recommended where there is any question of future instability or further danger to property or the environment.

- Consult specialists where there are any questions regarding the effectiveness of restoration efforts. Chapter 14 provides general directions for restoration of MX sites.
- Schedule remediation work as soon as practicable after the event as fresh slide surfaces are more receptive to seeding than older surfaces. In addition, prompt restoration will minimize the impacts on local environmental resources.

Checklist: Terrain

The consideration and management of terrain stability issues is essential to a mineral exploration program.

- ❑ Have you assessed terrain stability in the area of your exploration activities through:
  - ❑ Review of reconnaissance terrain stability maps;
  - ❑ Review of detailed terrain stability maps;
  - ❑ Terrain stability field assessments; and
  - ❑ Aerial photograph interpretation?
- ❑ If there are any indications of instability, have you sought the advice of a qualified person:
  - ❑ In the assessment of terrain stability; and
  - ❑ In the design of surface-disturbing features?
- ❑ Are your exploration activities planned and designed to prevent or reduce the likelihood of unstable conditions?
- ❑ Do you have an emergency response plan for instability events that addresses:
  - ❑ Human safety;
  - ❑ Protection of property and the environment; and
  - ❑ Remediation of the damaged area?

6.5 Resources

Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) http://www.apeg.bc.ca/

B.C. Ministry of Forests. Mapping and Assessing Terrain Stability Guidebook. For. Prac. Br., B.C. Min. For., Victoria, B.C. Forest Practices Code of British Columbia Guidebook. http://www.for.gov.bc.ca/TASB/LEGSREGS/FPC/FPCGUIDE/terrain/index.htm

B.C. Ministry of Sustainable Resource Management, Resources Inventory Committee. 1999. *Terrain Stability Mapping in British Columbia* http://srmwww.gov.bc.ca/terrain/inventory/stability/

Chatwin, S.C., D.E. Howes, J.W. Schwab and D.N. Swanston. 1994. *A Guide for the Management of Landslide-prone Terrain in the Pacific Northwest.* 2nd ed. Land Management Handbook 18. B.C. Ministry of Forests, Research Branch. Victoria, B.C. 220 pp.

Varnes, D.J. 1974. The logic of geological maps with reference to their interpretation and use for engineering purposes. U.S. Geol. Surv. Prof. Paper 837. Table modified for use in B.C. Ministry of Sustainable Resource Management, Resources Inventory Committee. 1999. *Terrain Stability Mapping in British Columbia.* http://srmwww.gov.bc.ca/terrain/inventory/stability/

7 Water Management

Example of rill and gully erosion.

7.1 Background

Good management of surface and subsurface drainage is key to the protection of the environment surrounding exploration accesses, excavations, and camps. This chapter deals with water management on active exploration sites. For water management measures on reclaimed sites, see Chapter 14.

7.1.1 Surface Drainage

Surface waters include any stream, wetland and other type of watercourse and their associated drainage systems, as well as stormwater (the surface runoff resulting from rain or snowmelt).

Exploration activities may change natural drainage systems, flows and water quality, immediately and over time.

- Removing existing vegetation and increasing areas of hard surface (buildings, compacted areas, roads, etc.) increases stormwater runoff. Without measures to compensate for these actions, flooding and environmental damage may occur from even relatively minor storms.
- Disrupting natural drainage patterns can have long-lasting effects on the hydrology in nearby streams and aquifers. It can cause much higher peak flows in streams in winter and extremely low flows in summer, which in turn may impact negatively on aquatic habitat.
- Uncontrolled surface drainage can also pick up contaminants from MX activities, particularly sediment but also petroleum and chemical contaminants, and deposit them for considerable distances downstream of the site.

7.1.2 Subsurface Drainage

Subsurface water (groundwater) is an important component of natural aquatic systems. In addition, up to 20% of the province's population depend on groundwater for their water supply, with some areas entirely dependent on groundwater.

MX activities can have several impacts on groundwater.

- Drilling that penetrates aquifers at different levels can result in cross contamination. Disused boreholes can provide a vertical conduit connecting previously separate water sources. Drill holes can also release underground water sources to the surface, causing saturation of the ground and increasing the risk of erosion or landslide.

- Exploration activities carried out near wells, such as storing or mixing chemicals, fuelling or waste dumping, can contribute to groundwater contamination.
- Underground exploration and diamond drilling can alter local water tables.

7.2 Objectives

Objectives of the "Water Management" portion of the MX Code are to:

- ensure that any drainage from exploration sites and modifications to natural drainage systems caused by exploration activities do not negatively impact water quality and quantity in nearby surface water aquatic systems;
- protect the long-term quality and quantity of groundwater and potable water supplies of adjacent property owners; and
- prevent water ponding or soil saturation that may lead to slope failures.

7.3 What's Required under Legislation

The MX Code requires the construction of drainage systems on exploration sites that controls water flows onto and off the site, and minimizes erosion or creation of saturated soils and unstable slopes. It also requires that water be prevented from flowing uncontrolled onto reclaimed areas.

An explorationist must outline a program for the protection and reclamation of land, watercourses and groundwater as part of the NoW process. These plans are reviewed in the context of the *Drinking Water Protection Act*, *Health Act, Environmental Management Act, Water Act* and *Fish Protection Act*.

In addition, Section 35 of the federal *Fisheries Act* prohibits any "harmful alteration, disruption or destruction of fish habitat" (a HADD) that is not authorized by DFO. Depositing sediment, chemical contaminants or other "deleterious substances" into streams that support fish or fish habitat is also prohibited under the *Fisheries Act,* and any party doing so is therefore liable to conviction under the Act.

Finally, section 44(3) of the *Water Act*. Regulation (Part 7) exempts MX operators from submitting a notification to the Ministry of Environment if the person:

- holds a permit under the *Mines Act;*
- complies with Part 9 of the Health, Safety and Reclamation Code, and
- complies with all conditions in the permit respecting changes in and about a stream.

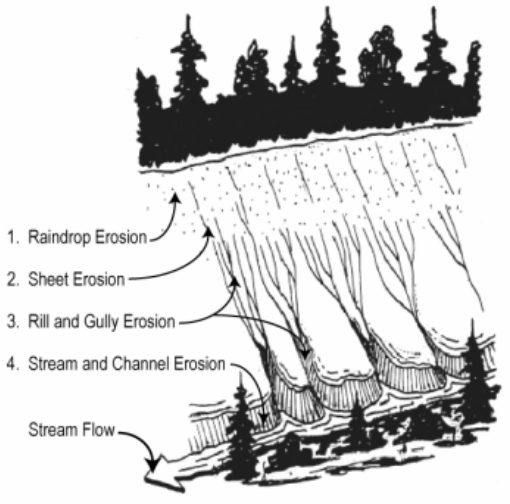
If the person wishes to undertake more complex activities or works not covered under the regulation or requires the diversion or use of water, they may require an approval or licence under the *Water Act*. The "Users Guide to Working In and Around Water" (see Section 7.5: Resources) provides further details.

7.4 Recommended Practices

Erosion is the movement of soil particles by wind, water, ice and mass movements. Water is by far the most common cause of erosion. Dealing with erosion is a major part of managing both surface and subsurface drainage in exploration activities.

There are various types of water-caused erosion, as shown in Figure 7.1. Understanding the type of erosion can help in selecting the appropriate management practices to prevent erosion altogether or control it before it gets out of hand.

Erosion control measures fall into three general categories: source control, drainage or runoff control, and sediment control. The first three subsections below address each of these in turn.



Types of Water Erosion	
Raindrop Splash Erosion	The impact of falling droplets of rain mechanically dislodges soil particles causing them to be carried away by runoff.
Sheet Erosion	Before concentrating into small channels. Raindrop splash and runoff moves as broad sheets over the land and removes layers of exposed soil.
Rill and Gully Erosion	As runoff concentrates in rivulets, it cuts grooves called rills. If the flow of water is sufficient, rills will develop into gullies.
Stream and Channel Erosion	Large volumes of fast-flowing water in unprotected channels will cause stream bank and stream bottom instability, scouring and removal of significant portions of the stream or channel banks and stream bottoms.

Figure 7.1: Types of Water Erosion (*Aggregate Operators BMP Handbook*)

7.4.1 Source Control

Source control recommended practices reduce the amount of surface runoff that is generated and reduce the exposure of soil and materials to rainfall,

running water and wind. In essence, source control measures aim to prevent erosion before it gets started (Figure 7.2). The recommended practices listed below are specifically aimed at source control.

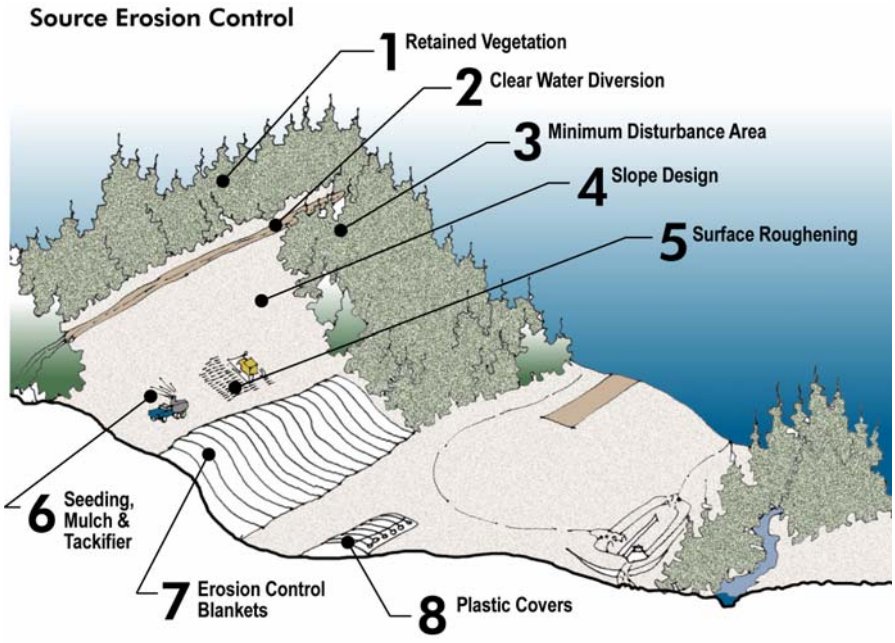


Figure 7.2: Source Control Measures to Prevent Erosion

Erosion Potential Assessment

- Potential erosion hazards should be assessed based on the types of soils and slope in the area (see Table 7.1).

Table 7.1: Guide for Assessing Soil Erosion Hazard

Soil Texture	Slope				
	0-5% (0-3⁰)	5-9% (3-5⁰)	9-30% (5-17⁰)	30-60% (17-31⁰)	>60% (31⁰)
Fine	Moderate	High	High	High	High
Fine-medium	Moderate	Moderate	High	High	High
Medium	Low	Low	Moderate	High	High
Medium-coarse	Low	Low	Moderate	Moderate	High
Coarse	Low	Low	Low	Moderate	High

Source: Ministry of Energy, Mines and Petroleum Resources, 1992

Minimization of Disturbed Areas

- The extent of the area that is cleared and disturbed during MX should be minimized to effectively and economically prevent erosion and reduce runoff.
- Grubbing, grading and blading should be avoided whenever practicable. Retain existing natural vegetation wherever practicable; it provides the best and lowest cost runoff and erosion control.
- If clearing is required, you should limit or delay grubbing (pulling out) tree roots until grading and construction is to proceed; the root masses and associated organic matter provide substantial erosion control.
- Damage to the natural soil surface can be avoided when working in the winter by clearing snow in a manner that leaves the surface of the ground undisturbed. This will help avoid excessive soil loss in the spring as the ground thaws.

Scheduling of Exploration Work

- Earth-moving activities should be conducted during dry weather with ample time for effective revegetation (see Chapter 14). Heavy construction activities in the winter can mix snow and ice with soils; this can create problems with runoff in the spring. The possibility of erosion should be considered in determining timing of exploration activities.
- Where feasible, exploration works should be scheduled so that work in one area is completed and disturbed sites restored prior to moving on to the next area. This will avoid the problems associated with many disturbed areas open to erosion at once and will reduce the amount of erosion protection work at the end of the season. Revegetation can often be completed sequentially throughout the growing season, thus further reducing the potential for erosion.

Application of Surface Covers

- Erodible exposed soil surfaces should be covered immediately with either an impervious material (plastic sheeting) or protective material (straw or jute mat, mulches, erosion resistant gravel) to prevent rain-splash erosion. Note that mats and blankets are rarely effective in dealing with rill or gully erosion that has already started.
- Disturbed areas expected to be left dormant for more than 45 days should be seeded. A qualified person can provide advice on appropriate seed mixes and application timing.[3]
- Mulches and tackifiers applied to steeply sloping sites will help to stabilize soils until germination occurs.

[3] Persons qualified to provide seeding advice include professional agrologists, reclamation specialists and, in some cases, seed suppliers.

Creation of Rough Surfaces

- Creating a rough uneven surface will help control sheet erosion by slowing runoff and encouraging infiltration. This can be done by running a bulldozer with large cleats up and down the slope to create horizontal grooves.
- Strippings, woody debris and other obstructions to overland flow can be added to a slope surface to help prevent sheet and rill erosion.

7.4.2 Runoff Control

Once surface runoff has started, drainage and runoff controls aim to reduce the erosive energy of surface runoff and/or convey drainage using non-erodible surfaces (Figure 7.3).

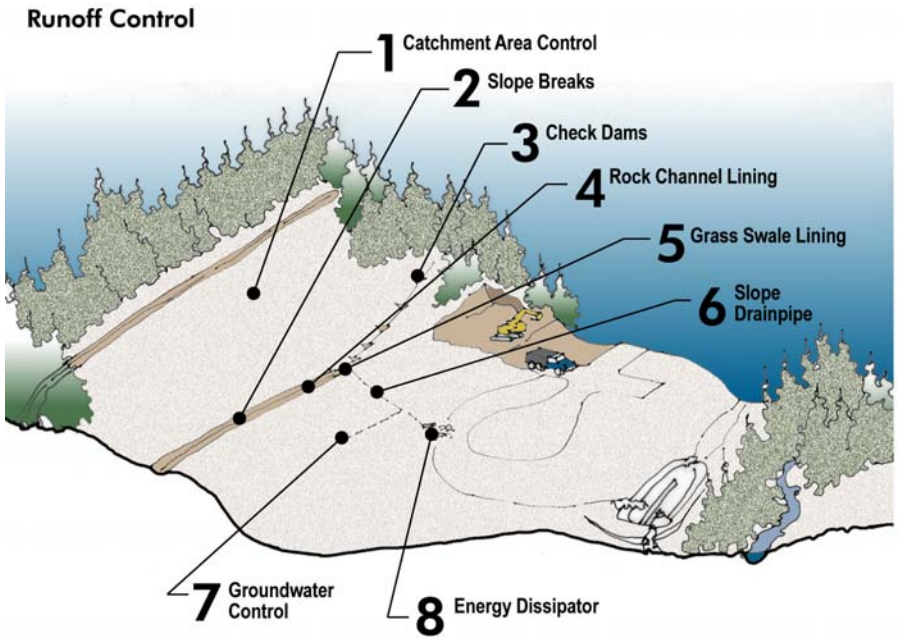


Figure 7.3: Surface Runoff Control

Drainage Design

- Design of drainage systems on a site-specific basis is recommended to ensure they are capable of carrying the maximum expected runoff, while maintaining natural drainage patterns as closely as practicable.
- The project area should be divided into catchment areas and consideration given to determining how runoff from each catchment area will be collected and conveyed. The nature of the site and the need for drainage should suggest particular drainage structures or techniques (e.g., collection of runoff by creating a slope break and diversion swale or installing a slope drainpipe).

- Expected flows should be calculated for each water conveyance, and used to determine its size and level of erosion protection accordingly. Size and lining of swales or the need for pipes will increase with soil erodibility and steepness of slope.

Clean Water Diversion

- Diversion swales should be installed above graded areas to direct clean water draining from undisturbed areas away from the disturbed area. In erodible soils, diversion swales should have gentle grades (1% or less) or be lined with grass or rock.
- Separate ditch/dyke systems are useful in channelling dirty water from the site to sediment-control structures.

Management of Groundwater Seepage

- Areas of sand or silt soils with groundwater seepage are highly susceptible to erosion and shallow sloughing. Install perforated drains to intercept the groundwater before it surfaces.
- A surface drainage blanket or riprap can stabilize a slope subject to seepage. Seek engineering advice for proper design.

Groundwater Control

- Drill holes may release artesian waters to the surface, which in turn can cause ground saturation and subsequent slope failure. Ensure drill holes are adequately sealed wherever the release of artesian water creates a risk.
- Groundwater "piping" occurs when groundwater exits the ground, carrying soil particles with it. Where road or trench cuts intersect aquifers, piping may become a major problem. Treatments of piping problems involve allowing the water to exit the soil without taking the soil with it. Well-graded granular filter blankets can be used.

Failure of erosion-control matting.

Slope Design

- Creating slopes greater than a 2:1 grade in erodible soils (very fine sands and silts) should be avoided, as should slope lengths greater than 30 m between slope breaks.
- The effective length of slopes can be reduced by creating slope breaks (i.e., terraces with diversion swales or dykes that collect sheet runoff from a catchment area and direct it to a slope drainpipe or other drop structure).

Management of Drainage Channels

- Swales with grades up to 5% in stable soils may be grass lined. Establish the lining prior to exposing the swale to high flows. Install erosion-control or turf-reinforcement blankets to increase swale stability in higher risk situations (e.g., velocities greater than 0.6m/sec).
- For steeper swales (>5% in stable soils), place check dams to slow velocity and reduce channel erosion. The best check dams are drain rock with a finer material core and coarse drain rock surface. The base elevation of a check dam should be the same level as the top of the check dam below.
- For low-energy flows, consider straw-bale/silt-fence structures as temporary measures; these decay over time and will not function well as check dams in high-energy channels. Straw bales and silt fences require regular maintenance including the removal of trapped sediment, repair and replacement.
- Protection for channels that handle runoff velocities greater than 2 m per second should incorporate geotextile and rock linings. Determine the mix of sizes of rock pieces based on the volume and design velocity of the channel. The toe of rock riprap at channel ends should be trenched (keyed) in.
- Energy dissipaters (precast concrete or riprap/rock aprons) should be installed at the outfall of pipes or high-velocity channels to reduce runoff velocities.

7.4.3 Sediment Control

Sediment control measures slow down and pond runoff to reduce water velocities and allow sediment to settle - they do **not** filter sediment. Runoff must be ponded for several hours to settle out sand, days to settle out silts, and weeks to settle out fines. Sediment control is an expensive last resort—not a replacement for source control.

Sediment Barriers

Silt fence is the most common sediment barrier, but alternatives include straw bales (Figure 7.4) or continuous berms of gravel or earth.

- Sediment barriers should be installed correctly; otherwise, more sediment may be generated than collected. The key to proper installation is to ensure that water can't flow around or under the bales or fences.
- Barriers should be trenched (keyed) in at the base and staked to support the weight of water. Clean out collected sediment often. Sediment barriers should not be used in concentrated flow conditions (i.e., channels).
- Sediment barriers may be installed to create ponded water—on flatter ground below exposed slopes, along the contour with ends curved uphill to contain water. Slopes draining down to sediment barriers should be less than 30 m long.

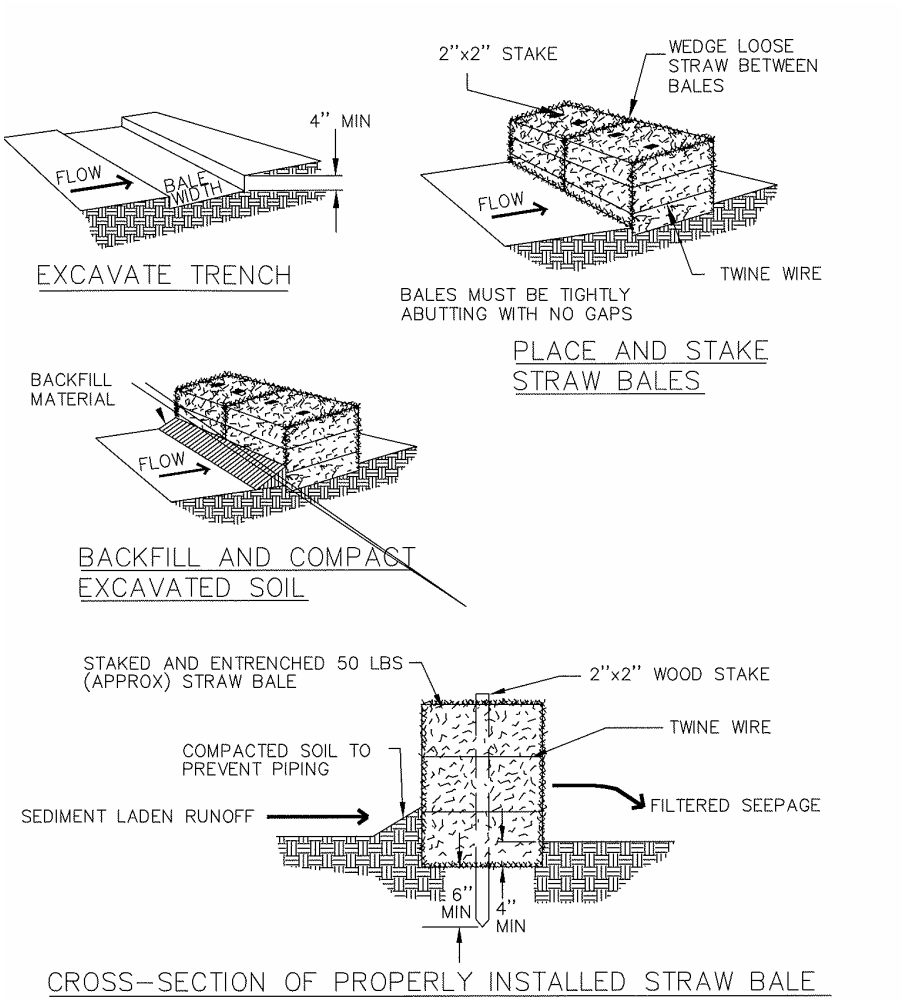


Figure 7.4: Straw Bale Installation
(http://www.ci.boulder.co.us/buildingservices/dcs/pdf_files/725.pdf)

Sediment Traps

Sediment traps are small settling ponds used for drainage areas less than 2 ha. They are typically installed in phases as clearing and construction progresses.

