



April 2016

ST. LAWRENCE FLUORSPAR PROJECT

Environmental Protection Plan for Project Construction Phase

Submitted to:

Newfoundland and Labrador Department of Environment
and Conservation, Environmental Assessment Division

Submitted by:

Canada Fluorspar (NL) Inc.



Report Number: 0040-1407707-7.2-R-Rev2-EPP

Distribution:

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Revision Control Table

Revision Date	Section Revised	Control Copy Holder Signature



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Revision Control Sheet

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1.0 INTRODUCTION

Canada Fluorspar (NL) Inc. (CFI) is in the process of developing the St. Lawrence Fluorspar Mine (the Project) located in St. Lawrence, Newfoundland and Labrador (NL). The Project is located partly on a brownfield site used historically for mining. The Project includes the construction, operation, rehabilitation and closure of a surface and underground Mine, a Mill, a Tailings Management Facility (TMF), and ancillary infrastructure. Concentrate will be trucked to an existing ship loading facility in Mortier Bay. The surface Mine will consist of four open pits: Open Cut Pit (OCP), Central Pit North (CPN), Central Pit South (CPS) and Grebes Nest Pit (GNP). Underground mining will be phased in when portal access can be established within the open pits, which will not occur until the operations phase of the Project. As such, the underground mining activities are not covered in the *Environmental Protection Plan (EPP) for the Construction Phase*. The construction phase is expected to last approximately two years and will be followed by the operations phase projected to last ten years. The length of the operations phase is based on the current resource estimate and may be lengthened should additional resources be identified in the AGS Vein. The Mine will supply adequate ore to meet a production of 200,000 tonnes per year of concentrate throughout the life of the Mine.

1.1 Purpose

The Project's Environmental Assessment (EA) Registration, completed by Golder Associates Ltd. (Golder) and submitted to the NL Department of Environment and Conservation (NL DOEC) in June 2015, identified potential environmental effects related to routine activities associated with construction, operation, rehabilitation and closure of the Project. It also identified possible accident scenarios during all Project phases (CFI 2015). Mitigation measures are required for each phase of the Project to properly address these potential environmental effects either from routine activities or from potential accident scenarios.

The Project was released from further EA by the Minister of Environment and Conservation on November 5, 2015, subject to certain conditions. One of the conditions is that an Environmental Protection Plan (EPP) must be submitted to and approved by the Minister of Environment and Conservation prior to the start of construction. This *EPP for the Construction Phase* has been prepared by Golder on behalf of CFI to document mitigation measures for the construction phase of the Project. This document will evolve through the various Project phases and will be adapted as engineering progresses and for the operating, decommissioning and mine closure phases, as appropriate.

1.2 Objective

Environmental Protection Plans (EPPs) are important to mining projects. This EPP documents the applicable environmental regulations and the practices and procedures that must be implemented to mitigate adverse environmental effects associated with the Project.

CFI is committed to implementing and continually developing this EPP (i.e., adaptive management). In this way, a high level of environmental protection will be ensured throughout the Project's work areas and activities. This EPP is a working document to be used on-site by Project personnel and contractors. It is also to be used at the corporate level to ensure policy statements are followed. This EPP can serve as a tool for site personnel, contractors, and regulators to monitor regulatory compliance, and for CFI to improve on their environmental performance.

This EPP contains environmental protection procedures for routine activities anticipated during the construction phase of the Project; identifies applicable permits, authorizations and approvals; and provides general guidance for responding to incidental events.