- Sediment traps should be constructed by excavating in stable soils, and/or by building compacted dykes. Pond outfalls and banks should be armoured with riprap or a suitable geotextile if erosion is possible. Trap sizing should use engineering calculations that estimate volume according to runoff estimates and settling time required. Baffles are helpful in preventing inflow water from flowing directly to the trap outlet.

Roadside Swales or Silt Fences

- Consider ways to control silt-laden runoff before it leaves the working area. Where grade allows, install a temporary roadside swale uphill of paved roadways to pond site runoff and allow sediment to settle.
- On sloping sites, use silt-fence sediment barriers or continuous roadside berms to pond runoff.

7.4.4 Maintenance Practices

Regular maintenance and inspection is key to ensuring drainage systems function as designed.

- Inspections of all runoff control and sediment interception devices should be completed after each storm event and any problems or failures addressed promptly. Accumulated sediment should be removed regularly to maintain capacity.
- Regular worker education programs will help prevent accidental discharges of polluting materials to both surface water and groundwater.
- By simply moving materials indoors or raising them off the ground and covering them to prevent contact with rain and surface drainage, the potential to generate polluted runoff can be reduced.

Checklist: Water Management

The MX Code requires the management of surface and subsurface water in areas impacted by mineral exploration activities.

- ❑ Have you taken steps to ensure that surface watercourses and groundwater are not impacted by your site drainage through:
  - ❑ Implementing **source controls** for water-caused erosion by:
    - ❑ Assessing the erosion potential of your site;
    - ❑ Minimizing the clearing, grubbing and removal of natural vegetation;
    - ❑ Limiting the disturbance of natural soil surfaces;
    - ❑ Scheduling earth-moving activities for dry weather;
    - ❑ Using progressive site restoration to stabilize and recover disturbed areas before moving on the next area;
    - ❑ Applying surface covering materials like sheeting, mats, mulches and seed; and
    - ❑ Creating rough slope surfaces?
  - ❑ Incorporating **runoff controls** by:
    - ❑ Designing drainage systems to fit site conditions, handle flow volumes and match natural drainage patterns/catchment areas;
    - ❑ Diverting clean water around disturbed areas;
    - ❑ Collecting sediment-laden water and directing it to sediment-control structures;
    - ❑ Managing groundwater seepage with interception drains and surface stabilization;
    - ❑ Sealing drill holes in areas of potential artesian flow;
    - ❑ Managing groundwater "piping" from slope cuts;
    - ❑ Reducing slope grades and lengths, using slope breaks, terraces and diversion channels on longer slopes; and
    - ❑ Using grass-lined swales, check dams, energy dissipation structures and geotextiles to protect drainage channels?
  - ❑ Applying **sediment controls** by:
    - ❑ Using properly installed sediment barriers;
    - ❑ Constructing adequately sized sediment traps to allow the settling of particles; and
    - ❑ Constructing roadside swales upslope of roads to pond or capture surface runoff and allow sediment to settle?
  - ❑ **Maintaining** control structures and treatments by:
    - ❑ Cleaning them regularly;
    - ❑ Inspecting all structures and devices after each storm event; and
    - ❑ Repairing any problems or failures quickly?

7.5 Resources

B.C. Ministry of Energy and Mines. 2002. *Aggregate Operators Best Management Practices Handbook for British Columbia.* http://www.em.gov.bc.ca/Mining/MiningStats/55AOBMPHand_pdf.htm

B.C. Ministry of Energy, Mines and Petroleum Resources. 1992. *Guidelines for MX: Environmental, Reclamation and Approval Requirements.* 57 pp.

B.C. Ministry of Environment. *Groundwater Resources of British Columbia*, http://www.env.gov.bc.ca/wat/gws/index.html

Land and Water British Columbia Inc. 2005. *A Users Guide to Working In and Around Water – Regulation under B.C.'s* Water Act. http://www.lwbc.bc.ca/03water/licencing/docs/working_around_water.pdf

8 Metal Leaching and Acid Rock Drainage

8.1 Background

Acid Rock Drainage in MX

Several sections of this document address aspects of mineral and coal exploration (e.g., exploration access; drilling; pits, trenches and excavations; reclamation) where ARD may need to be considered.

Potential ARD?

In each of these sections, a reference has been made to this portion of the document through the placement of the "Potential ARD?" box shown above.

Metal leaching (ML) and acid generation are naturally occurring processes that may have negative impacts on the receiving environment if they occur in the absence of adequate neutralization, dilution and/or attenuation. Acid generation occurs when sulphide minerals and elemental sulphur are exposed to the weathering effects of oxygen and water. The oxidation of sulphur and the precipitation of ferric iron generate acidity. Acid Rock Drainage (ARD) results when this acidity is entrained by water.

Although ARD has received most of the attention, the primary source of toxicity is metals. For many rock types, metal leaching will only be significant if drainage pH drops below 5.5 or 6. However, neutral pH drainage does not necessarily prevent metal leaching from occurring in sufficient quantities to cause negative impacts. While the solubility of aluminum, iron and copper is greatly reduced in neutral pH drainage, elements such as antimony, arsenic, cadmium, molybdenum, selenium, and zinc remain relatively soluble and can occur in significantly high concentrations. Neutral pH metal leaching is generally only a concern if discharge is into a sensitive resource or with little dilution. High concentrations of metals in neutral pH drainage often result from localized, relatively small zones of acidic weathering.

8.2 Objectives

One of the overarching goals of the MX Code is to ensure the protection of land and water resources during exploration activities. Mineral explorationists should:

- ensure that suitable, effective ML/ARD prevention practices are employed while undertaking exploration activities such as blasting for access construction, excavating trenches, and underground adit development;
- consider the sensitivity of the area surrounding your exploration works;
- develop site-appropriate mitigation measures if acid generating potential is identified; and
- assess drill core and surface rock exposures early in exploration activities and project planning to identify any potential for ML/ARD that would require prevention and management strategies during advanced exploration or as a mine develops.

8.3 What's Required under Legislation

The Ministry of Energy, Mines and Petroleum Resources and the Ministry of Environment have jointly developed policies and guidelines regarding the management of ARD. Sections of the *Mines Act* and the HSR Code ensure the protection of land and watercourses, including the requirement for permitting which entails, in part, ML/ARD prediction and prevention planning. The *Environmental Management Act* applies waste management requirements and water quality criteria, and the *Water Act* regulates the use, storage and diversion of water.

8.4 Recommended Practices

The Ministry of Energy, Mines and Petroleum Resources' website hosts two policy and guideline documents regarding ML/ARD at mine sites in British Columbia (see 8.4 Resources). While much of the information contained in these documents is oriented to larger scale mining activities, a number of the recommended practices should also be helpful to the exploration sector at the advanced exploration stage.

It is recommended that the following guidelines be followed whenever exploration activities require excavating or exposing significant bedrock or unconsolidated earth, or include developing underground adits.

8.4.1 ML/ARD Program

- For broad exploratory works, explorationists should design a ML/ARD program for their exploration activities that contains prediction, prevention, mitigation and monitoring strategies.
- A prediction program should:
    1) Identify and describe the geological materials to be excavated, drilled, exposed or otherwise disturbed by exploration activities, and
    2) Provide an assessment to an appropriate level which determines the ML/ARD potential for each geological material in the forms (i.e. particle size) and environmental conditions in which it will be exposed.
- Following the prediction program, explorationists should develop a mitigation and monitoring program based on the predicted ML/ARD potential.
- As a primary measure, the material of concern should be avoided where practicable and not used as material for site preparation or access construction.
- Where there exists a high degree of uncertainty about ML/ARD potential or environmental risk, mineral explorationists should develop contingency plans.

8.4.2 Advanced Exploration Projects

For more advanced exploration projects, explorationists may also need to consider the following:

ML/ARD – What to Watch for in the Field

- **Sulphide bearing rocks** (pyrite and pyrrhotite are the major acid forming minerals).
- **Gossanous weathering, hydrothermal alteration** (a bleached and/or silicified appearance), **or extremely fractured rock**.
- **pH below 6**.
- **Precipitates** - white, yellow, and iron precipitates (sludge) usually indicate a change in water quality due to changing pH or Eh.
- **Stressed vegetation** or vegetative kill zones.
- **Growth of green filamentous bacteria/algae** - often found in acidic environments and may be responding to leached phosphorous.
- **Changing hydrological conditions** – changes in climate, water use, and natural ecological recovery can change the water balance, affect nutrient inputs, and alter the oxidative vs. reductive environment. These changes may remobilize contaminants.

(From the Ministry of Energy, Mines and Petroleum Resources' *Quick Facts About ML/ARD*)

General Testing Requirements

- ML/ARD testing and analysis can be costly and time consuming, it is important that the correct information is collected to resolve pertinent ML/ARD issues. A licenced professional with expertise in ML/ARD should be consulted for assistance with the design of assessment programs and mitigation strategies.
- Basic static testing requirements include acid base accounting (ABA) and metals by ICP scan. ABA typically includes sulphur speciation, bulk Sobek NP, carbonate NP (based on total inorganic carbon) and paste pH.
- Weathered materials should also have rinse pH and shake flask testing.
- Several kinetic test procedures are available; these include columns, humidity cells, and on-site kinetic tests such as field test pads and wall-washing stations.
- Water quality analyses should include pH, sulphate, conductivity, hardness, alkalinity/acidity, major cations and low level total and dissolved metals (including Hg and Se). Metal detection limits should be low enough for comparison to provincial water quality guidelines for appropriate downstream use (i.e., fresh water aquatic life, marine aquatic life, irrigation, drinking water uses).

Mitigation Strategies

- As it often takes decades for neutralization to be exhausted and ML/ARD to develop, explorationists should be aware that many sites with ML/ARD (or the potential for significant ML/ARD) need to be designed, managed and operated in a manner that allows them to perform indefinitely. ML/ARD mitigation strategies to consider include avoidance, underwater storage, blending, covers and chemical treatment; each strategy has benefits and drawbacks.

Checklist: Metal Leachate & Acid Rock Drainage

- ❑ Will your exploration program be disturbing significant quantities (over 1000 tonnes) of overburden, waste rock or mineralized ore?
- ❑ Is your program located near sensitive resources?
- ❑ Do you anticipate the disturbance or exposure of rock types that may have the potential for ML/ARD?
- ❑ Do you have any laboratory data to predict metal leaching and acid rock drainage?
- ❑ If laboratory data indicates suggests a metal leaching or acid rock drainage concern:
  - ❑ Can you avoid this material (e.g., by re-routing accesses if the material is exposed in a rock cut)?
  - ❑ Do you have a plan in place to ensure the material will not be used for access construction or site preparation?
  - ❑ Do you have a plan to reclaim the site and ensure the prevention of any long-term ARD/ML issues?

8.5 Resources

Price, William A. and John C. Errington. 1998. *Ministry of Energy and Mines Guidelines For Metal Leaching and Acid Rock Drainage at Minesites in British Columbia.* http://www.em.gov.bc.ca/Mining/MinePer/ardguide.htm

B.C. Ministry of Energy and Mines and B.C. Ministry of Environment, Lands and Parks. 1998. *Policy for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia.* http://www.em.gov.bc.ca/Mining/MinePer/ardpolicy.htm

9 Fuels and Lubricants

9.1 Background

Fuel and lubricants should be stored and used in a manner that reduces risk to human safety and protects the environment from accidental release. This applies to both surface and subsurface contamination potential.

Requirements and guidelines for handling, transportation and storage of fuels and lubricants, including statutory requirements and recommended practices, are described in detail in *A Field Guide to Fuel Handling, Transportation and Storage* published by the Ministry of Environment (see Section 9.5: Resources).

Additional Resources

The Ministry of Environment document, *A Field Guide to Fuel Handling, Transportation and Storage*. 3rd ed. February 2002. contains useful information and can be found at the following website:

http://www.env.gov.bc.ca/epd/epdpa/industrial_waste/petrochemical/pdfs/fuel_handle_guide.pdf

9.2 Objectives

The "Fuels and Lubricants" section of the MX Code directs mineral explorationists to:

- ensure that suitable, effective pollution prevention practices are employed while transporting, handling and storing fuel and lubricating products;
- prevent risk of fire and explosion; and
- ensure that practices involving fuel and lubricants do not damage any natural resources.

9.3 What's Required under Legislation

The handling, storage and transportation of fuels are governed by a variety of statutes, industry standards and codes of practice. In addition to the HSR and MX Codes, those that may affect MX are listed in Table 9.1.

The MX Code sets requirements regarding the storage of fuels. It particularly requires that machinery not be fuelled or serviced within the riparian setbacks specified in the Code (see Chapter 4, Table 4.2) other than pumps and machinery that are hand held, required for firefighting, broken down or require fuel or service to be moved, or are authorized by the chief inspector to be fuelled or serviced in those areas.

Table 9.1 Statutes, Standards and Codes of Practice Affecting Fuel Use

Statutes, Standards and Codes
BC Fire Code 1998; Office of Fire Commissioner Interpretation Bulletins
Fire Services Act
Fisheries Act
Motor Vehicle Act
***Transportation of Dangerous Goods Act* and Regulation**
ULC/CSA Standards
Water Act
Environmental Management Act - **Petroleum Storage & Distribution Facilities Stormwater Regulation** - **Special Waste Regulation** - **Spill Reporting Regulation**
Workplace Hazardous Materials Information System (WHMIS)

Source: adapted from *Field Guide to Fuel Handling, Transportation & Storage*, Ministry of Environment.

Note: These refer to legislation and standards in effect at the time of publication; readers should reference current versions for the most recent requirements.

9.4 Recommended Practices

The *Field Guide to Fuel Handling, Transportation and Storage* is the most up-to-date reference for acceptable industry practice in managing fuel use in rural and remote areas of British Columbia. The following recommended practices summarize some of the key elements from that guide that are relevant to MX. The reader is referred to the guide for greater detail.

Camp generator and fuel. Note several items for improvement: the horizontal fuel drum, small drip tray, and lack of blanket material to absorb any fuel leaks

Additional information on managing petroleum products can be obtained from the Canadian Council of Ministers of the Environment publication – *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products*. The document can be purchased through: http://www.ccohs.ca/legislation/

9.4.1 Storage

- For containers greater than 230-L capacity used to store flammable or combustible liquids (gasoline, diesel fuel, etc.), use only those that meet appropriate design specifications under the Fire Code.
- Containers should be maintained in good condition and not used if they are damaged, rusting or leaking.
- Containers should be adequately sealed with proper fitting lids, caps, bungs or valves to prevent spills and leaks.
- Containers should be marked at a safe maximum fill level corresponding to about 90% capacity.
- Label all fuel containers in accordance with WHMIS and the Fire Code.

- Store fuels and lubricants at a distance greater than 30 m from a stream, lake or wetland. Any storage at a closer distance must be approved by an inspector.
- Signs should be posted prohibiting smoking in areas near fuel caches or where storage and dispensing is carried out.
- Provide one 20-B:C rated or two 10-B:C rated fire extinguishers where containers are stored within a building or structure.
- Storage sites or facilities should be kept clean and well organized.
- Containers, empty or full, used for hydrocarbon storage should be removed from all locations, both remote and central, at the end of a field season and returned for refilling or recycling. Authorization by an inspector is required to keep containers on-site from one season to the next.
- Check that the depot receiving returned hydrocarbon containers removes the project or company name before reissuing the drums to others.

Spill containment pallet.

9.4.2 Refuelling (Dispensing)

- Maintenance and operating procedures should be established to prevent spills. Ensure that dispensing procedures are clearly outlined and posted where all operators can see them.
- Containers should not be filled beyond their safe filling level (see above).
- The use of an electric or manual fuel pump is recommended when dispensing from a drum. Always store and secure the fuel hose above the drum to prevent siphoning. Follow proper grounding procedures.
- Gravity-aided dispensing from horizontal drums poses an increased risk of accidental spills, and so vertical drums should be used where practicable. If horizontal drums are to be used, containment measures should address the increased risk of spillage.
- Refuelling or servicing ground-based machinery should be avoided within the riparian setback distances specified in Table 4.2, except pumps and machinery that are hand held, required for fire fighting, broken down or require fuel or service to be moved, or are authorized by the chief inspector to be fuelled or serviced in riparian areas.

9.4.3 Spill Protection (Containment)

- Locate storage and refuelling sites to preventing any spills from entering watercourses.
- Good site water management will help prevent spills from entering waterways. Grading the storage/refuelling site away from waterways and digging a separate trench to a holding area will help to divert spills away from waterways, stormwater drains and ditches.

- Secondary containment should be provided for large containers (larger than 454 litres). These include:
  - double-walled containers (tank within a tank design);
  - steel or concrete container that can contain 110% of the storage volume (tank within a box design);
  - an earth or clay dyke line with impermeable material capable of containing 110% of the storage volume; or
  - a site sloped to divert spills into a collection system that will not impact human safety or the environment. The containment should be lined with an impervious geomembrane to prevent contaminating the subsurface soil layer.

9.4.4 Emergency Response in Case of a Spill

Provincial Emergency Program

1-800-663-3456

- Immediately report any flammable liquids (i.e., *Transportation of Dangerous Goods Act* Class 3 materials) spill of 100L or more. Call the Provincial Emergency Program at 1-800-663-3456 with full and complete details of the spill.
- A spill-response plan should be established and at least one kit capable of containing and absorbing fuel spills should be available on site. See Section 9.3 of the *Field Guide to Fuel Handling, Transportation and Storage* for a listing of spill-response equipment for fuel storage and cache sites, pickup trucks and tank vehicles.
- Initial spill-response procedures should be posted at fuel storage and dispensing sites and with all transport trucks. See Section 9 of the *Field Guide to Fuel Handling, Transportation and Storage* for details on appropriate procedures for spill assessment and response.
- All spills should be recovered, and all contaminated soil should be removed and treated. In-situ treatment should only be considered under the advice of an appropriately qualified specialist in environmental remediation.

Helicopter transport.

9.4.5 Training

- Appropriate training should be provided to all individuals involved in the handling, transportation and storage of fuels and lubricants.

9.4.6 Helicopter Transport

- Ensure human safety and the protection of the environment by applying the following additional safety practices for transporting fuel by helicopter sling:
  - Secure all fill caps, plugs and drains against leakage.
  - Baffle all containers with a capacity greater than 500 L
  - Use a swivel on the longline. Make sure the rigging is in good condition and that the load is rigged correctly.

- Put barrels in a net whenever practicable.
- Make sure the pilot has a designated place to land the fuel. Secondary containment at the landing site is strongly advised.
- Maintain appropriate radio communication with the pilot.
- Ensure that ground personnel receive the load in a safe manner, avoiding positioning themselves below the load at all times.
- Remember that the pilot will always work into the wind.
- Use caution before reaching up and touching the load. In certain weather conditions, static electricity can be very dangerous. If bad static conditions exist, have the pilot ground the load first, then pick it back up to do the final positioning.
- Use caution when removing fuel caps. Wear eye and hand protection.

Checklist: Fuels and Lubricants

The MX Code requires that steps be taken to reduce the risk of accidental releases of fuels and lubricants to areas of mineral exploration activity.

- ❑ Have you taken steps to reduce risks to human and environmental safety risk by:
  - ❑ Storing fuels and lubricants
    - ❑ No closer than 30 m to a stream, lake and wetland, unless approved by an inspector;
    - ❑ According to legislated storage requirements; and
    - ❑ In safe, well-sealed and labelled containers in a clean storage site?
  - ❑ Removing all containers at the end of the field season unless otherwise authorized by an inspector?
  - ❑ Refueling and dispensing fluids
    - ❑ In accordance with posted safe operating procedures;
    - ❑ In a manner that avoids accidental spills; and
    - ❑ In a clean and tidy dispensing facility?
  - ❑ Protecting against spills by
    - ❑ Selecting storage and refueling sites away from watercourses;
    - ❑ Using spill containment structures in site drainage systems; and
    - ❑ Providing secondary containment for containers larger than 454 L?
  - ❑ Establishing an emergency spill response plan that provides for
    - ❑ A spill-response kit on-site;
    - ❑ Initial spill-response procedures posted at fuel storage and transport facilities;
    - ❑ Removal and treatment of any material contaminated in a spill; and
    - ❑ Training those who handle, transport and store fuels and lubricants?
  - ❑ Applying special safety practices for the helicopter transport of fuel?

9.5 Resources

B.C. Ministry of Water, Land and Air Protection. 2002. *A Field Guide to Fuel Handling, Transportation and Storage*. 3rd ed. February 2002. http://www.env.gov.bc.ca/epd/epdpa/industrial_waste/petrochemical/pdfs/fuel_handle_guide.pdf

Cominco American. 2000. *Exploration Drilling Best Management Practices*. 16 pp.

10 Exploration Access

10.1 Background

A typical access trail. Note that debris is not pushed into standing trees and is easily pulled back onto the road surface during reclamation.

MX occurs over a very large area using a province-wide network of roads and trails built to facilitate resource development, forest management and fire suppression. Construction of new road access is generally not required at the initial stages of exploration. However, short extensions from existing roads may be desirable for reasons of safety and practicality.

Later phases of exploration may involve subsurface testing of target areas using mechanical equipment such as drill rigs and backhoes. In order to drill or trench, an explorationist must have the ability to move such equipment to and around the target area in a safe manner. In many cases, this is done by air, particularly when the test program is small and the site is remote or in mountainous terrain. In other cases, ground access is preferred, particularly where the target area is near existing roads or trails.

10.2 Objectives

The objectives of the "Exploration Access" portion of the MX Code are to:

- provide for exploration access while ensuring minimal individual or cumulative impacts to other natural resource values;
- protect community and domestic water supplies;
- minimize impacts on wildlife and wildlife habitat;
- protect fish, fish passage and fish habitat upstream and downstream of road crossings on fish-bearing watercourses;
- avoid adverse impacts to downstream fish and fish habitat from road crossings on non-fish-bearing watercourses;
- minimize the falling of timber; and
- minimize visual impacts.

10.3 What's Required under Legislation

The MX Code sets out a variety of requirements with respect to the construction, maintenance and subsequent deactivation and reclamation of exploration accesses. These requirements focus on protecting stream habitat and avoiding impacts on surface and subsurface drainage, with a particular emphasis on reducing impacts and ensuring the safety of stream crossings.

As noted earlier, the ultimate authority for protecting fish habitat is the federal *Fisheries Act*, and particularly Section 35, which prohibits any "harmful alteration, disruption or destruction of fish habitat" (a HADD) that is not authorized by DFO. Along with any physical disruption of the stream itself, depositing sediment or other "deleterious substances" into streams that support fish or fish habitat or that flow into fish-supporting streams is

prohibited by the *Fisheries Act*. Therefore mineral explorationists may be liable to conviction under the *Fisheries Act* if a HADD occurs without specific authorization or if a deleterious substance is discharged to a watercourse. This is important to keep in mind when selecting ground-based access methods and constructing, operating and deactivating access roads and trails.

The provincial *Water Act* governs works in and around watercourses (e.g., road crossings). Section 44(3) of the *Water Act* Regulation (Part 7) exempts MX operators from submitting a notification to the Ministry of Environment if the person:

- holds a permit under the *Mines Act;*
- complies with Part 9 of the Health, Safety and Reclamation Code, and
- complies with all conditions in the permit respecting changes in and about a stream.

If the person wishes to undertake more complex activities or works not covered under the regulation or requires the diversion or use of water, they may require an approval or licence under the *Water Act*. The "Users Guide to Working In and Around Water" (see Section 10.5: Resources) provides further details

This picture shows some common road problems:
- **Poorly drained fine soils**
- **No drainage provision**
- **Trees pushed into standing timber**

10.4 Recommended Practices

10.4.1 Access Planning, Location and Design

The Notice of Work permitting process recognizes three types of exploration accesses: exploration trails, excavated trails and temporary access roads (Table 10.1). Depending on the type of access being proposed, an applicant will need to provide information about routing, stream crossing locations, the design of bridges, culverts and drainage systems, and inspection and maintenance. This section describes recommended practices for access planning, location and design.

- Access design should plan to create the minimum permanent road length practicable through the use of existing main access roads and secondary tote roads. Existing trails and roads should be used whenever practicable.
- Planning and construction should aim to create the narrowest access practicable, consistent with safety and traffic needs. This will avoid unnecessary disturbance, as well as costs in design, approvals, construction, and reclamation.
- The local Land and Resource Management Plan (LRMP), the mine inspector, and local Ministry of Forests and Range staff should be consulted to identify coordinated access plans or other access management planning processes that the access location and design may benefit from or be subject to.

Access Routes and Riparian Setbacks

Where no other viable options exist or where such options pose a high risk to other resources, accesses may be routed within riparian setbacks. In those cases, reduce the amount of disturbance to the riparian area by minimizing the width of right of way and trail or roadbed.

Construction and modification within a riparian setback must be approved by the inspector as part of the permit.

- Ground truthing and reconnaissance level surveys are recommended to validate the route and access design.
- Stream crossings should be minimized when planning accesses, drill sites and other exploration activities.
- Routing accesses within a riparian setback (see Chapter 4, Table 4.2) should be avoided wherever practicable and safe; preferably, they should be routed outside the setback and enter the setback area only to cross it.
- Other types of sensitive areas, such as wildlife winter ranges (southwest-facing grassy or shrubby slopes), salt licks, highly erodible areas (fine-textured soils on slopes—see Table 7.1 in Chapter 7), wetlands, alpine areas, community watersheds, designated wildlife management areas and recreation areas, and areas directly visible from recreation areas, should be avoided where practicable.

Table 10.1: Types of Exploration Access

	Exploration Trail	Excavated Trail	Temporary Access Road
Purpose	Minimal-impact access for movement of mechanical equipment, typically small drilling rigs, which do not require a wide route clearance. Includes corduroy trails.	More substantial access route designed for movement of equipment typically used in advanced exploration, but excludes use of trucks for hauling mined material. Does not provide for a running surface for regular haulage.	Provides for access to and on mineral and coal tenures by mechanized equipment, including haulage trucks; designed and built to higher standards than those required for an excavated trail.
Width (into mineral soil)	1.5 m excavated mineral soil	Up to 3.5 m excavated mineral soil; may be wider if cut and fill is used or only a shallow cut is required.	Professional design
Depth of cut	less than 30 cm into mineral soil	Greater than 30 cm into mineral soil	Professional design
Drainage	No ditching needed; water bars and outsloping surfaces adequate to handle expected flows.	Drainage ditches required to control movement of water.	Ditches, bridges and culverts must be designed to handle expected water flows.
NoW requirements	Locations of stream crossings and topographic features that influence the selection of a route must be noted on Schedule A map.	Show route on Schedule A map; information on impacts on timber, streams, wetlands and lakes, fish, wildlife and their habitats and their mitigation.	Survey, layout, design criteria, drainage, impacts on other resource values, management of sediment and unstable materials from road construction, terrain stability.
Terrain stability		Not permitted in areas with terrain stability Class 5, or in community watersheds classified as Class 4 or 5, unless a qualified person determines that area is not Class 4 or 5, or that trail or road would not cause terrain to become unstable.	
Maintenance		Must be maintained while in use.	Inspection schedule and remedies for road or drainage failures required. May be used for several field seasons.
Reclamation	Removal of bridges and stream culverts, restoration of channel and bank stability, and revegetation of exposed mineral soil required.	Same as those for Exploration Trail but must account for terrain stability and water quality.	Permanent reclamation required when road is no longer required or has not been used for more than 3 years.
Tenure off claims/leases	Application or Exemption for Special Use Permit under the *Forest and Range Act.*	Application or Exemption for Special Use Permit under the *Forest and Range Act.*	Application for Special Use Permit under the *Forest and Range Act.*

- Accesses should be fit to the topography, making use of natural benches, ridge tops and flatter slopes to avoid extensive cuts and fills. This will help to reduce construction costs, as well as minimize the potential for unstable embankments.
- Access construction in sensitive terrain areas (i.e., alpine areas and tundra) should be avoided where practicable. The use of tracked vehicles may allow the avoidance of road construction, but access alignments should be clearly flagged. This will not only help to confine travel to the selected routes, but will improve travel safety during poor visibility conditions.
- Grades should be kept as low as practicable, to a maximum of 8% to 10%, although short pitches up to 15% are acceptable when necessary. See Table 10.2 for general guidelines.

Table 10.2: Approximations - Re-grading Grades

Situation	Percent	Degrees	Horizontal: Vertical
Maximum for main haulage	8	5	11:1
Short pitches	10	6	10:1
2-wheel drive maximum	15	9	6:1
Maximum soil slope for re-vegetation	50	26	2:1
Angle of repose earth fill	67	34	1.5:1
Angle of repose loose angular rock	80	39	1.25:1

Source: Ministry of Energy, Mines and Petroleum Resources 1992

10.4.2 Drainage

Drainage design is a key element of access layout. Initial time spent in identifying drainage requirements of each segment of access trail or road and in ensuring the use of appropriate equipment and installation methods will be fully rewarded by savings during construction and maintenance.

- Drainage systems should be designed on a site-specific basis, to ensure that they are capable of carrying the maximum expected runoff while maintaining natural drainage patterns as closely as practicable.
- Particular care should be taken in areas of rapid runoff, such as steep slopes, shallow soils, impervious fine-textured soils, non-forested areas and south and west facing slopes where snowmelt is rapid.

Temporary Exploration and Excavated Trails

A system of dips and water bars may be sufficient for drainage and erosion control (Figure 10.1).

- Water bars should be placed sufficiently close together so that the surface runoff can be easily dispersed. Appropriate spacing of water bars on slopes in different soil types is indicated in Table 10.3.

- Water bars should be skewed or slanted to drain water downhill across the road.

- Water bars should be installed at the end of each field season along the

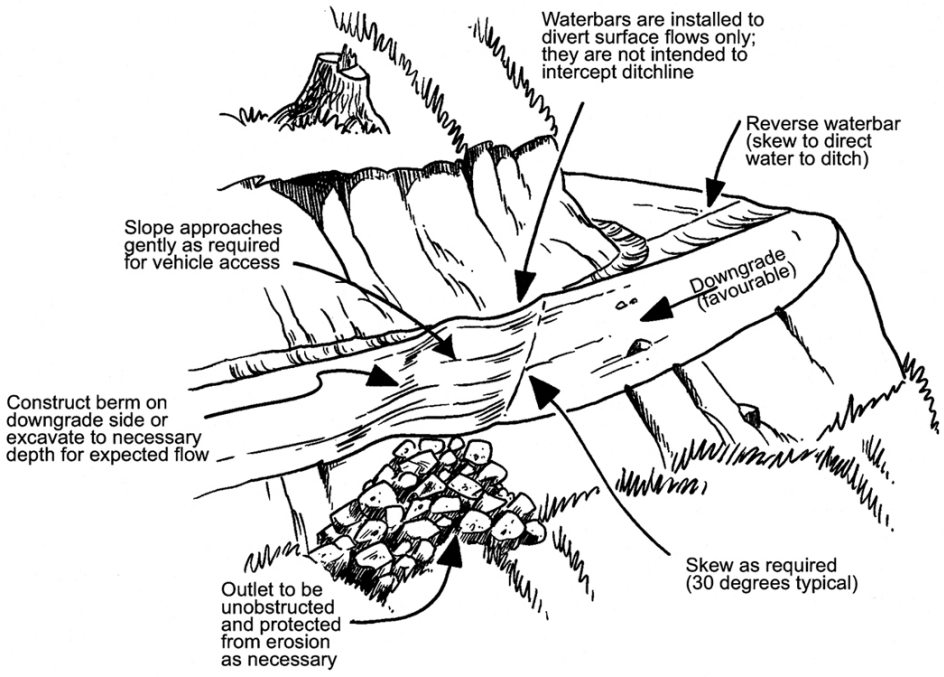


Figure 10.1: Water Bar Installation (from BC MOF, 2002)

entire trail or road network as a protective measure in anticipation of winter and spring runoff.

Table 10.3: Spacing of Water Bars

Slope Gradient	Erodible Soils (silts and clays)	Normal Soils (loams)	Rocky Soils (sand and gravel)
Under 5% (3º)	45 m	60 m	Nil
5-10% (3-6º)	35 m	45 m	60 m
Over 10% (6º)	15 m	30 m	45 m

Source: Ministry of Energy, Mines and Petroleum Resources, 1992: 21

Temporary Access Roads

Ditches and/or culverts are needed for frequently used temporary access roads or roads in highly erodible soils. Frequently used exploration roads are those that are constructed to withstand the wear of regular travel (heavy daily vehicle or equipment movement). Some exploration roads are high standard roads constructed initially for exploration, but expected to remain functional over a long duration for the continuing management of the resource. The section describes the recommended practices for their design and installation.

- Ditch and culvert design should ensure these structures are large enough to accommodate the 100-year return flood flow.
- Road surfaces should be crowned so that water flows into the ditches. Collection and discharge of runoff off at the end of roads or at switchbacks should be avoided.
- Culverts should be skewed across the road and installed with a minimum 1% slope. Under conditions of high debris loads and where deep fills are required, culverts should be installed along the natural slope. This requires installing a long culvert before any fill is placed, but improves the self-cleaning capability of the culvert and avoids discharge onto the fill slope.

Trail washout caused by improper drainage and organic debris in the sub-grade.

- Culvert intervals should be short enough to prevent concentrated discharges onto lower slopes.
- Catch basins installed above culvert inlets, with ditch blocks placed below the basins will help to direct water through the culvert. Riprap along the ditch block will minimize erosion and washout.
- Culverts should spill onto stable slopes. Place rocks or other energy dissipaters below the outlet to prevent erosion. If drainage must be discharged over deep fill, place a downspout or half-culvert on the slope.
- Marking culverts with large painted stakes will aid location and maintenance.
- Drainage ways should be kept clear of all construction debris and fill.
- Road ditches should not drain directly into a stream (Figure 9.2). Divert ditch water into a constructed sump or, where practicable, onto stable forested vegetation where it can infiltrate the ground. Slash from the road right of way may be windrowed along the toe of a fill slope to assist in filtering.
- Adequate cross drainage is important before a bridge or culvert crossing to minimize water volume directed into approach ditches.
- Divert drainage away from borrow pits and waste dump sites.

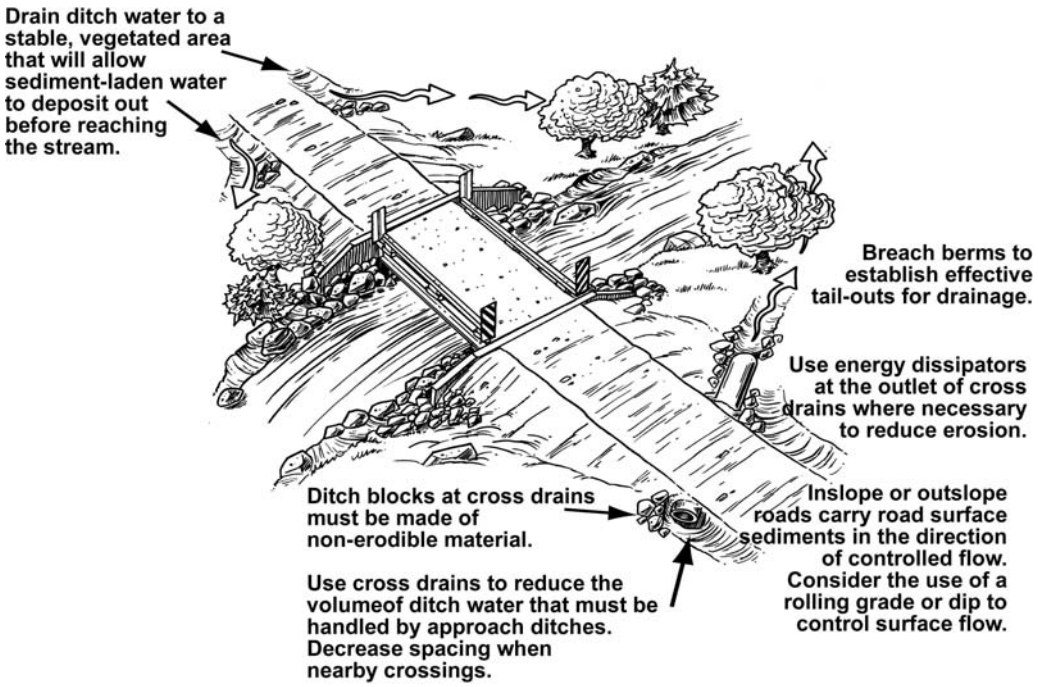


Figure 10.2: Road Drainage at Stream Crossing (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

10.4.3 Construction

The Ministry of Forests' *Forest Road Engineering Guidebook* contains valuable and detailed information on the construction of resource access roads. Explorationists are encouraged to refer to the guidebook (http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm) for a more comprehensive review of technical construction methods.

- Proposed access routes should be inspected and flagged on foot at least 2 km in advance of any construction equipment. Site-specific relocations may then be made to avoid problem areas.
- The felling of trees and vegetation clearance should be limited to the minimum area that is required to accommodate the planned road width, user safety and operational requirements.
- Construction on unstable soils or areas adjacent to streams should occur in periods of dry weather. If periods of heavy rainfall are expected, construction operations that have the potential to cause erosion should be temporarily suspended. If work is required in areas with easily erodible or poorly drained soils, higher floatation tracked equipment should be used or work should be staged off hardened construction pads.
- Material for ballast or road surfacing that can generate acid rock drainage should not be used. Often such materials can be identified by the presence of sulphide minerals and staining.

Potential ARD?

Review the "Metal Leaching and Acid Rock Drainage" section of this document

- Interference with surface and subsurface water flows in areas of a community or domestic water supply should be avoided.
- Road gravel should be obtained from site locations identified in the NoW permit and approved by the inspector, or identified under a Special Use Permit issued by the Ministry of Forests and Range.
- Road surfacing material with a high content of fine sediment should be avoided.

10.4.4 Road Embankments

- To stabilize road embankments, consider the following recommended practices:
  - Remove roots, vegetation and large rocks.
  - Pulverize large lumps of soil before compaction.
  - Control groundwater to prevent saturation of fill material, using pipe drains or filter blankets if necessary.
  - Protect embankments from erosion using riprap where necessary (e.g., close to streams).
  - Construct fill in lifts to achieve maximum compaction.
  - Reduce the slope angle of cut banks, round the tops of cut slopes and fall any trees that may become undercut by erosion.
  - Leave a top dressing of slash on embankments, seed and/or mulch immediately to establish vegetation or, if necessary, construct protective works such as terraces, cribs or retaining walls.
  - Limit excess side-casting, particularly onto unstable slopes or into watercourses.
  - Minimize access width when traversing steep slopes. In some cases, end-hauling, or the transport of cut material out to a more stable dump location, may be necessary.
  - Leave berms on roads that traverse steep slopes. Breach berms at appropriate intervals so that runoff does not become concentrated on the surface.
  - Revegetate all exposed soil surfaces as soon as practicable to avoid instability of cut slopes.

10.4.5 Stream Crossings

Stream crossings are given special attention in the MX Code. Stream crossings, even temporary ones, can affect fish by blocking fish migration routes, destroying in-stream or riparian (next-to-stream) habitat and silting downstream channels. This includes small channels that provide access to fishery-sensitive zones such as small side channels or wetlands.

As such, fish-stream crossing structures should retain pre-installation stream conditions as much as possible. The objective is to ensure that the crossing

permits peak flows (Table 10.4) but does not restrict the stream channel width (Figure 10.3) or change the stream gradient, and that the natural streambed characteristics are retained or replicated.[4]

Table 10.4 Minimum Design Peak Flows for Bridges and Culverts

Crossing Type	Return Period (Years)
Permanent Bridge	100
Temporary Bridge	50
All Stream culverts	100

Source: MX Code

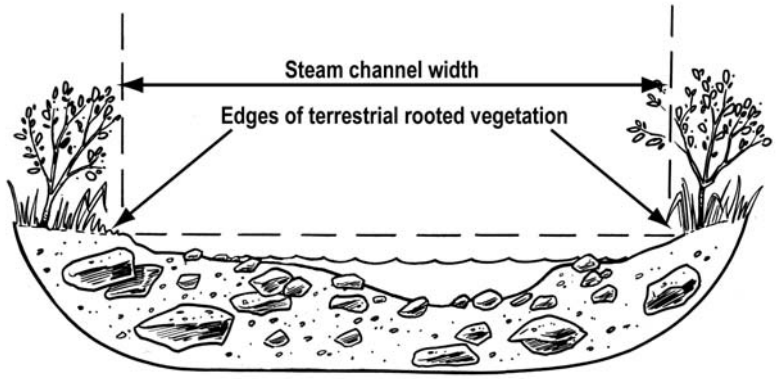


Figure 10.3: Stream Channel Width (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

The choice and design of fish-stream crossing structures are determined by a number of factors, including sensitivity of fish habitats, bed and bank composition and stability, bank height, water velocity, engineering requirements (e.g., type and weight of equipment using the structure, number of trips), cost and availability of materials, and cost of inspection, maintenance, and deactivation. Not all options are appropriate on all sites.

Crossing structures fall into three general categories:

- open-bottom structures (OBS), which include bridges and open-bottom culverts;
- closed-bottom structures (CBS), such as corrugated metal pipes; and

[4] Locating roads and crossing structures in alluvial fans, where streams are in active floodplains or where streams are meandering or braided, may require special design considerations not included in this guide. Where such installations are considered, a professional engineer and fisheries biologist should be consulted.

- snow-based structures, such as snowfill and ice bridges.

In general, if an OBS is constructed within the fisheries instream timing window, spans the stream without disturbing fish habitat and minimizes loss of riparian vegetation fisheries agency approvals will be facilitated. Note however, that under DFO's Regional Operating Statements (http://www.dfo-mpo.gc.ca/canwaters-eauxcan/epmp-pmpe/operational_e.asp), open bottom culverts are not considered as a low risk activity.

Ministry of Environment regional offices may also have information on specific instream work windows; as this may differ from DFO timing windows, contact your regional MoE office or check the following website: http://www.env.gov.bc.ca/wld/BMP/bmpintro.html.

CBSs are not allowed in critical fish habitat but are an option in small streams with a stream channel width of 2.5 m or less and 6% average stream gradients or less. They generally need site-specific fisheries authorization. The *Fish-stream Crossing Guidebook* provides a useful matrix for determining where OBS and CBS structures are suitable.[5]

General Recommended Practices for All Stream Crossings

- Crossings should be located at the narrowest part of the stream and its floodplain, and set at a right angle or perpendicular to the stream channel and flow (see Figure 4.4 in Section 4 of this document).
- The active floodplain should be maintained in a state as close to its existing condition as practicable (Figure 10.4).