This document forms an integral part of CFI's Health, Safety and Environment (HSE) Management System. This EPP will be used in conjunction with other Project documents and manuals to ensure compliance with regulatory requirements or conditions during Project construction. Specifically, the objectives of this EPP are to:

- Document and describe the measures to mitigate potential adverse environmental effects resulting from Project construction activities.
- Provide clear and concise direction to Project personnel and contractors regarding the procedures for protecting the environment.
- Communicate environmental mitigation requirements and provide instructions to contractors.
- Outline inspection and monitoring requirements for Project personnel and contractors.
- Provide the basis for the environmental monitoring and documentation process to ensure compliance and demonstrate that the Project's environmental commitments have been met.
- Be used as an education tool for the orientation and training of Project personnel and contractors.
- Define contractor roles and responsibilities for the protection of the environment under the terms of their contract with CFI.
- Communicate environmental commitments and mitigation measures to regulatory agencies, stakeholders and the public following the established protocol.
- Communicate changes in the Project through the revision process.
- Provide a reference to applicable legislative requirements and guidelines.

The environmental management practices and mitigation measures for Project construction presented in this EPP will be used for guidance in Project operation and maintenance activities. This EPP will be adapted as the Project moves into the operations phase.

In preparing this EPP, every effort has been made to include all of the environmental commitments made by CFI during the course of the regulatory permitting and approvals process for the Project. This EPP is a stand-alone document. As approvals and permits for the Project are issued, their conditions will be reviewed to determine if a revision to this EPP is warranted (see Section 3.1 for the revision control process).

1.3 Scope of Application

CFI's HSE Management System includes an environmental plan representing the way in which they will manage the environmental functions and requirements. This plan will be adapted throughout the progressive stages of the Project.

EPPs developed for each Project phase (e.g., construction, operation, rehabilitation and closure) are the foundations that support the Project's overall environmental management system. EPPs are critical for communicating environmental protection procedures and serve as an important reference for those that implement the environmental protection measures. Furthermore, it is against the EPP backdrop that the Project's environmental performance will be evaluated. Other plans and programs, which collectively form the Project's HSE Management System, include the following (note that these are in various stages of development or approval):



- Waste Management Plan;
- Environmental Effects Monitoring Plan (EEMP); and
- Rehabilitation and Closure Plan

The scope of this version of the EPP is intended only for the construction phase of the Project. This document will evolve through the various Project phases and will be adapted for the operation, rehabilitation and closure phases.

1.4 Degree of Application

The application of this procedure is:

- Mandatory
- Recommended
- Optional

1.5 Document Organization

This *EPP for the Construction Phase* comprises the following sections:

- *Section 1:* Introduces the purpose, objective, scope and degree of application and content of the EPP.
- *Section 2 and Section 3:* Roles and responsibilities of the Project's Environmental Management Team are discussed, as well as the strategy for development, implementation and maintenance of the EPP. Contact phone numbers are provided in Appendix A.
- *Section 4:* Provides relevant legislation, in addition to regulatory requirements, authorizations, permits and approvals required for the construction phase of the Project. This section includes references for useful information, some of which is referenced in Appendices B, C, D, and E.
- *Section 5:* Overview of environmental concerns and general environmental protection procedures associated with the variety of activities anticipated to occur during Project construction. Specific procedures are included in Appendix D.
- *Section 6:* Contains area specific information and procedures for the principle Project work areas (i.e., linear developments (e.g., roads, pipelines and transmission lines), the TMF and the Mine and Mill Sites). Other area specific information may be developed for other Project areas in the future, as appropriate. Area specific information will be modified or expanded as needed throughout the Project's construction phase as engineering design and construction methods evolve.
- *Section 7:* Provides general information on the contingency plans for incidents and unplanned events.
- *Section 8:* Outlines the communications protocol that will be implemented for the duration of the Project's construction phase.
- *Section 9:* Describes the forms to be used to document the implementation of the EPP during the Project's construction phase.



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The following appendices provide information and forms that are referred to in these sections. A short description of each of appendices is provided below:

- Appendix A:* Contact information for Project key individuals, which are referred to in Section 2.0 to Section 3.0;
- Appendix B:* Guidance Documents;
- Appendix C:* NL DOEC Species at Risk Data Sheets;
- Appendix D:* Environmental Protection Procedures; and
- Appendix E:* NL DOEC (Water Resources Management Division) Environmental Guidelines.