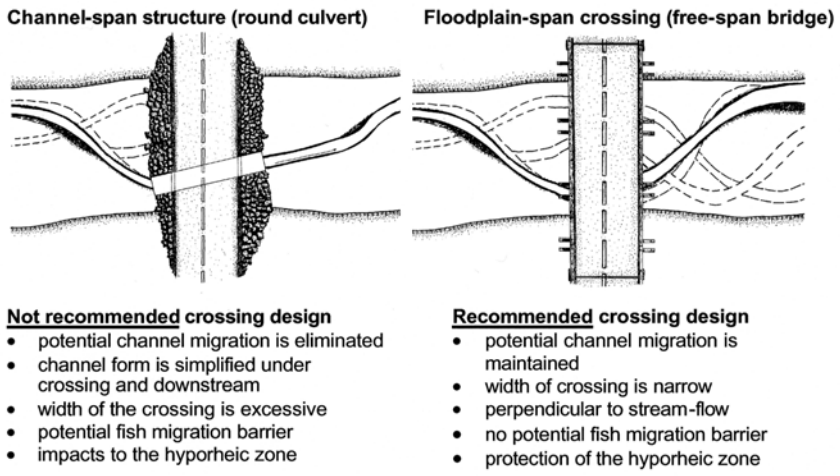


Figure 10.4: Channel Movement – Channel Span vs Floodplain Span Structures

[5] Forest Practices Code *Fish-stream Crossing Guidebook*, (March 2002)
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/FishStreamCrossing/FSCGdBk.pdf

- Stream crossings should be located where there are stable (non- or low-erodible) banks. Crossing where there is stable "large woody debris" (logs, stumps, etc.) in the stream, should be avoided as these are important natural stream stabilizers and sources of shade and cover for fish and aquatic organisms.

- Clearing widths should be minimized at the crossing site and streamside vegetation should be retained within the stream crossing right-of-way wherever practicable.

- Streams and side channels should not be artificially channelized to reduce the number of culverts required. Each channel should be adequately culverted at point of crossing.

- Practices that result in vibrations potentially harmful to fish or fish eggs, such as pile driving and blasting, should be completed during the instream timing windows. Fish salvage may be required to remove the fish from harm.

- Construction work, as well as deactivation and reclamation, should be completed during the appropriate instream work window. Information on specific instream work windows should be obtained from your regional MoE and DFO offices or through the following websites: http://wlapwww.gov.bc.ca/wld/BMP/bmpintro.html , and http://www.dfo-mpo.gc.ca/canwaters-eauxcan/epmp-pmpe/operational_e.asp

- Where feasible, all equipment should be operated from above the top of the stream bank, in isolation from water sources. Instream work areas should be isolated from flow, sediments generated within the work site should be contained, and sediment-laden water within the work cell should be pumped out to an upland settling site during construction and installation.

- Precautionary measures should be used to prevent deleterious substances such as new concrete, grout, paint, sediment, lubricants, fuel and preservatives from entering streams (see Chapter 7 for erosion control measures).

- If wood preservatives toxic to fish are used, they should be used in accordance with *Guidelines to Protect Fish and Fish Habitat from Treated Wood used in Aquatic Environments in the Pacific Region* (see Section 10.5: Resources).

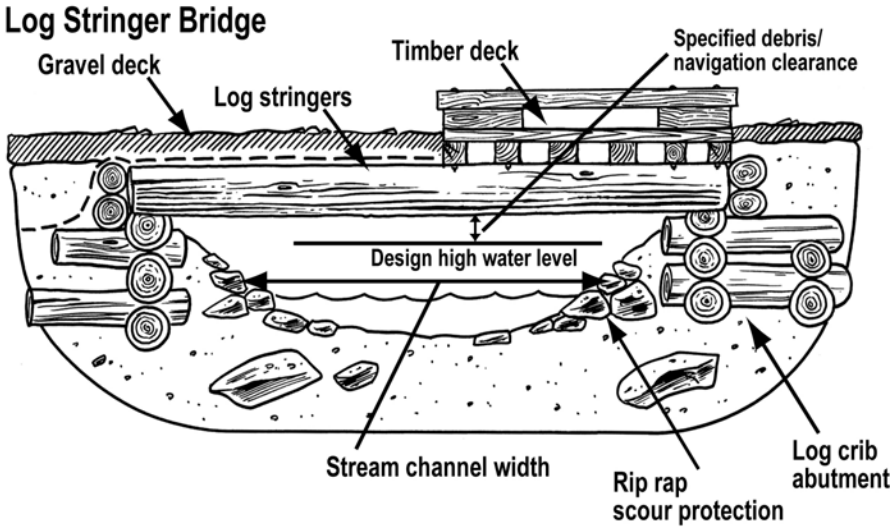
- Turnouts should be constructed far enough from crossings to prevent road material from entering the stream and to minimize impacts on riparian vegetation.

- Following construction, the site should be revegetated and stabilized to prevent post-construction erosion (see Chapter 7).

Bridges

Bridges can be designed for permanent, temporary or seasonal installation. They range from log stringer bridges with gravel or timber decks to steel girder bridges with timber or pre-cast concrete decks. Bridges can be supported by various means, including log cribs, steel pipes, steel bin walls, cast-in-place concrete, pre-cast "lock block" walls, timber and piers (Figure 10.5). Under the MX Code, bridge design and fabrication must be certified and approved by a qualified person.

A.



B.

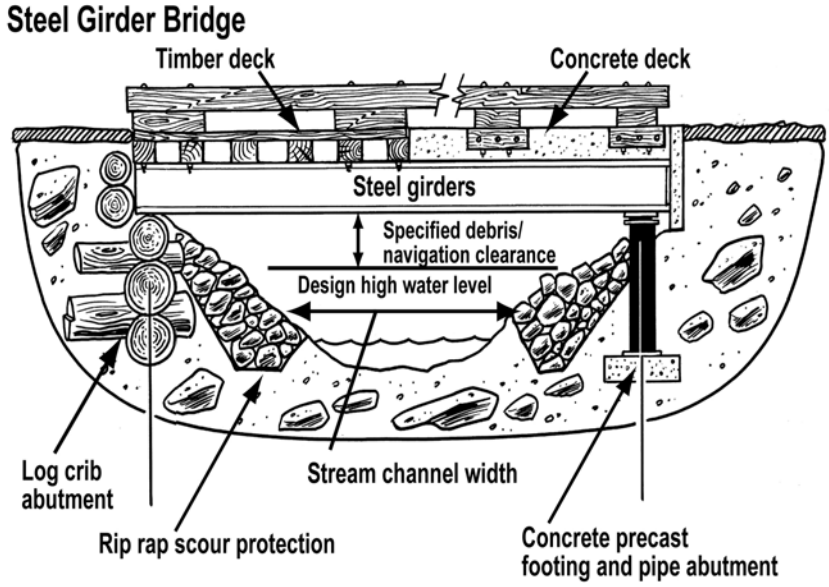


Figure 10.5: Types of Bridges (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

C.

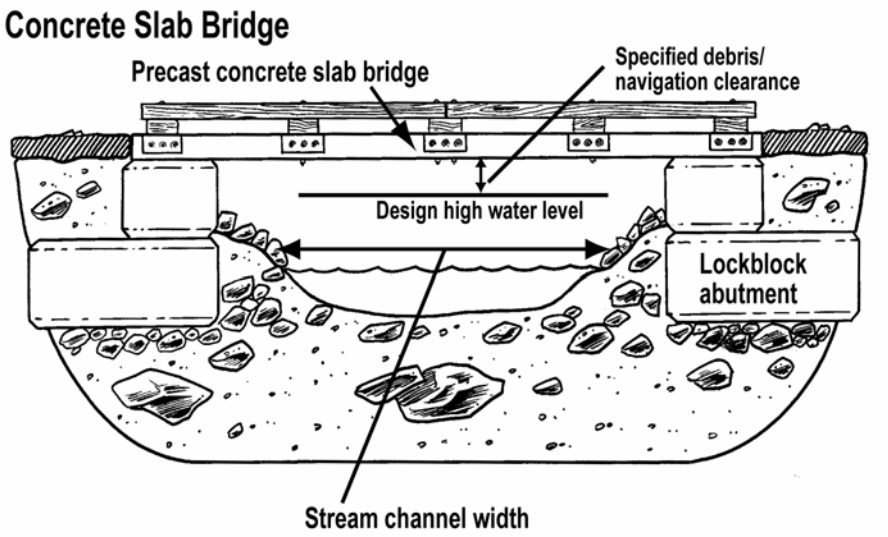


Figure 10.5 (continued): Types of Bridges (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

- Bridge design and construction methods should be selected to avoid impacts to fish passage and fish habitat in fish streams (e.g., select bridge designs with abutments that do not constrict the stream channel).
- Use of instream piers should be avoided where practicable as they can collect debris during flood events, resulting in scouring of bridge foundations. They can also result in hydrologic changes such as bedload scour or deposition, which may adversely affect fish habitat. Fisheries agencies may approve bridges with instream support piers only after all other feasible options have been exhausted.
- Portable bridges should be used for temporary crossings (in place for less than two years and removed at end of the operation).
- As required, permanent bridges should be constructed so that the deck is above the 1 in 100-year flood level with clearance for floating debris.
- As required, temporary bridges should be constructed so that the deck is above the 1 in 50-year flood level with clearance for floating debris.
- For gravel-decked bridges or log culverts some measure, such as geotextile filter fabric placed to fully cover the stringers, should be used to prevent road material from falling through to the stream.

Open-Bottom Culverts

Open-bottom culverts are similar to bridge structures, generally spanning the entire streambed and minimizing impacts to the natural stream channel. They are different from bridges in that the fill placed over these structures is an integral structural element.

The most common type of open-bottom structure is the log culvert (Figure 10.6). It is widely used in areas where the availability of suitable logs makes it an economical alternative to steel or concrete. Log culverts are readily adapted to meet flood requirements and generally do not pose a risk to fish passage when sill logs are placed to maintain the stream channel width.

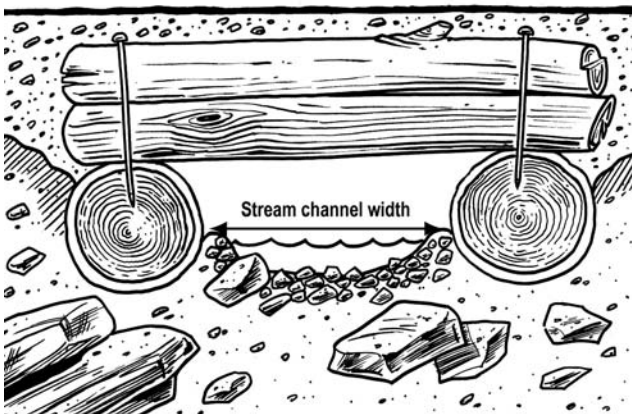


Figure 10.6: Log Culvert (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

Depending on the stream profile, large sill logs or log cribbing may be required with log culverts to achieve adequate flow capacity. Alternatively, small sill logs can be used, but the span should be increased to get sill logs well above and outside the scour zone of the stream.

Other types of open-bottom culverts include skid bridges and arches constructed of steel, plastic and other materials. Arches come in various shapes, ranging from low to high profiles and are typically installed on concrete or steel foundations (Figure 10.7).

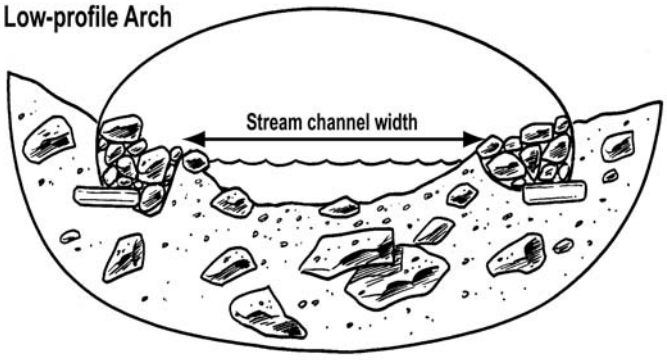


Figure 10.7: Arch Culvert (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

- Open-bottom culverts should be designed to span the stream channel width and so avoid impacts on fish habitat (stream bottom) and fish passage.
- Excavation and backfilling for footings should not encroach on the stream channel width.
- In arch culverts, use of geotextiles to prevent loss of fines and gravel through seepage along the arch wall should be considered. The fabric or other cut-off measures, such as sand-bagging or use of prefabricated seepage barriers along the arch wall near the inlet, are intended to prevent most of the seepage and mitigate potential erosion of the support fill that can occur along the arch.
- For gravel-decked log culverts, some measure should be used to prevent road material from falling through to the stream. A geotextile filter fabric to fully cover the stringers would be one choice to consider.

Closed-Bottom Structures

Closed-bottom structures are corrugated pipes (metal or plastic) that are "embedded" to retain stream bottom substrate that provides fish habitat and passage. The embedment methodology (also known as stream simulation) consists of selecting a culvert (pipe) of adequate size to encompass the stream channel width, and emulating a streambed within the culvert by lining the bottom with representative streambed rocks and sands. The natural substrate materials are supplemented with additional larger material to help retain the substrate within the culvert and assist fish passage. By emulating the streambed and stream channel width, the culvert's stream flow characteristics should reflect the natural flow characteristics.

- Installation of a closed-bottom structure requires a dry streambed. Installation should be scheduled during the dry season, when the stream may be naturally dry (for intermittent streams) or at lowest flows.

- All required materials should be brought on site and equipment mobilized in advance. This allows the installation to proceed without delay.
- Appropriate work-site isolation techniques should be applied as needed during installation in streams with year-round flows (see Section 4.6.1 of Fish Stream Crossing Guidebook, Ministry of Forests).
- The culvert bed should be prepared and graded to conform to the design culvert invert elevation and slope, using benchmarks and precise instruments. The barrel of the closed bottom structure should be set to the appropriate depth **below** the streambed and at the same natural stream gradient as shown by the longitudinal profile survey (Figure 10.8).

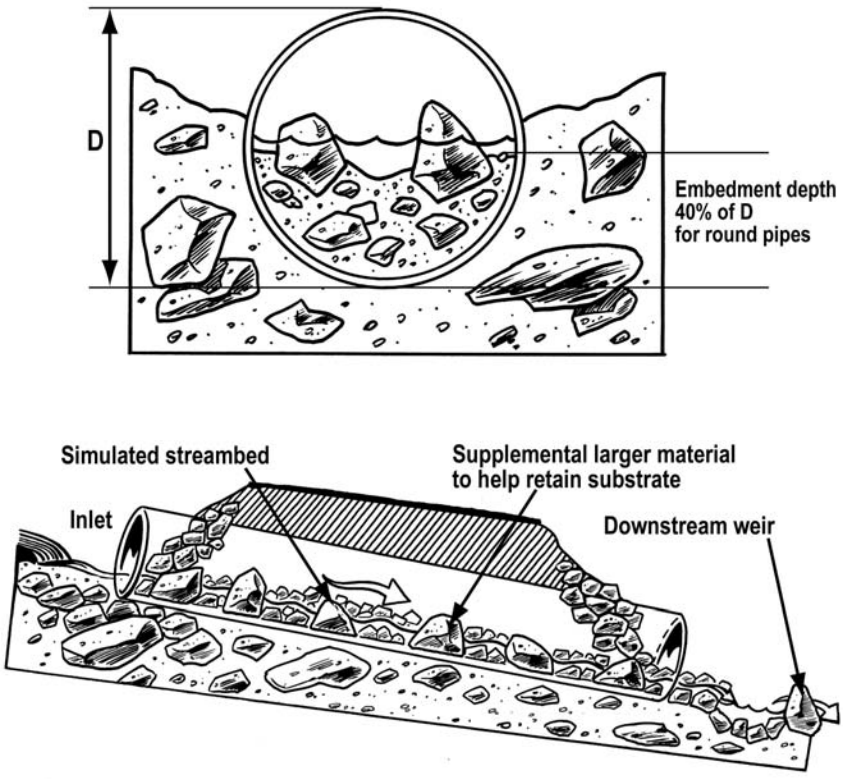


Figure 10.8: Culvert/Streambed Cross-section and Profile (from *Fish Stream Crossing Guidebook*. Ministry of Forests, 2002)

- The culvert foundation, trench walls and backfill should be free of logs, stumps, limbs or rocks that could damage or weaken the pipe.
- Consider using geotextiles to prevent loss of fines and gravel through seepage along the culvert wall. The fabric or other cut-off measures, such as sandbagging or use of prefabricated seepage barriers along the culvert near the inlet, are intended to cut off most of the seepage and mitigate potential erosion of support fill that can occur along the pipe.

- Any activities, including the placement of riprap that may cause any constriction of the stream channel width should be avoided.
- All exposed mineral soil should be erosion-proofed as soon as practicable after disturbance.
- An instream weir (Figure 10.9) should be established within one and a half to two channel widths downstream of the culvert outlet, particularly for streams greater than 3% gradient, to retain substrate within the culvert and to prevent the formation of a plunge pool. The residual pool depth formed by this weir should be less than 0.3 m.
- Backfill practices should conform to those specified by the culvert manufacturer or otherwise specified by an engineer, and should ensure compaction immediately adjacent to the culvert.
- For culverts installed at slopes greater than 3%, larger material (D90 or greater) should be mixed into the substrate to help retain the substrate in the pipe. The larger material should be placed so that it projects from the streambed. This should create velocity shadows to enhance fish passage, retain substrate, and simulate conditions in the natural stream.

D90
D90 is a particle size descriptor that refers to the largest size class of streambed substrate that may be moved by flowing water. Approximately 90% of the streambed substrate will be smaller than this size class.

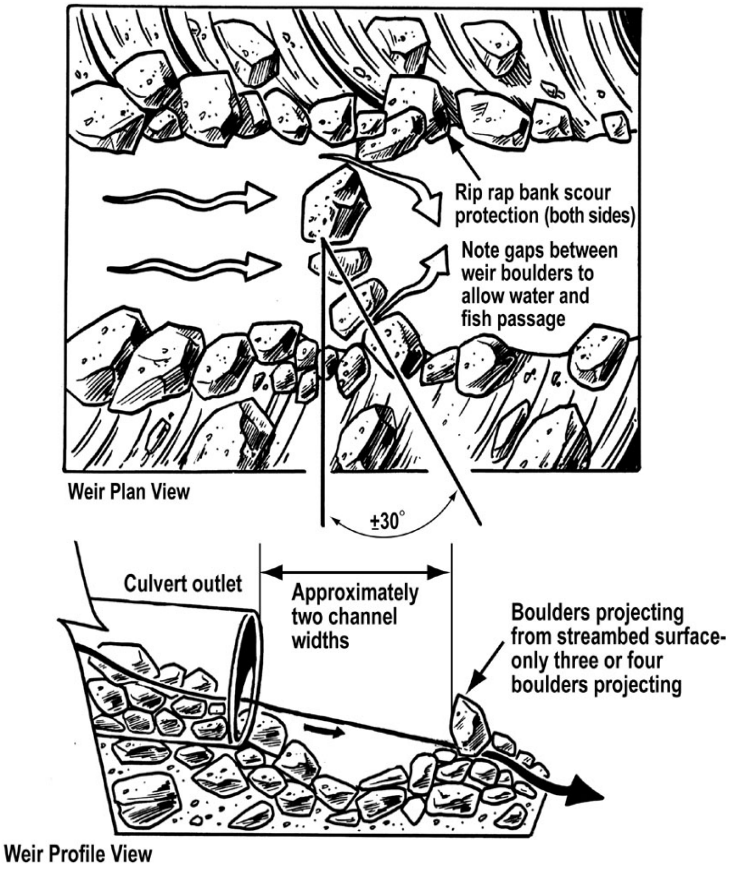


Figure 10.9: Instream Weir (from *Fish Stream Crossing Guidebook.* Ministry of Forests, 2002)

Snowfills

Snowfill crossings (Figure 10.10) are options that may be considered for seasonal use depending on the site, time of year and other environmental constraints.

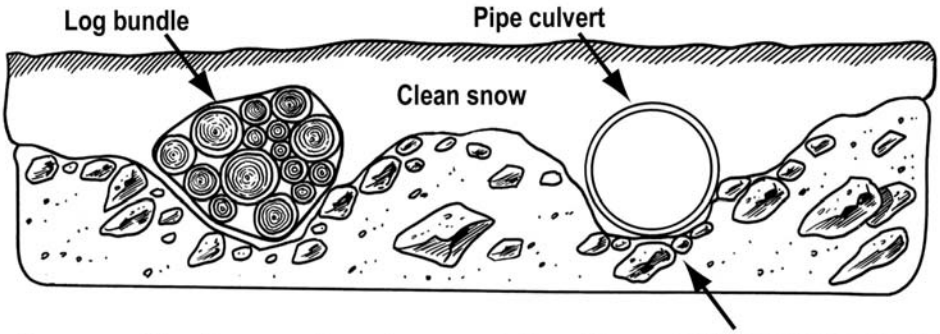


Figure 10.10: Snowfill Crossing (from *Fish Stream Crossing Guidebook*. Ministry of Forests, 2002)

Snowfills are constructed by filling the channel with compacted clean snow (i.e., free of dirt and debris). Their use should be considered if the stream is dry or the water is frozen to the stream bottom. Unanticipated stream flow due to unseasonable thaws can be accommodated by log bundles or culverts.

- Snowfills should be constructed only when there are sufficient quantities of dirt-free snow available for construction.
- Construction should begin after the stream has frozen solid to the bottom or has ceased to flow, or when there is sufficient ice over the stream to prevent snow loading from damming any free water beneath the ice.
- Where practicable, snow should be placed into the stream channel with an excavator. Crawler tractors may be used to push snow into the stream channel, but only if they can push snow unaccompanied by dirt and debris.
- Where stream flow is anticipated during periodic winter thaws, a pipe culvert, heavy steel pipe or bundles of clean, limbed and topped logs should be placed within the stream channel to allow for water movement beneath. The latter practice is not acceptable in streams where winter fish migration may be required. Heavy steel pipe is easier to salvage and has less chance of crushing under load and during removal.

- Snowfill should not be capped with soil. There is risk that soil placed within the stream channels could make its way into the stream during winter thaws.
- Any snowfill that may cause damage to the stream during warmer weather should be removed and then reconstructed when colder weather returns.
- All snowfills and support materials should be removed before the spring melt. Removed snow should be placed above the normal high water mark of the stream to prevent it from contributing to sedimentation and erosion. Deactivation should include the use of all appropriate measures to stabilize the site and facilitate its return to a vegetated state.

Ice Bridges

Ice bridges are effective stream-crossing structures for larger northern streams and rivers, where the water depth and stream flow under the ice are sufficient to prevent the structure from coming in contact with the stream bottom (grounding) and where there are no concerns regarding spring ice jams. Grounding can block stream flow and fish passage and cause scouring of the stream channel.

Ice bridges are generally in place for less than six months and are removed or destroyed by spring break-up. They provide winter access to exploration sites and enable crossing of large rivers where building a bridge would be too expensive.

- When planning the design of an ice bridge, you should consider depth of water, minimum winter daily stream flow, substrate, crossing location, maximum load strength, time of use, depth of ice required, approach construction, maintenance and monitoring, and decommissioning.
- Gold's formula[6] can be used to approximate permissible loading on an ice bridge:

  $P = Ah^2$ where:
  P = load in kilograms (short-term load, assuming vehicle is moving)
  A = constant (3.52 recommended)
  h = ice thickness in centimetres
- Logs may be used as reinforcing material, but consideration should be given to potential problems this may cause. There is a possibility that logs, if left in place through spring break-up, could contribute to debris jams and increase the risk of flooding, river channel alteration, erosion, habitat loss and destruction of downstream structures. If this is an unacceptable risk, logs should not be used. In most cases, log removal from a deteriorating ice bridge is an unsafe practice. The warmer weather

[6] Canadian Petroleum Association, 1988, *Environmental Operating Guidelines for the Alberta Petroleum Industry*.

and reduced ice thickness required to remove the logs can make working on the bridge unsafe for personnel and equipment. In these situations, removing all but the lowest logs from the ice bridge may be acceptable.

- Ice thickness and stream depth should be routinely measured and recorded. Evidence of grounding or an increased risk of the ice base grounding with the streambed may require that the bridge be temporarily or permanently decommissioned.
- Ice bridges should be located to minimize cutting into the stream bank during construction of the approaches.
- Debris and dirt should be removed from the bridge and placed at a stable location above the high water mark of the stream. Erosion protection measures should be in place.
- Approaches should be constructed of clean compacted snow and ice and built to a thickness adequate to protect stream banks and riparian vegetation. Construction should begin from the ice surface. Where limited snow is available, locally available gravel from approved pits can be used to build up approaches, but this should be removed when the ice bridge is deactivated.
- When it is time for deactivation, all ice bridge approaches should be removed. Where stream banks have been exposed to mineral soil, they should be recontoured and revegetated using appropriate measures to stabilize the site and facilitate its return to a vegetated state.

Fords

Fords, constructed as crossing structures, can result in habitat degradation through sedimentation, channel compaction, destruction of fish eggs and the creation of barriers to fish passage. The construction of fords on fish streams is discouraged. When a ford is being considered, referral is required to the appropriate fisheries agency or the inspector.

MX trail. Note tree canopy retention.

Vegetation Retention at Stream Crossings

- As much understory vegetation should be retained as practicable within the riparian setback area of the stream crossing to prevent erosion and minimize disturbance to fish habitat. Remove only the vegetation required to meet operational and safety concerns for the crossing structure and the approaches.
- Rooted shrubs should be salvaged during crossing construction to assist in post-construction site stabilization.
- Effort should be made to avoid and minimize impacts to the riparian habitat beyond the toes of the approach and abutment fills at the crossing site.

10.4.6 Inspection and Maintenance

Maintenance & Reclamation of Roads

Roads are assets and complete reclamation that obliterates them is not always necessary or desirable. However, in some circumstances, a challenge may be posed by the desire to retain a functioning access and the need to decommission or reclaim it to release the reclamation security bond.

Each road is a unique case. Before any deactivation or reclamation of roads and trail occurs, consul with the Mines Inspector to plan for maintenance or future management of the access.

- As required by the MX Code, establish a monitoring and maintenance program for all exploration roads (including crossing structures) to ensure that they are stable and safe for the use intended until they are reclaimed to the satisfaction of an inspector.
- As required by the MX Code, have all metal and concrete bridges inspected by a qualified person at least once every three years and other bridges at least once every two years, or as prescribed by the designer. Inspection records are to be maintained for the life of any bridge structure. Any deficiencies identified as a result of an inspection are to be corrected as soon as practicable.
- The reclamation security bond required by the Ministry of Energy, Mines and Petroleum Resources to cover the liabilities and reclamation costs of the access road and associated exploration activities will be retained until the ministry is satisfied that the appropriate level of decommissioning and reclamation has been achieved.

10.4.7 Deactivation or Reclamation of Roads

- Seasonal temporary deactivation or partial reclamation of access roads and trails may be used to manage stability and drainage concerns from one field season to the next. Further information on reclamation of roads can be found in Section 14, Reclamation.
- Where a decision has been made to deactivate or fully reclaim an access trail or road, original habitat components should be restored and the road should be closed to future access. Crossing locations should be restored to their pre-existing conditions - observable in the nearest unmodified section of the stream immediately upstream or downstream of the crossing.
- Deactivation around fish streams may pose special challenges, such as the control of sediment from deactivation operations.
- A sediment control plan should be in place for the deactivation and care should be taken to implement it well.
- Fill removed during deactivation should be safely placed in a stable location. End-hauling or transporting material off-site may be necessary.
- Work should be performed during dry weather to prevent sedimentation. Habitat features should be installed, and the resulting channel should be allowed to stabilize before water is re-introduced to the restored channel.
- Many of the guidelines outlined in construction practices also apply to deactivation activity. Pay particular attention to those guidelines that relate to sediment control and revegetation (Chapters 7 and 14).

Reclaimed and revegetated trail with debris pulled back on to trail surface.

Checklist: Exploration Access

The MX Code sets out a variety of requirements with respect to the construction, maintenance and subsequent deactivation and reclamation of exploration accesses.

- ❑ Have you taken steps to minimize the environmental impacts of your exploration access activities, particularly to aquatic habitats and drainage systems at crossings, by:
  - ❑ Planning your access location and design to avoid, minimize and mitigate impacts to riparian and other sensitive areas?
  - ❑ Providing appropriate drainage and erosion control for temporary and permanent roads?
  - ❑ Selecting construction methods that limit vegetation removal, soil disturbance, and disruption of surface drainage?
  - ❑ Stabilizing road embankments?
  - ❑ Selecting stream-crossing structures appropriate to physical and biological characteristics of the watercourse by:
    - ❑ Choosing free-span bridges or open bottom structures in watercourses used by fish;
    - ❑ Protecting aquatic organisms and habitat during crossing construction; and
    - ❑ Retaining as much vegetation as possible in riparian areas adjacent to crossings?
  - ❑ Inspecting and maintaining exploration accesses yearly until the road is reclaimed to ensure they remain stable and safe?
  - ❑ Deactivating crossings and accesses following the completion of exploration activities?

10.5 Resources

B.C. Ministry of Energy, Mines and Petroleum Resources. 1992. *Guidelines for MX: Environmental, Reclamation and Approval Requirements.* 57 pp.

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11 Drilling

Heliportable fly drill on edge of a glacier.

11.1 Background

Cuttings produced in the drilling process and additives used while drilling during exploration can sometimes be harmful to fish, wildlife and humans. In locations where there is potential to affect water quality, drill operators should take appropriate measures to contain drill cuttings and reuse and ultimately dispose of drilling fluids. In addition, site location and construction can have affect soil quality and slope stability. Appropriate measures are required to ensure retention of slope stability and control of drainage when preparing and using a drill site.

11.2 Objectives

Mineral explorationists are directed by the "Drilling" section of the MX Code to:

- conduct drilling operations in a way that does not expose exploration personnel to undue risk;
- cost effectively evaluate mineral deposits while minimizing disturbance to other natural resources, particularly aquatic resources and habitats;
- minimize individual and cumulative hydrological impacts to surface and groundwater flows and quality; and
- minimize impacts on soil quality and reduce risk of landslides, slope failure or other events that might contribute to delivery of sediment to streams.

Heliportable diamond drill—large clearing required for crew changes with helicopter.

11.3 What's Required under Legislation

The MX Code prevents drilling in streams, lakes, wetlands and riparian setback areas unless appropriately authorized. It also requires the implementation of a number of measures to reduce environmental impacts during and after drilling has been completed.

11.4 Recommended Practices

11.4.1 Siting

Although the location of drill holes is dictated by geological, geophysical and geochemical characteristics, slight alterations in the location of drill holes are often possible to avoid special or problem areas.

- Drill sites should not be located on unstable slopes, overly steep terrain or areas of saturated soils, as this could significantly increase construction and reclamation costs and effort.

- Drill holes must not be located in a stream.
- Drill holes in lakes and wetlands should be avoided except under unusual circumstances. A management plan approved in your exploration permit is required for such a location.
- Drill sites should also be avoided in riparian setbacks (see Chapter 4, Table 4.2) unless:
  - no other practicable option exists;
  - risk to health and safety can be reduced; and/or
  - locating the drill site inside rather than outside a setback can reduce the risk of adverse impacts to the environment.
- If you are proposing drill sites in riparian setbacks, you need to prepare a management plan and ensure it is acceptable to an inspector. The plan must show how the drill site preparation, operation and abandonment will maintain the integrity of, prevent the introduction of deleterious substances to and minimize disturbance to the stream, wetland or lake.
- Drill sites should be selected and prepared in a manner that will minimize visual impact to surrounding public use areas.
- Previous sites or existing clearings should be used whenever practicable to minimize additional work and environmental impact.
- Drill sites and water lines should be located in areas where access to them and their operation will create the least amount of disturbance.

Potential ARD?

Review the "Metal Leaching and Acid Rock Drainage" section of this document

Small diamond drill.

Nodwell mounted auger drill.

11.4.2 Environmental Management of Drilling Activities

- Scheduling and siting of drilling activities should avoid disturbing wildlife during crucial seasons in their life cycles, particularly nesting birds protected under the Wildlife Act (bald eagles, gyrfalcons, peregrine falcons, great blue herons).
- Where practicable, directional drilling should be considered to avoid environmentally sensitive areas.
- Drill core should be assessed for the potential for ML/ARD as this will assist further exploration and mine development planning to avoid, prevent, or manage ML/ARD impacts.
- The smallest practicable drill pad area consistent with safe working practices should be used.
- Tree cutting should be minimized. Cut slopes should only be as large as necessary for access and safety.
- If stripping or levelling a drill site area is required for safe location of a drill pad, topsoil and overburden should be removed as required and saved separately, nearby in low mounds. It should be returned as soon as practicable in the reverse order to its excavation (see Chapters 5 and 13).

- Topsoil and overburden should be stored on the upslope side of the drill pad when safe and practicable to do so to minimize risk of erosion.
- Design of surface drainage structures should be based on the expected flow, subgrade soil conditions and the expected duration of their use. Ditches should be constructed on the upslope side of the drill pad, and a sump should be built on the downslope side of the pad. Surface drainage structures (e.g., interceptor ditches) should be constructed to intercept and divert runoff, preventing erosion of the drill pad and sump.
- The production of excess muds, additives and process water should be limited.
- Solid waste, such as additive containers, rags, domestic refuse and drill core boxes should not be disposed of on-site. Make suitable collection containers available for use by drill contractors that can be emptied at an approved facility off-site.
- Oil-absorbent matting should be on-site and available to be used to catch grease and oil around the drill rig. .

11.4.3 Drilling Safety Measures

AME BC's Health and Safety Manual

Information on drilling safety can be found in the updated AME BC *Safety Manual: Mineral Exploration in Western Canada* (www.amebc.ca/healthsafety.htm).

- Care should be taken when working with drills to ensure safety hazards are avoided and managed where avoidance is not practicable. Principal hazards to exploration personnel working at a drill include:
  - loose clothing which can catch in the drill and cause serious or fatal injuries;
  - slippery floors in a drill shack that may cause serious falls;
  - noise of the drill rig which can cause hearing loss, although few explorationists are exposed to the prolonged noise levels experienced by drillers;
  - poor air quality that can make breathing difficult when sampling in dusty environments, particularly around percussion rigs;
  - poisoning from licking drill core; and
  - head injuries from falling objects off the drill mast or upper deck.

11.4.4 Drilling Fluids and Cuttings Management

- Borehole erosion and enlargement should be reduced by using drilling fluids that minimize reactions with the drilled formation.
- Only industry-approved, biodegradable drill additives should be used. Copies of Material Safety Data Sheets for drill additives should be maintained in locations readily available to emergency responders or regulatory officials. If a question exists about the applicability of certain drill additives, it is the responsibility of the project manager to seek guidance before their use.
- Alternative drilling fluids and additives should be used where practicable to reduce toxicity; these include organic or synthetic additives (mineral

oil) instead of diesel-based additives; lubricants such as lubra beads and gilsonite-based additives; low solids non-dispersed drilling fluid systems to replace dispersed systems that typically require large volumes of water; sulphite and organic phosphate corrosion inhibitors to replace chromate corrosion inhibitors.

- Toxic drill fluids, additives and cuttings that have the potential to harm aquatic species and habitat should not be released into waterways or allowed to run uncontrolled. An adequate closed-circuit facility should be provided for drilling mud and flocculating agents. Acceptable collection techniques include dug sumps, tanks and well-constructed settling ponds (i.e., impervious walled) a short distance downslope from the drill.
- Upon completion of the drilling program, all unused chemicals, additives and muds should be removed from the site and returned to the supplier/vendor where accepted.
- If water held in control devices is turbid but chemically-unaltered, consider allowing it to infiltrate the ground rather than storing it in an excavation. The water should not discharge directly into waterways or wetlands or harm surrounding vegetation.
- In some situations where a dug sump is not provided, solid cuttings may be disposed of on-site. The cuttings should be dispersed around the site and reclaimed (e.g., re-seeded) as appropriate.
- Diesel should not be used as a mixing agent or downhole as a lubricant.
- Ensure safe handling and storage of drill additives as directed in the Material Safety Data Sheets supplied by the manufacturer or distributor.
- Use fuel pumps, pouring spouts and funnels, and spill or rip trays when refuelling to minimize risk of spill.

11.4.5 Water Pumps

- Water supply pumps should be located above the high-water line of any watercourse and bermed adequately to prevent fuel spills into the stream (see Chapter 9).
- The pump and associated machinery should be placed in a drip tray and preferably covered with a rain cover. Ensure solid footing under the pump.

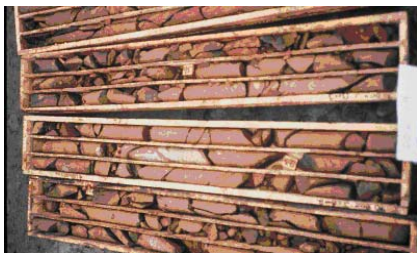
11.4.6 Groundwater and Drill Hole Closure

- If any groundwater issues from a borehole once a hole is completed:
  - the flow of water should be stopped or;
  - where the flow of water cannot be stopped, the water should initially be contained or otherwise managed to prevent potential

environmental, health and site safety impacts and the drill hole location reported immediately to an inspector, and

- any subsequent requirements of the inspector for managing environment, health and site safety issues implemented as soon as possible.

- Seal all surface drill holes that encounter uranium mineralization at a grade of 0.05% by weight or greater or thorium at a grade of 0.15% by weight or greater by completely filling them with concrete.
- Drill sites should be reclaimed to their original contour and site productivity to the extent practicable.
- Drill sites should be ripped along the contour of the slope to loosen soil and avoid creating erosion gullies and reseeded with plant species best suited to the elevation and latitude.
- Surface and subsurface water flow should be returned to the original pattern to allow for unimpeded flow.



Drill cores.

- All rubbish, materials and equipment should be removed and properly disposed of at a regional landfill facility.
- Contaminated soil should be collected from under or near the drill rig, and removed for appropriate disposal on completion of drilling.
- Felled timber should be bucked, limbed and laid in close contact with the ground to promote decomposition.

11.4.7 Drill Core Management

Drill core has significant scientific value as a physical record of a mineral resource as well as intrinsic asset value that may exceed many thousands if not millions of dollars. Given the effort and cost invested in obtaining it, drill core should be preserved wherever practicable. Future exploration activities may be targeted at ores or commodities not presently economical; in this case, access to past core samples may allow inventory of these 'new' targets without the impacts of another drilling program.

- All diamond drill core left in the field should be properly and safely stored (e.g., cross-stacked, cubed or otherwise racked) to protect against collapse and prevent wildlife from accessing it.
- Core boxes and core storage areas should be protected by marking them with warning notices identifying drill core and storage area as assets that should not be disturbed or destroyed.
- As part of a reclamation program, drill core stored safely should not be targeted for destruction. Core that has lost its value either through natural degradation or vandalism, however, should be included in the reclamation program. An inspector or regional geologist may be able to advise on the best approach to manage such core.

Checklist: Drilling

The MX Code requires the implementation of a number of measures to reduce environmental impacts during and after drilling.

- ❑ Have you taken steps to reduce the risk drilling cuttings and additives pose to human safety and the environment by:
  - ❑ Locating drill sites
    - ❑ Away from unstable areas and watercourses;
    - ❑ In lakes and riparian setbacks only with a clear management plan and the approval of the inspector;
    - ❑ To avoid visual impacts;
    - ❑ To reuse past sites where possible; and
    - ❑ To minimize disturbance to surrounding areas?
  - ❑ Managing drilling activities to
    - ❑ Avoid disturbing wildlife at critical times of the year;
    - ❑ Use directional drilling where practicable;
    - ❑ Create the smallest disturbance to slopes and vegetation as safe and practicable;
    - ❑ Conserve and replace disturbed topsoil;
    - ❑ Use surface drainage structures (sumps and ditches) to manage runoff; and
    - ❑ Limit the production of excess muds, additives and process water?
  - ❑ Using applicable drilling safety measures and ensuring drill sties and drill holes are left in a safe condition?
  - ❑ Using drilling fluids that
    - ❑ Minimize reactions with drilled material;
    - ❑ Are biodegradable and industry approved; and
    - ❑ Reduce the volume and toxicity of wastewater?
  - ❑ Constructing appropriate closed-circuit collection facilities to contain fluids, additives and cuttings?
  - ❑ Appropriately disposing of solid wastes?
  - ❑ Containing, reporting and testing any groundwater issuing from a borehole?
  - ❑ Capping abandoned drill holes on an *as needed* basis?
  - ❑ Reclaiming drill sites?
  - ❑ Removing rubbish, equipment and any contaminated materials for proper disposal off-site?
  - ❑ Providing for safe and secure long-term storage of valuable drill core?

11.5 Resources

B.C. Ministry of Energy, Mines and Petroleum Resources. 1992. *Guidelines for MX: Environmental, Reclamation and Approval Requirements.* Victoria. 57 pp.

Cominco American. 2000. *Exploration Drilling Best Management Practice*s. 14 pp.

12 Pits, Trenches and Excavations

Small trench in alpine site excavated by heliportable excavator.

12.1 Background

Trenches, pits and other forms of excavation are used in exploration work to establish the surface trend, width and mineral character of an ore body or mineralized zone. Many types of ore weather readily at the surface, and these surface effects may need to be removed if the true character of the mineralization is to be determined.

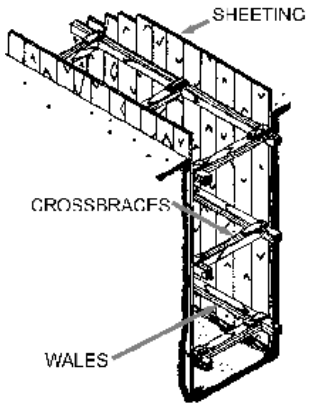
If excavation activities are poorly planned they can result in lasting local impacts to soils and surface resources.

Working in and about shafts, adits and underground workings/excavations trigger compliance with many other aspects of the *Mines Act* and HSR Code not covered in this Handbook.

12.2 Objectives

The objectives of the "Pits, Trenches and Excavations" portion of the MX Code are to ensure mineral explorationists:

- conduct excavation operations in a way that does not expose personnel to undue risk;
- limit risks to workers or the public beyond those risks associated with the natural terrain in the vicinity of the activities;
- minimize disturbance to other natural resources, such as aquatic habitats; and
- ensure minimal individual and cumulative hydrological effects on the flow and quality of surface and groundwater resources.



Trench shoring system (from Virginia Polytechnic Institute, Figure 2—see Section 12.5: Resources).

12.3 What's Required under Legislation

The MX Code and the HSR Code set out extensive requirements regarding excavation specifications and activities around them.

- **Trench width:** The MX Code specifies that when it is necessary for persons to enter a trench, the excavation shall be wide enough to allow a person to turn around without contacting the sides of the trench.
- **Trench shoring:** The MX Code also states that no person is permitted to enter any excavation over 1.2 m in depth unless the sides are sloped to a safe angle down to 1.2 m or the sides are

supported according to specifications of Part 4 of the HSR Code. Part 4.17 of the HSR Code also specifies what type of lumber can be used for shoring; the use of steel, hydraulic pneumatic jacks; and how shoring should be installed.