2.0 ROLES AND RESPONSIBILITIES

This section provides an outline of the participants in the Project construction phase, their roles, and their respective responsibility for environmental compliance, stewardship, mitigation, reporting and monitoring. All parties are responsible for the protection of the environment and it is critical that roles and responsibilities in both general duties and emergency situations are defined and understood to ensure clarity.

The EPP will be implemented by an Environmental Management Team comprised of CFI and the Engineering, Procurement, Construction Management (EPCM) contractor employees. It is expected that all personnel working on the Project site be familiar with and implement protection measures outlined in the EPP.

2.1 CFI General and Construction Managers

CFI's General and Construction Managers are responsible for providing overall direction for the Project and its (HSE) Management System, and approving environmental policies and plans. CFI's General and Construction Managers have executive responsibility for ensuring that the EPP is developed and the Project is implemented such that the EPP objectives are achieved and regulatory requirements are met. CFI's managers will review the effectiveness of the environmental management practices with respect to compliance with the EPP requirements, Project-specific environmental requirements, and applicable environmental laws and regulations. CFI's managers will ensure plans for corrective action are developed and implemented for any identified non-compliances.

2.2 Health, Safety, Environment (HSE) Manager

CFI's HSE Manager will report directly to CFI's CEO, and will be responsible for the implementation of the EPP, initiating / participating in team meetings, being involved in obtaining required environmental permits and authorizations, and will be responsible for site environmental monitoring. During construction, the HSE Manager will provide leadership, oversight, and accountability to each contractor who will be directly supported by their own HSE teams. The HSE Manager is also responsible for the integration and implementation of CFI's Occupational Health and Safety (OH&S) Standards in the EPP and on the Project site.

The HSE Manager has the authority to provide direction to contractors, including issuance of stop-work orders where contractors are not in compliance with approved health, safety or environmental procedures. The HSE Manager will be a resource to the EPCM Project and Construction Managers and contractors, and will provide advice on all environmental matters as they arise.

Specific responsibilities include, but are not limited to:

- Promoting an understanding of the approved environmental programs and plans; and promoting environmental awareness among onsite personnel.
- When required, providing Project personnel training on the EPP, environmental management, and social responsibility requirements.
- As appropriate, assisting and supporting all Project personnel on environmental issues, and follow-up on environmental concerns / issues, incidents and malfunctions, as well as unsafe acts and conditions to ensure that they are addressed in a timely manner.
- Providing oversight and guidance to the HSE technician.
- Reviewing Job Environmental Analysis (JEAs) in coordination with the EPCM Management Team as appropriate, and provide feed-back to originators.



- Conducting formal and informal HSE inspections and issue reports as required. This may include environmental issues, as appropriate.
- Immediately reporting to CFI's CEO any environmental compliance issue, failed mitigation, and changes to the schedule that may affect environmental mitigation implementation or monitoring.
- Immediately reporting to CFI's CEO identification of any species at risk.
- Immediately reporting to CFI's CEO any identification of cultural heritage artifacts.
- Updating the EPCM Management Team on environmental issues occurring on the Project construction site, if identified.
- Verifying and ensuring emergency readiness, and participate in response and recovery, in coordination with the EPCM Management Team.

2.3 HSE Technician

The environmental monitoring will be completed by an HSE technician who will report to the HSE Manager. The HSE technician will be responsible for monitoring compliance of contractors with measures identified in this EPP and verifying implementation of environmental mitigation measures to ensure that the construction activities are implemented in a safe, environmentally responsible and productive manner.