- **Trench sloping:** The sides of excavations may be sloped instead of shored, depending on soil or rock conditions, as long as stable excavations can be maintained. Slopes must not be steeper than 1 (horizontal): 1 (vertical).
- **Excavation preparation:** Any underground utilities shall be located prior to starting excavating or drilling. Pointed tools shall not be used to probe for underground gas and electrical services. Trees, utility poles, rocks and other objects near an area to be excavated must be removed or secured before excavation is started.
- **Working in excavations:** Excavated material shall be kept back a minimum distance of 1 m from the edge of any trench and 1.5 m from any other type of excavation. An excavation shall be inspected by a qualified person before anyone is allowed to work in it. A ladder must be kept near anyone working in any excavation over 1.2 m deep. Excavations must be covered or guardrails installed where there is danger of people falling into them.

Trenching using explosives.

Further direction on the HSR Code requirements for constructing and working in excavations can be found in Appendix 2. Explorationists should also note that WorkSafe BC also provides guidelines for the use and design of excavations, including shoring and sloping requirements.

12.4 Recommended Practices

12.4.1 Excavation

- Where practicable, trenches should be oriented to follow the contour of the slope on slopes greater than 26º (2 h:1 v). This reduces erosion exposure and allows excavated material to be more easily deposited to one side of the trench.
- Where slope is not an issue, topsoil should be selectively placed to one side and overburden (subsurface material) to the other, so that the trench can be refilled in reverse once sampling has been completed.
- On particularly steep slopes where the trench may be in use for an extended period (more than one month), as necessary, topsoil and overburden should be removed from the site and stockpiled separately in a safe, flatter location.
- Topsoil and overburden piles should be covered during wet seasons or weather to reduce the risk of soil erosion (see Chapter 7 for erosion control measures).

Reclaimed trench site; note the width of disturbance, which reflects the depth of overburden.

- Topsoil, subsurface material or other excavation spoils should be placed safely near the excavation. Losing the material downslope of a trench, pit or adit may make recovery for reclamation difficult. In some cases, the material should be placed at the ends of the excavation or removed and stockpiled.
- Consider the use of all-terrain vehicles with backhoe attachments in trenching operations to limit the need for road construction.
- The potential for ML/ARD should be assessed to ensure materials with the potential to leach metals or generate acid rock drainage which are exposed during excavation are managed appropriately.

12.4.2 Seasonal Cleanup—Temporary Sealing

Seasonal clean up takes place when a work program that will continue in the following year is halted for the current season. The objective of the clean up is to ensure that each exploration site is left in a condition that does not pose a danger to personal safety or a potential threat to the environment during the period of inactivity.

- Adit and shaft entrances should be sealed and a means provided for relieving any water pressure that may build up inside the adit or shaft.
- Pit, trench and excavation entrances should be blocked and an appropriate means of relieving and dispersing any water that may overflow should be provided.
- The sides of pits or trenches should be sloped to a stable and safe angle or fenced to prevent inadvertent access by people and wildlife.

Potential ARD?

Review the "Metal Leaching and Acid Rock Drainage" section of this document

12.4.3 Reclamation

Reclamation refers to the activities required to restore a site once exploration is completed and prior to site abandonment. For information on the reclamation of excavations, see Chapter 14.

Checklist: Pits, Trenches and Excavations

Poorly planned excavation activities can cause significant environmental disturbance.

- ❑ Have you taken steps to reduce your excavation's impacts on soils and surface resources by:
  - ❑ Orienting trenches to follow slope contour;
  - ❑ Storing topsoil and overburden separately to aid their replacement;
  - ❑ Assessing the potential for ML/ARD?
  - ❑ Protecting excavated material from erosion;
  - ❑ Preparing the site for seasonal closure by sealing shaft entrances and stabilizing sides of pits and trenches; and
  - ❑ Reclaiming excavations following the completion of work?

12.5 Resources

Alaska Mineral Resources Team, U.S. Dept of the Interior. *Anatomy of a Mine.* http://imcg.wr.usgs.gov/usbmak/anat9.html

B.C. Minister of Energy and Mines. 2003. *The Health, Safety and Reclamation Code for Mines in British Columbia.* http://www.em.gov.bc.ca/Mining/Healsafe/mxready/mxcode01.htm

B.C. Ministry of Energy, Mines and Petroleum Resources. 1981. *Guidelines for Coal Exploration.* Victoria, B.C. 79 pp.

Rebagliati, Mark and Cam Stephen. 2002. *Mineral Exploration Primer.* Part II: Exploration Methods. (British Columbia & Yukon Chamber of Mines) http://www.bc-mining-house.com/mineralexplorationprimer.htm

Smee, Barry M., Smee and Associates Consulting Ltd. *Mineral Exploration Primer.* Part III: Exploration Sampling and Assaying. (British Columbia & Yukon Chamber of Mines) http://www.bc-mining-house.com/mineralexplorationprimer.htm

Virginia Polytechnic Institute and State University. Environmental Health and Safety Services—Glossary. http://www.ehss.vt.edu/Programs/OSD/ExcavationSafety/08_glossary.htm

13 Camps

Exploration Campsite

13.1 Background

Exploration camp construction is regulated under permit conditions and/or legislation. It is your responsibility to be aware of and abide by all the requirements of the permits and the legislation that apply. Camps are usually the most "permanent" structures that are constructed during the program, so choice and location must be well planned to have the least impact on the environment and local communities in the area. A well-planned and organized camp will leave an excellent impression on visitors and will increase the overall efficiency of the exploration operation.

Exploration camps can be at some distance from their associated exploration site or sites. Depending on their location, size and length of use, camps can be subject to more or different environmental issues than other exploration activities (e.g., conflicts with wildlife due to poor practices in handling food or garbage, or contaminants associated with human waste).

13.2 Objectives

Objectives of the MX Code applicable to camps include:

- protecting public health and safety;
- minimizing disturbance to other natural resources, particularly wildlife populations and their habitats by proper waste disposal and handling;
- ensuring minimal individual and cumulative hydrological effects on the flow and quality of surface and groundwater resources;
- minimizing impacts on vegetation and landscapes so as to allow the return to a stable land use that reflects the original use or an acceptable alterative; and
- ensuring cleanup and restoration of campsites on a seasonal basis and at the end of the exploration project.

13.3 What's Required under Legislation

13.3.1 MX Code

The MX Code contains several requirements related to camp management, particularly with respect to their closure at the end of a season and reclamation on permanent closure.

In addition, any camp supporting exploration activities that require permitting should be identified in the Notice of Work application. A reclamation security deposit specifically for the camp may be required in an amount determined by the inspector.

13.3.2 *Health Act*

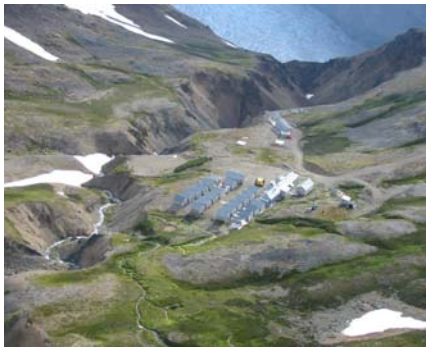
Explorationists who propose camps of a more substantial nature need to be aware of the requirements of the *Health Act's* Industrial Camps Regulation (http://www.qp.gov.bc.ca/statreg/reg/H/Health/427_83.htm#17). This Regulation covers such topics as water source and storage, living space requirements, toilet and washing facilities and garbage handling. The Regulation does not apply to camps that house fewer than five persons or are used for emergency purposes for less than seven days.

Under the *Health Act's* Industrial Camps Regulation, the operator shall dispose of the sewage in the camp in an approved manner that does not create a nuisance, pollute any stream, lake or other body of water or contaminate a water supply, bathing place or shellfish growing area.

The Regional Health Unit office for the area where the camp will be located should be contacted in order to determine necessary authorizations under the Act. The process through the local Health Unit may be time consuming, therefore adequate planning is important.

13.3.3 *Water Act* and *Environmental Management Act*

If usage is greater than one year, a camp may require permits for water use and for waste disposal.



Camp for a large MX project. Camp access was via air transport and given the elevation, care was taken to construct the camp to withstand snow loading.

Water use: An approval to use water is not required if water usage from a surface source is for less than one year. A water approval can be obtained on a year-to-year basis for a fee. A water licence is issued when usage is for a longer period. These authorizations are issued under the *Water Act* by the Water Stewardship Division of the Ministry of Environment.

Liquid waste disposal: Discharges of domestic sewage of less than 22.7 m^3 per day do not require a Waste Management Permit but are required to comply with the *Health Act Industrial Camp Health Regulation*.. Sewage discharges greater than this volume require permitting under the *Environmental Management Act*, administered by the Ministry of Environment.

The major source of sewage in most exploration camps and small construction camps is wash water and human waste. Except in the largest camps, pit privies are used for human waste. The privy should be downslope of the camp and must be downslope of the water intake. Only human waste and chemicals used to promote decay and/or reduce fly populations should be put into the privies. When full, privies are to be capped with at least 30 cm of thoroughly compacted soils.

Wash water from the kitchen and washing facilities should also be disposed of in an approved manner. For small camps, the best method is to discharge the wastewater to a kitchen sump located at least 30 m from any body of water. The pit must be secured against collapse and inadvertent access. For larger camps (more than 12 people) wash water and human waste should be handled by a sewage treatment facility that is properly designed and installed.

Solid waste disposal: Disposal of non-sewage wastes can be by transport to an authorized disposal site, or by burial and/or burning on-site. Disposal should comply with the provisions of the applicable regional district Solid Waste Management Plan where one exists. Check with the local regional district office. These actions should happen as often as is practical throughout the exploration season and completely at the cessation of the exploration program.

13.3.4 Other Requirements

Permits may be required from provincial or local government authorities for campfires and garbage burning; check with the local regional district.

Firefighting equipment is also required under the HSR Code and the British Columbia Fire Code; check with the inspector or local fire district for further information.

Many camps operate electrical generators. For such "electrified" camps, electrical installations must meet requirements of the Canadian Electrical Code.

Temporary field core shack, easily disposed of by either removal or burning.

13.4 Recommended Practices

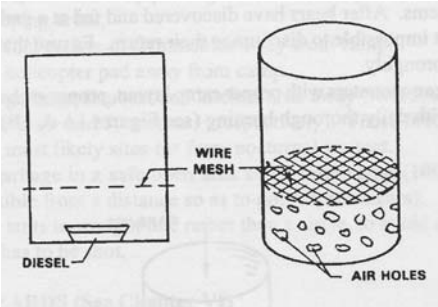
Chapter IV "Camp Management" of the British Columbia and Yukon Chamber of Mines *Safety Manual* (see Section 12.5: Resources) provides guidance on locating, designing and running a small- to medium-sized camp. The following recommended practices are key points to consider; the reader is directed to the manual for more details.

13.4.1 Location and Layout

Selection of an acceptable location for a camp is of paramount importance and proper planning will reduce the need for future mitigation.

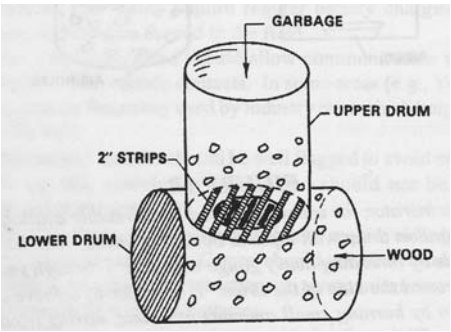
- Consider the following factors in locating a camp:
  - accessibility;
  - presence of high-value vegetation, sites of First Nation significance or other special areas;
  - risk of flooding at times of high runoff;
  - vulnerability to potential forest fires;
  - vulnerability to avalanche, rockfalls or slides;
  - risk of tree fall;
  - supply of safe drinking water;
  - wildlife use (e.g., risk of bear encounters may be higher near old garbage dumps, old camps, bear trails, spawning creeks and berry patches);
  - size of the area (i.e., is it large enough to carry out operations safely and have an allowance for expansion); and

Core storage built for long-term use and able to withstand snow loads.



For use where wood is not available

1. Cut the top from a 45-gallon drum.
2. Punch air holes in the lower quarter of the drum.
3. Place a tray to hold fuel (diesel) on the drum bottom.
4. Suspend a layer of wire mesh above the fuel tray.
5. Burn small amounts at a time, stirring occasionally, to achieve more complete incineration.



For use where wood is available

1. Cut the tops from top of two 45-gallon drums.
2. Punch holes in drums to aid burning.
3. Cut a hole in the side of the lower drum that is smaller than diameter of upper drum.
4. Cut 2" strips out of the bottom of upper drum.
5. Flatten the side of lower drum to hold the base of upper drum.

Figure 12.1: Incinerator design using 45-gallon drums (from BC & Yukon Chamber of Mines, *Safety Manual*: p 23-24.)

- potential wind and snow drifting problems for winter camps (i.e., is the campsite sheltered from strong winds well enough to provide crew comfort and aircraft safety).

- Preference should be given, when locating a camp, to a previously cleared site or area where other land use possibilities are low. If the site was used previously, ask previous users about its suitability and any hazards.
- Tents should be kept at safe distances to decrease fire hazards; it is especially important to locate the kitchen tent away from sleeping tents.
- Fuel caches and flammables should be located away from camp and water sources.
- Sleeping areas should be located at least 100 m away from garbage disposal sites and at least 50 m from kitchen tents to prevent disturbance from nocturnal wildlife.
- Tents should be laid out in straight lines rather than a circle to avoid crossfire if a bear has to be shot.

13.4.2 Garbage and Privy Facilities

Proper garbage handing and disposal greatly reduces problems with bears and other wildlife, as well as human health problems and unsightliness.

- Privies and refuse disposal facilities should be located so that they have the least potential to impact on the environment.
- Garbage should be burned in a safe open area 100 m or more away from camp and visible from a distance so as not to surprise bears. See Figure 13.1 for an example of an incinerator design. The homemade incinerator should have a good venting system and mesh to suspend the garbage, as well as slow-burning accelerant such as diesel fuel to promote a complete burn. A commercial forced-air, fuel-fired incinerator should be considered for large camps.
- Garbage should be burned daily and the remains removed to a legal dump or buried in a pit at least 1 m deep.
- For fly camps of less than one-week duration, refuse, tin cans and other non-combustible waste should be washed, compressed and stored in airtight garbage bags for return to the main camp or town.

13.4.3 Firefighting

- Protect all sleeping units with smoke detectors, checked at least monthly.
- Have a plan for fire break out and conduct fire drills regularly.
- Keep appropriate firefighting equipment in a separate cache and use only for firefighting.
- Ensure that everyone in camp is aware of the location of extinguishers

and firefighting equipment. A simple training program is suggested for all employees so they are better prepared in case of an emergency.

- Provide chemical extinguishers in kitchen and office areas and near engines (e.g., generators). A bucket of sand beside each tent may extinguish a small fire at early stages. There should be at least one 5 lb. fire extinguisher in each sleeping unit.

13.4.4 Problem Wildlife

- Problem animals should be reported to local wildlife authorities.
- Bear spray should be provided as a defence and personnel trained to use it.
- A suitable firearm should be kept in base camp for use as a last resort to protect life or property. Follow current gun legislation. If an animal is shot, it is a legal requirement to turn in certain portions of the remains to wildlife authorities for recording.

Reporting Wildlife Interactions

Report problems with wildlife and the shooting of any animal to the Conservation Officer Service of the Ministry of Environment.

In cooperation with the Provincial Emergency Program, the Conservation Officer Service of the Ministry of Environment operates a 24-hour Call Centre in Victoria to handle calls related to wildlife/human conflicts as well as public reports of environmental violations.

Please call:

1-877-952-7277

13.4.5 Seasonal Closure

- When a work-program that will continue in the following year is halted for the current season ensure each exploration site is left in a condition that does not pose a danger to personal safety or a potential threat to the environment during the period of inactivity.
- fuel and lubricants that have been authorized for storage should be securely stored. Fuel or oil left on-site for future work programs require specific approval of an inspector. Fuel drums left on-site must be stored in a central, secure location away from watercourses. Removal costs must be provided for in the reclamation security deposit.
- All buildings should be secured so that they are not easily accessible by wildlife.
- Non-functioning equipment and large pieces of non-combustible materials should be removed from the site. All equipment and parts to be left on-site should be collected in a central, secure location.
- All refuse must be hauled out for disposal at an authorized landfill or burned and buried in a pit at least 1 m deep.

Abandoned Camps

Any camps that remain inactive for three years are considered to be abandoned and must be removed and the site fully reclaimed. General reclamation provision and practices are listed in Chapter 14. The recommended practices listed here are particular to the closure and reclamation of camps.

13.4.6 Reclamation

- Any petroleum contamination should be effectively remediated prior to abandonment of the camp site (ongoing remediation of any contamination should have occurred during occupation of the site).
- All buildings and structures must be dismantled and removed unless otherwise exempted in writing by an inspector.
- Refuse must be removed, burned or buried.
- All refuse pits should be backfilled.

- Drill cores left on the site should be properly stored in a safe location.
- Remove all fuel and oil drums, both empty and full.
- Remove all non-combustibles (construction materials, drilling rods and cable, metal roofing, etc.) to an authorized landfill/recycling facility or return to the supplier as appropriate.
- Replace previously stockpiled overburden and organic soils and revegetate the area with species appropriate to the site.
- Ensure that all reclamation and rehabilitation measures are well documented and accompanied with a written plan, maps and photographs to the Inspector of Mines.

Checklist: Camps

The MX Code contains several requirements related to camp management, particularly with respect to their closure at the end of a season and reclamation on permanent closure.

- ❑ Have you taken steps to reduce the environmental impacts of your exploration camp by:
  - ❑ Locating the camp in consideration of site environmental factors?
  - ❑ Selecting camp layout design to minimize risks of fire, wildlife interaction and accidental fuel spills?
  - ❑ Locating garbage and privy facilities away from water sources and in areas of low environmental impact?
  - ❑ Designing safe burning facilities to manage garbage on-site?
  - ❑ Equipping the camp with appropriate firefighting facilities?
  - ❑ Addressing problem wildlife through reporting and deterrents?
  - ❑ Ensuring fuels and lubricants, buildings and equipment are stored safely and securely during seasonal closures?
  - ❑ Removing all non-combustible garbage for proper disposal during camp closures?
  - ❑ Reclaiming the site following camp closure by:
    - ❑ Remediating contaminated areas;
    - ❑ Dismantling and removing buildings and other structures;
    - ❑ Burning, burying, or removing refuse to an authorized landfill;
    - ❑ Backfilling all refuse pits;
    - ❑ Removing all fuel containers;
    - ❑ Replacing soils and vegetation; and
    - ❑ Documenting all reclamation and remediation works?

13.5 Resources

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14 Reclamation

14.1 Background

Reclamation on a trail with a 10-m right-of-way. Soil and debris have been pulled back onto the trail and are ready to be replanted.

Reclamation refers to activities undertaken after MX has ceased that are intended to return the land to an appropriate post-exploration condition—typically one that replicates pre-exploration conditions. Reclamation works should be undertaken during active exploration as much as practicable—don't wait until it is all over. In applying for a Notice of Work permit, an explorationist is required to identify reclamation needs for exploration grids, campsites, trails and roads, helicopter accesses, etc. and estimate their costs to derive a reclamation security deposit. To have the reclamation security deposit returned, the explorationist will be required to demonstrate that appropriate reclamation work has been done. This chapter provides details on efficient and effective reclamation practices to meet these requirements.

14.2 Objectives

The objectives of the "Reclamation" portion of the MX Code are to:

- ensure that reclamation work is conducted in a prompt and effective manner;
- provide for the safety of the reclaimed sites;
- minimize the likelihood of adverse environmental impacts over the long term once the site is reclaimed; and
- provide documentation of the reclamation work that was undertaken and allow the owner to recover any security deposit that has been applied under the Section 10(4) of the *Mines Act*.

14.3 What's Required under Legislation

The MX Code requires that all disturbed sites be reclaimed within one year of the cessation of exploration activities unless authorized in writing by an inspector. Pits and trenches are to be backfilled, contoured, seeded and made safe for the long-term; and sites are to be revegetated to a "self-sustaining state." Reclamation measures and results must be reported to the inspector. Only once the reclamation program has met the requirements of the Code can the owner or manager of the exploration site apply for a refund of the reclamation security deposit.

14.4 Recommended Practices

The following steps provide effective reclamation of exploration disturbances:

- removal of all of buildings, old machinery and debris;
- re-establishment of natural landscape shapes;
- replacement of growth media (e.g., soils and organic debris);
- establishment of suitable vegetation; and
- monitoring of progress of reclamation work.

The following sections provide an overview of the recommended practices associated with each of these steps in the reclamation process.

14.4.1 Removal of Buildings, Old Machinery and Debris

- Remove and properly dispose of all buildings, machinery, equipment, cables, culverts and other debris from the exploration areas.
- Where removal of large machinery or foundations is not practical, and where the material will not create an environmental hazard, obtain written permission from the inspector to bury the material on-site with suitable overburden and growth media and revegetate the site.
- Pay particular attention to the removal and safe disposal of petroleum products and any other chemicals used in the exploration work; see Chapter 9 for applicable requirements and regulations.

14.4.2 Re-establishment of Natural Landscapes

Exploration activities often result in landscape modification. Roads and trails, drill pads, campsites, trenches and test pits cause changes in the natural landscape shape. These changes can modify moisture, drainage and nutrient flows in the adjacent ecosystems and can therefore have a profound, although inadvertent, effect on adjacent ecosystems.

Re-contour ground surface shape, simulating pre-disturbance shapes to:

- allow natural ecosystems and processes to re-establish;
- reduce the probability of fill induced landslides;
- allow normal slope processes to continue, and
- minimize restrictions in animal movement

The following sections describe the reshaping of exploration disturbances to re-integrate the sites with the natural surroundings.

Building Removal Exemption

Under 9.12.1 (2) of the MX Code, there is an option for the removal of buildings or camp to be exempted.

The exemption option was provided, among other reasons, to facilitate the transfer of a camp from an operator wanting to meet his permit reclamation requirements and receive his bonding back to a subsequent party or operator who is applying for a permit under its name and would be using and taking responsibility for the camp.