Specific responsibilities include, but are not limited to:

- Monitoring construction activities for compliance with all applicable environmental commitments, laws, standards and regulations, and the provincial / federal environmental regulations and permit requirements.
- Providing construction site personnel support and guidance on the Project's environmental requirements.
- Conducting site visits, as appropriate for the condition and the Project activity, and assessing the implementation and effectiveness of the environmental mitigation.
- Attending any high risk procedures undertaken at the site (e.g., work within water bodies or environmentally sensitive areas).
- Initiating actions to resolve environmental issues, where appropriate.
- Working with the contractor to improve any mitigation measures that are ineffective or equipment that is in a state of disrepair. In urgent conditions, where a contractor is unavailable and the environment is in imminent danger, repairing mitigation controls that have been damaged, where it is safe to do so.
- Collecting and reporting on required environmental monitoring data.
- Maintaining environmental monitoring and sampling equipment.
- Collecting, preserving, appropriately documenting, and sending for analysis, all samples, including Quality Assurance / Quality Control (QA/QC) samples, requiring off-site analysis for monitoring the Project construction as defined in the construction based EEMP and supporting documentation.
- Conducting and documenting the results of field analysis (e.g., water sampling programs).
- Assisting and supporting supervisors, workers and contractors on the appropriate training and education needed to perform the required tasks in an environmentally responsible manner.



- Assisting in the delivery of Project specific training (e.g., orientations, supervisor responsibilities, wildlife awareness, mitigation) and supplemental on-the-job training in environmental mitigation, spills prevention and other tasks, as required.
- Providing input to the HSE Manager for the HSE performance reports (e.g., weekly and monthly environmental performance statistics).
- Keeping the HSE Manager informed of any concerns, incidents, and unmitigated risk.
- In conjunction with the HSE Manager, confirming that applicable permits and approvals are in place prior to initiation of work, and communicating Project scope changes that could require additional permits or amendments to existing approvals.
- Recognizing and rewarding people who have positively affected environmental performance.
- Conducting formal and informal environmental inspections and issuing reports as required by the HSE Manager.

2.4 EPCM Project Manager

The EPCM Project Manager is responsible for managing the EPCM contract, including the Project's environmental management system, and reporting directly to CFI's General and Construction Managers and working in collaboration with the CFI HSE Manager. The EPCM Project Manager is responsible for ensuring that Project teams and sub-contractors understand the Project commitments and the expectations for dealing with stakeholders, including the public.

During construction, the EPCM Project Manager will provide leadership, oversight, and accountability to each contractor, who will be directly supported by their own environmental teams.

Specific responsibilities include but are not limited to:

- Allocating resources and assigning responsibilities for the implementation, operation and ongoing improvement of the Project's environmental management processes including all requirements of the EPP.
- Requiring that adequate resources including competent personnel are provided, and processes are in place for the achievement of environmental objectives.
- Visibly leading by personal example the implementation of the EPP and to support all Project environmental initiatives.
- Setting expectations and holding discipline managers accountable for environmental deliverables and meeting agreed performance metrics.
- Monitoring, reviewing and reporting on environmental performance as required.
- Actively promoting environmental excellence and the environmental vision to create a strong culture of environmental protection awareness.
- As appropriate, liaising with external regulators and stakeholders.
- Reporting any onsite occurrences of non-compliance issues to CFI's General and Construction Managers, as well as the HSE Manager.
- Intervening and correcting at-risk behaviour and correcting inappropriate environmental performance.



- Understanding and applying general legislative environmental requirements.
- Developing and providing data required for permitting, approvals and other reporting requirements.
- Having and applying a full working knowledge of the EPP and an understanding of the requirements of the environmental management system as they apply to the Project.
- Consulting on and resolving environmental issues, including leading incident investigations, etc.
- Recognizing and rewarding people who have positively affected environmental performance.

2.5 EPCM Construction Manager

The EPCM Construction Manager will be located on the Project site and will be responsible for overseeing construction management and Project development. The EPCM Construction Manager will report directly to the EPCM Project Manager and will work in collaboration with CFI's HSE Manager.

The EPCM Construction Manager provides senior Project direction to site engineers / supervisors, and contractors in the application of the provisions of the EPP and associated procedures. The EPCM Project Manager and the HSE Manager provide guidance to the EPCM Construction Manager, as required. Under the direction of the EPCM Project Manager, the EPCM Construction Manager has overall accountability for the environmental performance at the Project site.