Reclaimed trail on flat terrain; nonmerchantable timber and root balls laid across to discourage use of all-terrain vehicles (ATVs).

Recontoured trail on a steep slope. The site is to be seeded with grass to control erosion.

Roads and Trails

Roads are assets and complete reclamation that obliterates them is not always necessary or desirable. Before any deactivation or reclamation of roads and trail occurs, consult Ministry of Energy, Mines and Petroleum Resources representatives for advice on the level of deactivation and reclamation required.

- Tracked excavators should be used to efficiently re-contour old roads. A significant amount of this work has been completed by the forest industry, and Atkins *et al.* (2000) provides an excellent account of the practices to follow in the restoration of roads and trails.
- Old road surfaces should be ripped and loosened so that they do not act to impede normal groundwater flows.
- Former road ditches should be regraded so that they do not continue to channel water across the slope.
- Where bank seepage exists, provide coarse drain rock with appropriate filter materials to carry seepage safely through the replaced fill materials (see the discussion on groundwater piping in Section 5.2.3).
- Pay particular attention to the re-establishment of natural gullies and swales that occur above and below the old road so that surface drainage patterns are re-established.
- Address road cuts that may be barriers to wildlife by ensuring the cut is filled in a manner that permits animal movement. .
- Sidecast fill material should be recovered so that berms of old fill at the toe of the old fill slope that might impede natural surface water flows are avoided.
- Where end-hauling has been used to dispose of excess cut materials, stockpiled materials should be used where practicable to re-contour the old road.
- Where roads and trails are built across relatively flat terrain, the need to re-contour is not as great. The following points are specific to roads across relatively flat ground:
  - Culverts should be removed to restore natural drainage patterns;
  - Road surfaces should be ripped to loosen compaction and allow natural permeability to be restored; and
  - Any berms or ditches that have been built to should be regraded to prevent the channelling or concentration of surface water.

Recontoured and seeded drill site.

Drill Pads

- Sumps that have been constructed to collect drilling mud should be buried providing the drilling mud does not contain materials harmful to plants or groundwater.

- Drill pad surfaces should be ripped to reduce compaction and promote natural infiltration by rain and snowmelt.
- Safe discharge structures should be provided for seepage sites.
- High cut banks should be reduced to the extent practicable.
- Natural surface water flows should be restored to the extent practicable.

Campsites

An example of a reclaimed campsite. The planted areas provide small forest openings with different aged vegetation.

- Compacted surfaces should be ripped to allow normal water infiltration and growth of vegetation.
- Septic systems including drain fields and holding tanks should be removed and/or deactivated.
- All utilities should be removed and/or deactivated.
- Concrete foundations should be ripped up and removed or buried.
- All refuse, scrap materials and contaminated soils should be removed and disposed of a in an appropriate manner.

Trenches and Test Pits

- If they are not required for future assessment, trenches and test pits should be refilled or slopes regraded to a safe and stable angle that is congruent with the surrounding landforms. The Ministry of Energy, Mines and Petroleum Resources may approve trenches left open for future assessment, provided they are safe and do not create environmental problems.
- All spoil from the excavation of trenches and test pits placed in large mounds should be regraded so that the side slopes are at an angle of 2:1 (26º) or less. They should also be contoured to a shape that is appropriate for the surrounding natural area.

Mine opening closed with rail salvage. This allows passage for bats, permitting their colonization of old workings.

http://www.batcon.org/home/index.asp?idPage=53

Adits and Underground Workings

Unless exploration has determined conclusively that the prospect will never be economic, the Ministry of Energy, Mines and Petroleum Resources may permit the tenure holder to retain access to underground workings.

- Where workings are to be closed:
  - All access roads to surface areas that may be dangerous shall be effectively blocked to prevent inadvertent vehicular access;
  - where there is a possibility of subsidence (cave ins), all shafts, raises, slope openings, adits, or drifts opening to the surface shall be either capped with a stopping of reinforced concrete or filled with material so that subsidence of the material will not pose a future hazard;
  - where there is evidence or a potential for use by wildlife, mine openings may be fitted with a barrier that allows wildlife passage but prevents human entry;

- when openings are permanently closed and where it may be possible for accumulated water to build dangerous pressures and cause a blow-out of the fill or concrete with sudden and dangerous force, a permanent and effective drain shall be installed.
- once the portals are sealed, regrade the portal areas to conform to the surrounding topography.

- Drainage from the underground workings should be tested to ensure it is acceptable for discharge. Where there is a potential for metal leaching or acid rock drainage, continued monitoring and mitigation may be required.

Potential ARD?

Review the "Metal Leaching and Acid Rock Drainage" section of this document

- Once acceptability has been determined, a channel should be constructed to take the drainage water safely to a local natural watercourse. Drainage structures constructed of drain rock can be used to capture diffuse seepage from portal areas and carry it to a safe discharge point at a natural watercourse. A qualified professional should prepare detailed designs for such systems.

14.4.3 Replacement of Growth Media

- Natural soils assist in the growth of vegetation and provide the foundation of productive, self-sustaining plant communities. Once the exploration sites have been regraded, soil materials salvaged prior to the construction of the site (see Chapter 5) should be replaced. Applied soils should:
  - be rough and loose with lots of microsites (small depressions) for seeds to lodge in and germinate;
  - be keyed into the materials under the soils so that they do not slide or slump off;
  - incorporate roots, stumps and other woody debris to reduce erosion and create greater biological diversity; and
  - be revegetated promptly.
- Application of soil materials should be avoided when weather conditions will result in excess erosion and/or degradation of soil structure.
- Where soil stockpiles have been host to invasive plants and noxious weeds, spreading this soil on the reclamation sites will spread the invasive to these sites. A list of the noxious weeds designated for British Columbia is provided in Table 13.1. Management of noxious weeds is a complex topic that is outside the scope of this document; however, where weeds present a problem, the District Inspector can assist in the development of solutions.

Invasive Plant Strategy for British Columbia

Invasive plant species – also known as noxious weeds – are taking over large tracks of land throughout the province. Annual economic losses from invasive plants in BC are in the tens of millions of dollars each year. Without natural enemies to control their populations, these weeds have a competitive advantage over local native plants that makes them very difficult to control. Invasive plants adversely affect crop yields, reduce range productivity (as many weeds are non-palatable or injurious to domestic livestock), reduce wildlife forage and the land's recreational values, impact conifer regeneration efforts and even impact personal health. More information may be obtained at: http://www.fraserbasin.bc.ca/publications/fbc_reports.html

Table 13.1: Weeds Classified as Noxious in All Regions of British Columbia

Common Name	Scientific (Latin) Name
Annual Sow Thistle	*Sonchus oleraceus* L.
Canada Thistle	*Cirsium arvense* (L.) Scop.
Common Crupina	Crupina vulgaris Cass.
Common Toadflax	*Linaria vulgaris* Mill.
Dalmatian Toadflax	*Linaria dalmatica* (L.) Mill.
Diffuse Knapweed	*Centaurea diffusa* Lam.
Dodder	*Cuscuta* L. spp.
Gorse	*Ulex europaeus* L.
Hound's-tongue	*Cynoglossum officinale* L.
Jointed Goatgrass	*Aegilops cylindrica* Host.
Leafy Spurge	*Euphorbia esula* L.
Perennial Sow Thistle	*Sonchus arvensis* L.
Purple Nutsedge	*Cyperus rotundus* L.
Rush Skeletonweed	*Chondrilla juncea* L.
Scentless Chamomile	*Matricaria maritima* L.
Spotted Knapweed	*Centaurea maculosa* Lam.
Tansy Ragwort	*Senecio jacobaea* L.
Velvetleaf	*Abutilon theophrasti* Medic.
Wild Oats	*Avena fatua* L.
Yellow Nutsedge	*Cyperus esculentus* L.
Yellow Starthistle	*Centaurea solstitialis* L.

Source: *BC Weed Control Act,* Ministry of Agriculture and Lands website http://www.agf.gov.bc.ca/cropprot/noxious.htm

14.4.4 Revegetation

Revegetation of exploration sites can be relatively easy once the sites have been regraded and the soil materials have been applied. The following should be considered in the establishment of a suitable, self-sustaining vegetation cover on the disturbed sites:

- natural vegetation in the area;
- natural successional processes operating in the area;
- vegetation establishment procedures; and
- any constraints to revegetation.

Biogeoclimatic Zones
The vegetation of British Columbia has been divided into 14 major units called biogeoclimatic zones. By knowing which zone your exploration activities are located in, you can gain a significant amount of information about the ecological conditions of your site. A series of books dealing with site identification and interpretations have been developed by the Ministry of Forests and Range for each forest region. These are available at Crown Publications and may be viewed at local Ministry of Forests and Range offices.

Natural Vegetation

- Use plant species appropriate to the site. The natural vegetation in an area can be an excellent indicator of the vegetation that can be potentially established on exploration disturbances. There is little point in planting Douglas fir trees in an area where there are no Douglas fir growing naturally. Similarly, if the adjacent vegetation is sparse and indicative of dry conditions, then planting species that can grow under dry conditions

will probably be more successful than planting species that need moist sites to grow.

Natural Successional Processes

The most effective means of establishing a self-sustaining vegetation cover on disturbed sites is to re-integrate the site into the natural successional processes that operate in the area (Polster 1989). Creating conditions that encourage the colonization of the disturbed site by native pioneering species will help to ensure that suitable species will be present as the site revegetates. It must be noted, however, that providing conditions for the establishment of native pioneer species may also permit the spread of invasive plants should a seed source be present in the area.

Native vegetation needs:

- stable soil surfaces to aid new vegetation in becoming established;
- appropriate microsites into which native seeds can lodge and germinate; and
- suitable seed sources in the surrounding local area.

Vegetation Establishment Procedures

The initial vegetation that is established on a site plays a significant role in the establishment of subsequent vegetation. Seeding in a suitable cover of grasses and legumes is the normal means of getting this initial cover established. In most cases, agronomic species are used, as the availability of native species is limited. However, more and more native species are becoming available and should be used if practicable. The following key points need to be considered in the establishment of an initial vegetation cover on exploration sites.

Site Fertility

- Most reclamation sites have little in the way of available plant nutrients and an application of fertilizer with the seeded cover to assist in the establishment of this vegetation.
- When applying fertilizer:
  - Use of a balanced fertilizer (e.g., 13—16-10 or 19-19-19) is generally suitable for most sites
  - Suit application rates to soil conditions – in most cases approximately 200 kg/ha at time of seeding
  - For sandy type soils with poor nutrient retention, apply a slow release fertilizer 3/4 times per growing season (approx. 50 kg/ha/application)
  - Do not over-apply, as this may create a dense grass thatch that may impede establishment of legumes and native pioneering species.

Suitable Grass and Legume Mixes

The vegetation expected to result from the application of seed will ideally control erosion while remaining open enough to allow natural regeneration by native species.

- A seed mix should be chosen appropriate to the site characteristics, including:
  - Soil, moisture and nutrient regimes – seed mixes should be selected to provide vegetative coverage suited to these basic site conditions;
  - Use by wildlife – on alpine rangelands, attraction of wildlife is desirable so a mix that is palatable to the species of wildlife in question would be best; and
  - Rate of successional processes – where natural regeneration of vegetation is expected to be rapid, a high proportion of the selected species should be relatively short lived.
- Mixes with a larger number of species should be selected as they will provide better coverage on a diversity of sites than mixes with fewer species.
- Quality seed mixes should be chosen. The quality of the seed that goes into a seed mix can have a significant influence on the successful establishment of vegetation. Seed mixes with a high tolerance for weed seeds can result in the introduction of invasive plant species.
- Seed mixes balanced on the basis of seed weight so that smaller seeded species do not occupy an inordinate percentage of the mix by species composition are preferred.
- Desired re-vegetation objectives should be promoted by:
  - Choosing a Canada Certified No.1 seed prior to mixing or a Varietal Blend No.1
  - Avoiding No.1 Common, Forage or Ground Cover mix as these may have as little as 60% pure live seed.
  - Always selecting the best quality seed given seed costs are a small proportion of overall costs.

Trail being reclaimed in a plantation.

Application Methods

Getting the seed and fertilizer in the right spots on the ground can be difficult and costly if the wrong methods are used. Table 13.2 provides a listing of the basic seeding methods and the advantages and disadvantages of each.

Table 13.2: Seed Methods—Advantages and Limitations

Seeding Method	Advantages	Limitations
Hydroseeding	- Useful for steep slopes - Can add tackifier/binders - Can be helicopter applied	- Seed not in soil - Costly - Relatively slow - Needs water - Heavier seeding rates
Broadcast seeding	- Useful for large areas - Can be helicopter applied - Relatively inexpensive - Can use available equipment	- Seed not in soil except by harrowing - Not very accurate - Heavier seeding rates - May have uneven seeding
Drill seeding	- Seed placed in soil - Good seedbed prepared - Can use lower seeding rates	- Restricted by land based operations and access - Need specialised equipment - Seed spread in rows
Air seeding	- More even than broadcast - Seed may not be buried except by harrowing	- Costly equipment - Restricted by land based operations and access

- For small areas, hand-held broadcast seeders should be used as they are the easiest and least costly means of applying seed and fertilizer.
- For large diffuse areas such as often occur with MX, consider the use of a helicopter to effectively broadcast the seed on reclaimed roads, drill pads and other such sites.
- Small four-wheeled recreational motorcycles (quads) or small farm tractors may be used to broadcast seed over and harrow long linear disturbances that are reasonably groomed.
- Large areas such as the top of a large tailings pond may be seeded using a tractor pulling a seed drill. Seed drills actually insert the seed into the substrate and care must be taken with perennial grasses and legumes that the seed is not inserted too deeply.
- On relatively rough terrain, choose one of the variety of rangeland seeders available on the market.
- Consider hydroseeding as an effective means of applying seed and fertilizer.
    - The ability to apply tackifiers (seed glue) and mulch makes hydroseeding a preferred method for very steep slopes, although larger than normal quantities of seed must be applied.
    - In some cases, hydroseeding using heavy mulch applications at high elevations results in very poor seed germination as the mulch insulates the seed and prevents it from germinating.
    - Hydroseeding slurries can be pumped into helicopter seeding buckets and applied from a helicopter. Such applications are costly but useful for sites such as remote drill sites where steep slopes and poor access makes other seeding methods ineffective.

Revegetation Scheduling

Timing of revegetation work is critical to its success. Knowledge of the climate can help to determine the best time for seeding. Environment Canada publishes the climatic normal (averages over 30 years) for about 300 stations in British Columbia at http://www.msc-smc.ec.gc.ca/climate/climate_normals/index_e.cfm. Select a period when there will be ample moisture for germination and early growth of the seeded species and when there will be mild temperatures for the best results.

An example of a reclaimed gold drill site. Woody debris was retained; grass was planted and then replanted with trees. At the time of the photo the trees were about six years old.

- Seeding should be conducted when the seed has an opportunity to germinate and grow or when it will remain dormant until such a time as weather conditions allow germination and growth.
- In some cases, consider seeding a portion of the exploration area during the optimum seeding period and the remaining areas at the end of the season just before the winter snow begins.
- Consider specific site conditions when selecting the optimum seeding period. Seeding in the middle of August has proven to work well in many higher elevation locations throughout British Columbia as there is still ample warmth in the sun, and often there is enough moisture to allow germination and growth before winter sets in.
- In many interior locations, consider applying seed and fertilizer just prior to the first permanent winter snow to allow the seed to lie dormant under the snow for the winter and to germinate and grow in the spring with the melting snow. Care should be taken to ensure the seed does not start germinating before it is covered with snow and goes dormant.

Planting Woody Species

In some cases, it will be necessary or desirable to plant trees and shrubs to attain some specific conditions in the reclaimed environment. Reforestation may be required under the *Forest and Range Practices Act* when exploration is conducted on forestland.

Reclaiming a road. Soil has been loosened and large debris and root balls pulled over the roughened surface.

Replacement of riparian vegetation may be required where exploration activities encroach on the riparian zone along streams, rivers, lakes and the ocean. Details on the establishment of woody species in your area can be obtained from the Ministry of Forests district offices.

- Planting container-grown trees and shrubs selected for their ability to grow in the exploration area can be the simplest means of establishing woody species.
- In moist locations willow, cottonwood and red-osier dogwood can often be established from live stakes or cuttings. Cuttings should be a minimum of 2.5 cm in diameter and at least 50 cm long. These should be planted so that only 10 cm is above the soil surface. Stakes and cuttings will need to be installed at a high density to

accommodate this method's low expected survival rate (estimated to average between 10% and 25%).

Constraints to Revegetation

- Steep slopes can limit revegetation success. To aid vegetation establishment, consider flattening slopes or providing slope breaks.
- Dark substrates on south-facing slopes can get too hot to allow plant growth. Consider using mulching to assist in establishing vegetation.
- Where soil toxicities such as sodic (alkaline) soils, high metals contents or pH extremes can result in poor plant growth, plant species should be selected for their tolerance of extreme conditions. These can be used to establish an initial cover.
- Lack of moisture commonly limits plant growth. Free draining soils or sites with low rainfall can result in a lack of moisture for plant growth. Consider selecting plant species that are drought tolerant in these conditions.
- Cool temperatures associated with high elevation sites can prevent some species from germinating and growing. Species tolerant to cool temperatures should be selected.
- Heavily compacted soils can limit plant growth. To address this constraint, compacted sites should be ripped to a depth of at least 50 cm.

14.4.5 Monitoring Reclamation Work

Monitoring reclamation work is an effective way of ensuring that the work is done correctly.

- If a contractor is completing the reclamation work, checks should be completed to ensure the works and terms of the contract are carried out correctly.
- Once the work is complete, monitoring should be completed to determine how effective the reclamation work has been and to provide an indication of what changes might be incorporated in any future work.

Checklist: Reclamation

The MX Code requires that all disturbed sites be reclaimed within one year of the cessation of exploration activities unless otherwise authorized by an inspector; that pits and trenches are made safe; and that sites are revegetated to a "self-sustaining state."

- ❑ Have you adequately completed reclamation for your mineral exploration activities?
- ❑ Has monitoring of the reclaimed area confirmed that, within one year of ending your exploration activities, the area of your activity is:
  - ❑ Clear of all buildings (unless authorized by an inspector), utilities, machinery and debris, including petroleum products and other chemicals;
  - ❑ Re-established to its natural landscape shape, with altered sites re-contoured and deactivated, surface drainage patterns re-established, and slopes stabilized;
  - ❑ Covered with replaced growth media salvaged from the site; and
  - ❑ Revegetated with plant species suitable for the site's soil nutrient and moisture conditions?

14.5 Resources

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Appendix 1

Part 9 of the Health, Safety and Reclamation Code for Mines in British Columbia: Mineral Exploration (MX)

Contents

Definitions

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Definitions

*"**acid rock drainage (ARD)**"* means low pH surface or ground water that results from the oxidation of sulphide minerals or, elemental sulphur, or the dissolution of acid generating minerals found in rocks and coal.

*"**bridge**"* means a temporary or permanent structure carrying an exploration access above a stream or other topographic depression.

*"**clearing width**"* means the width required to be cleared of standing timber to accommodate exploration access construction, maintenance and use.

*"**community watershed**"* has the same meaning as defined in the *Forest and Range Practices Act.*

*"**culvert**"* means a transverse drain pipe or log structure buried below the exploration access surface.

*"**deactivation**"* means stabilization of an exploration site or exploration access when active use of the site or access is suspended seasonally or for other reasons for a period up to 3 years or longer if approved by an inspector.

*"**deleterious substance**"* means any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man or fish that frequent that water.

*"**exploration access**"* means trails and roads constructed, modified, excavated, bladed or created through frequent use including any associated structures.

*"**exploration activities"*** are those activities which are undertaken in the search for and development of coal and minerals, as defined in the *Mineral Tenure Act*, with the exception of placer minerals:

(a) and include:

(i) disturbance of the ground by mechanical means such as drilling, trenching and excavating;

(ii) blasting;

(iii) construction, modification, deactivation and reclamation of an exploration access and camps;

(iv) induced polarization surveys using exposed electrodes; and

(v) site reclamation.

(b) but do not include:

(i) prospecting using hand tools;

(ii) geological/geochemical surveying;

(iii) airborne geophysical surveying;

(iv) ground geophysical surveying without the use of exposed, energized electrodes;

(v) hand trenching without the use of explosives; or

(vi) establishment of exploration grid lines that do not require the felling of trees, with the exception of trees and shrubs that create a hazard to safe passage and danger trees as defined in the Workers' Compensation Board Regulation.

*"**fish passage**"* means the movement of fish at all life stages consistent with the natural state of fish streams.

*"**fish stream**"* means all streams, unless:

(a) a report from a qualified professional or technologist with adequate training or knowledge of fish habitat determines that the stream is a non-fish bearing stream; or

(b) the stream has been identified in a fish inventory carried out in accordance with the Ministry of Forests' publication "Fish Stream Identification Guidebook", as amended from time to time, as not containing any fish; or

(c) the stream is located upstream of a known barrier to fish passage, identified on a fish and fish habitat inventory map, where all reaches upstream of the barrier are simultaneously dry at any time during the year and no perennial fish habitats occur in any part of the upland drainage.

*"**reach**"* means a portion of a watercourse that has a consistent channel width, morphology and gradient.

*"**regionally significant wildlife habitat**"* means those site specific habitats identified through formal government processes as requiring special management attention.

*"**riparian setback**"* means an area of land adjacent to a stream, wetland or lake of a width defined in Table 9.1.

*"**road prism**"* means cross-section of the ground containing the exploration access surface, including the cut and fill slopes.

*"**soil**"* means the naturally occurring, unconsolidated mineral or organic material that is capable of supporting plant life.

*"**stream**"* means any naturally occurring reach flowing on a perennial or seasonal basis with a continuous channel bed and banks, whether or not the bed or banks of the reach are locally obscured by overhanging or bridging vegetation or soil mats, if the channel bed:

(a) is scoured by water; or

(b) contains any material collection of inorganic alluvium deposited by water.

*"**stream width**"* means the horizontal distance between stream banks on opposite sides of the stream measured:

(a) at right angles to the general orientation of the banks; and

(b) between the points on each bank indicated by a definite change in vegetation and sediment texture marking the normal annual flood level and sometimes shown by the edges of rooted terrestrial vegetation.

*"**temporary bridge**"* means a bridge whose expected life at its current location is 15 years or less.

*"**wetland**"* means an area of 0.25 hectares or greater, unless a smaller area is identified as regionally significant wildlife habitat, that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in wet or saturated soil conditions.

Application

9.1.1 This part applies to persons engaged in mineral and coal exploration activities under the authority of the *Mines Act*.

Notice Requirements

9.2.1

1) Prior to undertaking proposed exploration activities and pursuant to Section 10 of the *Mines Act*, a Notice of Work as prescribed by the chief inspector shall be submitted to an inspector and shall include:

   (a) information required pursuant to the Mines Act and Code and any additional information as may be prescribed by an inspector;

   (b) maps and schedules of the proposed exploration activity, applicable land use designation, up-to-date resource inventory and tenure information which is available from Provincial agencies 30 days prior to the time of application; and

(c) details of actions designed to minimize any adverse impacts of the proposed activity.

2) A copy of all permits and authorizations issued with respect to the exploration activities shall be maintained at the exploration site while exploration activities are taking place; and

3) An annual summary of exploration activities, as prescribed by the chief inspector, shall be submitted by March 31.

Health & Safety

First Aid

9.3.1 In addition to complying with the emergency preparedness provisions of Part 3 of the Code:

1) Active exploration sites of mechanical disturbance shall be equipped with a minimum Level-2 first aid kit, a stretcher and an epinephrine auto injector, and have provision made for continuous and consistent emergency communication; and

2) At exploration drill sites, at least two members of the drill crew shall have a valid Worker's Compensation Board Level 1 or equivalent first aid certificate unless the work site is accessible in all weather conditions and within 5 minutes of a facility where there is a qualified first aid attendant.

Training

9.3.2 All persons employed at an exploration site shall be trained in accordance with Section 1.11, including where applicable:

(a) safety with respect to wildlife;

(b) wearing of appropriate clothing;

(c) use of personal protective equipment;

(d) need for and use of suitable equipment to avoid becoming lost;

(e) safety procedures to be adopted for boat handling operations; and

(f) safe practices when working in or around aircraft, including effective communication.

Pits, Trenches & Excavations

9.3.3

1) No person shall be permitted to enter any excavation over 1.2 metres in depth unless:

a) the sides of the excavation are sloped to a safe angle down to 1.2 metres from the bottom of the trench; or

b) the sides have been supported according to the requirements of Part 4 of this Code.

2) When it is required for persons to enter an excavation the minimum width of an excavation shall be such that a person is able to turn around without coming into contact with the sides;

3) Excavated material shall be kept back a minimum distance of 1 metre from the edge of any trench. excavation, and 1.5 metres from any other excavation;

4) A qualified person shall inspect an excavation immediately before any person is allowed to enter, and any hazard shall be made safe before persons are allowed to conduct other work in the excavation;

5) Sloping of the sides of excavations may be undertaken instead of shoring only where the protection afforded to personnel is equivalent to that provided by shoring; and

6) Where excavation walls are sloped as a substitute for shoring, the walls shall be sloped at angles, dependent upon soil or rock conditions, which will provide stable faces. In no case shall such a slope be steeper than a ratio of one horizontal to one vertical. When shoring is installed or removed, the work procedure shall ensure that persons are not exposed to undue risk.

Uranium & Thorium

9.3.4 Unless the chief inspector permits otherwise, where standard assay results show, or are expected to show uranium mineralization in a grade of 0.05% by weight or greater or thorium mineralization in a grade of 0.15% by weight or greater, the owner agent or manager shall ensure that:

(a) all drill holes must be completely sealed with concrete on completion of exploration;

(b) all practicable precautions are taken to ensure no drilling fluid, water or drill cuttings contaminate any drinking water supply, irrigation water supply, or surface water;

(c) all persons working at the exploration site are provided with a gamma radiation dosimeter of an approved type; and

(d) no person is exposed to a whole body dose of more than 5 millisieverts in a 12 month period.

Induced Polarization Geophysical Survey Systems

9.3.5

1) Where an induced polarization geophysical system is being operated

(a) energized wires shall be sufficiently insulated to prevent electric shock;

(b) induced polarization electrodes shall have visible warning stickers stating "Danger - High Voltage;"

(c) signs shall be posted to warn other persons who may enter the area;

(d) electronic communication shall be provided to every member of the crew whose movements are out of sight and sound of the other crew members; and

(e) all signs shall be removed on completion of the survey and no wires used during the survey shall be left on the site after the survey is completed.

2) Electric blasting activities shall be coordinated with active induced polarization and active electromagnetic survey work.

9.3.6

Use & Storage of Explosives

1) The use and storage of explosives shall be pursuant to the provisions of Part 8 of this Code; and

2) Blasters shall have a valid blasting certificate granted pursuant to Part 8 of this Code.

Community Watersheds

9.4.1

1) Exploration activities shall:

(a) maintain surface and subsurface drainage patterns within the range of natural variability;

(b) protect stream channel stability; and

(c) not degrade water quality at a potable water supply intake so that it fails to meet the potable water requirements of the Drinking Water Protection Act and regulations as amended from time to time.

Notification Requirements

9.4.2 An owner, agent or manager responsible for exploration activities in a community watershed shall:

(a) notify, at least 48 hours prior to the start date of the activities, the water licence holder of record or the representative of record;

(b) prior to commencing work ensure a contingency plan is in place to restore potable water in the event that exploration activities adversely impact potable water quality and quantity; and

(c) immediately cease exploration activities and take remedial action if those activities adversely impact potable water quality and quantity.

Riparian Management

Table 9.1: Riparian Setback Distances (measured horizontally from the top of bank)

Riparian Type	Size	Drilling (m)	Exploration Access (m)
Stream	**Stream widths (m)**		
	>20	**50**	**70**
	>5≤20	**30**	**50**
	1.5≤5	**20**	**40**
	<1.5	**5**	**30**
	<0.5 in alpine areas above timberline	**5**	**15**
Wetland	**Wetland Size (ha)**		
	> 5	**10**	**30**
	>1.0 <5.0	**10**	**20**
	>0.25 <1.0	**10**	**10**
Lake	-	**10**	**30**

9.5.1

1) The following activities may be carried out within the setback distances noted in Table 9.1:

   (a) construction, maintenance, deactivation and reclamation of stream crossings;

   (b) access from water landings for the purpose of servicing exploration camps and equipment;

   (c) access to set up and service water supply pumps and lines; and

   (d) access to service drill sites.

2) Exploration activities in addition to those in (1) may occur within the riparian setback distances noted in Table 9.1 when one or more of the following conditions apply:

   (a) no other practicable option exists;

(b) risk to health and safety can be reduced; or

(c) risk of adverse impact to the environment can be reduced.

3) When there is an intent to operate within the riparian setback distances noted in Table 9.1 pursuant to (2) the owner, agent or manager shall prepare a management plan, acceptable to an inspector, shall be approved and the plan must show how the proposed activities will to the extent practicable:

(a) maintain the integrity of the stream, lake or wetland;

(b) prevent the introduction of deleterious substances into a stream, lake or wetland; and

(c) minimize the disturbance caused by the activity.

Soil Conservation

9.6.1 Exploration activities shall be carried out in a manner that minimizes soil loss so that the site can be reasonably reclaimed to support appropriate self-sustaining vegetation.

Terrain

9.7.1

1) Exploration activities shall be designed and implemented by a qualified person to minimize the risk of those activities causing any of the following events:

(a) landslide;

(b) channelized debris or mud flow;

(c) gully bank destabilization;

(d) debris fan;

(e) snow avalanche; or

(f) destabilization of an alluvial fan.

2) if an exploration activity causes an event as noted in Section 9.7.1 the owner agent or manager shall as soon as practicable

(a) take necessary steps to protect human life and safety;

(b) stabilize any disturbed areas;

(c) promptly report the event to an inspector; and

(d) where the event as noted in Section 9.7.1:

i) places human life or safety at risk;

ii) damages property or infrastructure;

iii) adversely affects water quality, or damage water supply infrastructure;

iv) results in harmful alteration to fish habitat; or

v) results in harmful alteration of regionally significant wildlife habitat.

Ensure the preparation, within 30 days, by a qualified person of a remediation plan acceptable to an inspector and implement the plan within a time frame specified by the inspector.

Water Management 9.8.1

1) Where exploration activities or exploration access may impact the natural surface and subsurface drainage of an area, structurally sound, functional and stable drainage systems shall be constructed that minimize:

   (a) water flowing uncontrolled onto the exploration site;

   (b) erosion or destabilization of the exploration site;

   (c) water being directed onto, or creating, potentially unstable slopes or soil materials; and

   (d) water flowing onto reclaimed areas unless the reclaimed areas are protected with the use of riprap or other effective means or the water flow is an integral part of the reclamation scheme.

Fuel & Lubricants 9.9.1

1) liquid hydrocarbon products shall be stored within a containment that minimizes the possibility of accidental discharge to the environment;

2) unless authorized by an inspector, bulk liquid hydrocarbon products shall not be stored within 30 meters of a stream, lake or wetland;

3) ground-based machinery shall not be fuelled or serviced within the riparian setback distances for drilling specified in Table 9.1, other than pumps and machinery that are:

   (a) hand held;

   (b) required for firefighting;

   (c) broken down and requiring fuelling or servicing to be moved; or

   (d) authorized by an inspector to be fuelled or serviced in the area.

4) The owner, agent or manager shall remove all hydrocarbon containers, whether empty or full, from every exploration site by the end of each field season, unless otherwise authorized by an inspector.

Exploration Access 9.10.1

1) The construction, maintenance, deactivation and reclamation of exploration access and bridges or any other form of a stream, lake or wetland crossing shall result in exploration access and crossings that are stable, safe for the intended use, and which:

   (a) minimize erosion, mass wasting or the degradation of a stream, lake or wetland by the introduction of sediment, debris or deleterious matter;

   (b) minimize adverse impacts on stream channels;

   (c) make provision for drainage systems that maintain stability of the road prism;

   (d) do not cause harmful alteration, damage or destruction of fish habitat; and

   (e) has the minimum surface disturbance necessary to complete the proposed work.

2) Clearing of standing timber shall not exceed the minimum required to accommodate the road prism, user safety and other operational requirements;

3) Material known to be capable of generating acid rock drainage shall not be used for exploration access surfacing or ballasting unless approved by an inspector;

4) Exploration access shall not interfere with the subsurface flow of a drainage area that contributes to a water supply used for licensed domestic consumption unless:

   (a) there is no other practicable option; and

   (b) the impacts of the access construction can be mitigated.

5) There shall be a program to routinely monitor and maintain exploration access as necessary and prudent so that it is stable and safe for the intended use until it is reclaimed to the satisfaction of an inspector;

6) Deactivation of exploration sites and access shall result in:

   (a) stabilization of the exploration site, access road prism and clearing widths;

(b) restoration or maintenance of drainage patterns; and

(c) minimization of soil erosion to the extent practicable.

7) Reclamation of exploration access shall result in:

(a) restoration of drainage patterns;

(b) removal of bridge superstructures;

(c) removal of bridge substructures if failure would affect downstream values;

(d) removal of all stream culverts;

(e) a stable surface that minimizes future erosion; and

(f) the establishment of self sustaining vegetation appropriate for the site which may include reforestation if so directed by an inspector.

8) Stream crossings shall be constructed, maintained, deactivated and reclaimed in a manner that allows safe fish passage and protects fish habitat at, above and below the stream crossing;

9) Stream crossings on streams that do not contain fish shall be constructed, maintained, deactivated and reclaimed in a manner that does not adversely affect downstream fish values;

10) An owner, agent or manager shall ensure that bridge design and fabrication is certified or approved by a qualified person;

11) An owner, agent, or manager shall ensure that:

(a) metal and concrete bridges are inspected by a qualified person at least once every three years, and other bridges at least once every two years, or as prescribed by the designer;

(b) inspection records are maintained for the life of any bridge structure; and

(c) any deficiencies identified as a result of an inspection are corrected as soon as practicable.

12) Bridges, stream culverts and their approaches shall be designed, constructed and maintained to pass the peak flows set out in Table 9.2;

13) Despite 9.10.1 (12), a temporary bridge or stream culvert may be constructed at a crossing to meet the expected flow during the period of use if:

(a) the stream is not a fish stream;

(b) the installation and use will be in a period of low annual stream flows; and

(c) the culvert or temporary bridge is removed before the period of high annual stream flows.

Table 9.2: Minimum Design Peak Flow

Crossing Type	Return Period (Years)
Permanent bridges	**100**
Temporary bridges	**50**
All stream culverts	**100**

Drilling 9.11.1

1) Drill sites shall not be located:

   (a) within a stream;

   (b) within a lake unless a management plan has been approved by an inspector; or

   (c) within a known wetland unless:

      i) the exploration activity is conducted when the ground is frozen;

      ii) at the time that work is conducted there is no standing water at the drill site; or

      iii) a management plan has been approved by an inspector;

   (d) within a riparian setback area as defined in Table 9.1:

      i) unless authorization has been obtained pursuant to the provisions of Sections 9.5.1(2) and 9.5.1(3); and

      ii) management plans shall include provision for management of drilling discharge.

2) An owner, agent or manager shall ensure that pumps and pump fuel supplies use absorbent mats and containment devices to prevent spilled liquid hydrocarbons from escaping;

3) During drilling operations, practicable measures shall be taken to manage the flow of drilling discharge, and minimize the impact on streams, wetlands or lakes;

4) Appropriate emergency spill kits shall be readily available at all active drill and water supply pump sites;

5) Groundwater shall not be permitted to flow from completed drill holes without the written authorization of an inspector; and

6) Upon abandonment of an exploration drill site, all equipment, waste and other refuse shall be disposed of properly.

Camps

9.12.1

1) An exploration camp required to support future exploration activities shall be left in a clean and safe condition and where practicable secured from wildlife access at the end of each field season.

2) An exploration camp not required to support future exploration activities shall be dismantled, removed and the site reclaimed, unless otherwise exempted in writing by an inspector.

3) Before leaving a camp for the season or reclaiming a campsite, all refuse shall be removed or burned and buried so that it will not attract wildlife, refuse pits shall be backfilled, and food and explosives removed from the site.

Reclamation

9.13.1

1) Reclamation of mechanically disturbed sites, campsites and exploration access shall occur within one year of cessation of exploration unless authorized in writing by an inspector;

2) Pits and trenches shall be backfilled and reclaimed prior to abandonment, unless:

   (a) the sides of the pit or trench are sloped to a stable and safe angle as determined by a qualified person, or the pit or trench is fenced to prevent inadvertent access; and

   (b) there is a means of egress.

3) Appropriate measures shall be taken to minimize the establishment of noxious weeds and the erosion of exposed or disturbed soil;

4) Exploration sites shall be revegetated to a self-sustaining state with species appropriate for the site;

5) The results of reclamation measures shall be reported to an inspector upon completion of the reclamation work; and

6) Where a security deposit has been posted for reclamation, the owner, agent or manager may apply to an inspector in writing for a refund of the security deposit when the reclamation program has met the requirements of this code.

Appendix 2

Health, Safety and Reclamation Code for Mines in British Columbia
Part 4.17 - Excavations

Instructions of a Professional Engineer

4.17.1 All excavation work shall be carried out in accordance with the written instructions of a professional engineer where:

(1). the excavation is more than 6 m deep,

(2). timber shoring is used in excavations exceeding 3.7 m in width, or

(3). improvements or structures adjacent to the excavation could endanger persons, or

(4). the excavation is subjected to vibration or hydrostatic pressure.

Certification by a Professional Engineer

4.17.2 The written instructions required by Section 4.17.1 shall be signed and certified by the professional engineer and be available at the workplace. They shall describe the supporting or sloping requirements and indicate the sub-surface conditions likely to be encountered.

Manager's Requirement

4.17.3 The manager shall ensure that no person enters any excavation over 1.2 m in depth unless:

(1). the sides of the excavation are sloped to a safe angle not exceeding 3 horizontal to 4 vertical, or

(2). the sides have been supported in accordance with the minimum requirements specified in Tables 17.1 and 17.2 of this part, or

(3). the sides have been sloped or supported in accordance with the written instructions of a professional engineer.

Combination of Sloping and Shoring

4.17.4 When a combination of sloping and shoring is used, the protection provided to persons shall be equivalent to that meeting the minimum code requirements for the overall depth of the excavation.

Use of Lumber for Shoring and Timbering

4.17.5 Lumber used for shoring and timbering shall be #2 grade and better, and species to be limited to the following groups: Douglas Fir-Larch, Hem-Fir, Spruce-Pine-Fir or Coast Sitka Spruce. All lumber shall be graded to the National Lumber Grades Authority Rules or other grading rules approved by the chief inspector.

Shoring Contact With Faces of Excavation

4.17.6 Shoring or manufactured or prefabricated support systems shall be installed in firm contact with the faces of the excavation. Any voids shall be backfilled or blocked.

Hydraulic or Pneumatic Jacks

4.17.7 Hydraulic or pneumatic jacks shall have devices which maintain the jacks at their installed length in the event of a loss of internal pressure.

Steel Trench Jacks

4.17.8 Steel trench jacks, with minimum equivalent sizes as shown below, may be substituted for timber struts:

Diameter	Nominal Strut Size		Nominal Pipe Size
	Inches	(mm)	Inches (mm)
(38)	4x4	(89x89)	1.5 Standard
(50)	4x6, 6x6	(89x140, 140x140)	2.0 Standard
(76)	6x8, 8x8	(140x184, 184x184)	3.0 Standard

Use of Plywood

4.17.9 Plywood may be substituted for 50 mm (2") shoring elements provided that

(1). the plywood is not less than 19mm (3/4") in thickness;

(2). the trench is not over 2.7 m in depth; and

(3). uprights are installed at no more than 600 mm centre to centre, and struts do not bear directly on to plywood.

Ladder to Be Kept

4.17.10 A ladder shall be kept in the immediate area of persons working in any excavation over 1.2 m deep.

Requirements Prior to Starting Excavation or Drilling

4.17.11 Prior to starting excavating or drilling, the location of underground utility services in the area shall be accurately determined to ensure persons are not endangered.

Pointed Tools

4.17.12 Pointed tools shall not be used to probe for underground gas and electrical services.

Surrounding Equipment and Objects

4.17.13 Trees, utility poles, rocks and similar objects near an area to be excavated, shall be removed or secured before excavation is commenced.

Excavated Material

4.17.14 Excavated material shall be kept back a minimum distance of 600 mm from the edge of any trench excavation less than 3.6 m wide. In any other excavation, the minimum distance shall be 1.2 m.

Danger of Persons Falling Into Excavation

4.17.15 Where there is a danger of persons falling into an excavation, it shall be covered, or standard guardrails or barriers shall be placed along the exposed sides.

Table 17.1 Excavations over 1.2 m in Depth Size and Spacing of Members (Imperial Units)

Uprights			Wales		Struts			
Trench Depth (feet)	Minimum Dimension (inches)	Maximum Spacing (feet)	Minimum Dimension (inches)	Maximum Vertical Spacing (feet)	Width of Trench (feet)		Maximum Spacing	
					Up to 6	6 to 12	Vertical (feet)	Horizontal (feet)
					Minimum Dimensions (inches)			
Hard and Soft Solids								
4-10	2x10	6	4x6	4	4x4	6x6	4	6
10-15	2x10	3	6x6	4	4x6	6x8	4	6
Soils Likely to Crack and Crumble								
4-10	2x10	3	4x6	4	4x6	6x6	4	6
10-15	2x10	3	6x8	4	6x6	6x8	4	6
Soft, Sandy, Filled or Loose Soils								
4-10	2x10	Close tight	6x8	4	6x6	6x8	4	6
10-15	2x10	Close tight	8x8	4	6x8	6x8	4	6

Notes:

(1) Wales may be omitted in trenches not exceeding 8 feet (2.44 m) in depth provided the soil is sufficiently hard and solid to safely permit wale deletion and the trench is not in proximity to previously excavated ground.

(2) At least 2 struts shall be installed in each vertical plane where struts are required.

Table 17.2 Excavations over 1.2 m in Depth
Size and Spacing of Members (S.I. [Metric] Units)

Uprights			Wales		Struts			
Trench Depth (m)	Minimum Dimension (mm)	Maximum Spacing (m)	Minimum Dimension (mm)	Maximum Vertical Spacing (m)	Width of Trench (feet)		Maximum Spacing	
					Up to 6	6 to 12	Vertical (m)	Horizontal (m)
					Minimum Dimensions (mm)			
Hard and Soft Solids								
1.2-3	38x235	1.8	89x140	1.2	89x89	140x140	1.2	1.8
3-4.6	38x235	0.9	140x140	1.2	89x140	140x191	1.2	1.8
Soils Likely to Crack and Crumble								
1.2-3	38x235	0.9	89x140	1.2	89x140	140x140	1.2	1.8
3-4.6	38x235	0.9	140x191	1.2	140x140	140x140	1.2	1.8
Soft, Sandy, Filled or Loose Soils								
1.2-3	89x235	Close tight	140x191	1.2	140x140	140x191	1.2	1.8
3-4.6	89x235	Close tight	191x191	1.2	140x140	140x191	1.2	1.8

NOTES:

1) Notes on Table 17.1 apply to Table 17.2