Specific responsibilities include but are not limited to:

- Supporting the EPCM Project Manager, as well as CFI's General and Construction Managers and HSE Manager, in the implementation of the EPP and environmental plans and procedures.
- Complying with and administering all legal obligations imposed on a construction manager by governing regulations, codes and practices and provincial, federal, and local regulations and legislation.
- Apart from those activities performed by the EPCM Project Manager, allocating resources and assigning responsibilities for the implementation, operation and ongoing improvement of the Project environmental management processes as defined in the EPP and other Environmental Management Plans.
- Supporting the EPCM Project Manager with ensuring that adequate resources are provided and processes are in place for the achievement of the EPP objectives.
- Visibly leading by personal example the implementation of the EPP and supporting all Project environmental initiatives.
- Actively promoting environmental excellence and the environmental vision to create a strong culture of environmental protection awareness.
- Setting expectations and holding management accountable for delivery of environmental deliverables and meeting agreed performance metrics.
- Ensuring that all personnel receive the appropriate environmental training.
- Ensuring that all mitigation and spill containment equipment is supplied / maintained at the immediate workplace and is fit for purpose.



- Ensuring proper reporting and investigation of incidents that are the result of a near miss, harm to the environment or damage to equipment is initiated by supervisors and that corrective actions are followed through.
- Participating in and ensuring that contractors and labourers are conducting JEAs.
- Participating in contractor evaluation, selection and alignment sessions.
- Attending, and participating in, toolbox and weekly environment meetings.
- Intervening and correcting at-risk behaviour and correcting inappropriate environmental performance.
- Immediately reporting to the EPCM Project Manager and CFI's HSE Manager any environmental compliance issue, failed mitigation, and changes to the schedule that may affect environmental mitigation implementation or monitoring.
- Immediately reporting to the EPCM Project Manager and CFI's HSE Manager identification of any species at risk.
- Immediately reporting to the EPCM Project Manager and CFI's HSE Manager any identification of cultural heritage artifacts.
- Understanding and applying all legislative environmental requirements.
- Consulting on and resolving environmental issues, including leading incident investigations, etc.
- Recognizing and rewarding people who have positively affected environmental performance.
- Participating in management reviews of the Project's Environmental Management Plans' procedures as required, including the EPP.

2.6 Contractors

Contractors will undertake the construction of the Project and will report directly to the EPCM Construction Manager. The contractors are responsible for implementing environmental protection procedures as outlined in this EPP, and shall comply with all relevant regulations, policies, governing documents, guidelines, permits, approvals and authorizations. The EPP will be one of several Project documents that will be used to evaluate the contractors' environmental performance.

Specific responsibilities include but are not limited to:

- Understand and accept CFI's commitments and obligations as outlined in the EPP.
- Provide written procedures, where required, for CFI and regulatory review.
- Implement construction activities in accordance with the EPP, contractual requirements, and other Project-specific and regulatory requirements.
- Ensure all contractor site personnel are aware of the environmental requirements of the Project.
- Attend meetings with the HSE Manager, EPCM Managers and site personnel, as required.
- Keep a current version of the EPP and all applicable permits on hand.



- Communicate regularly with the HSE Manager and EPCM Construction Manager to ensure compliance with the requirements of the EPP and all applicable permits.
- Notify the HSE Manager and EPCM Construction Manager of non-compliances with the EPP or regulatory requirements.
- Immediately notify the HSE Manager and EPCM Construction Manager of any construction activity requiring agency notification (e.g., spills in reportable quantities) and / or other incidents that have the potential to affect the environment.

2.7 All Personnel

All Project personnel are responsible for following Project environmental requirements and undertaking their respective tasks in a manner that is respectful of the environment.

Specific responsibilities include but are not limited to:

- All personnel participating in the Project are responsible for the success of the environmental performance of the Project.
- Participating in the environmental training required for the Project.
- Understanding and applying Project environmental requirements.
- Utilizing the resources provided and the processes in place for the achievement of EPP objectives.
- Regarding health, safety and environment as a central theme in their actions.
- Maintaining their competence, as required, enabling them to contribute fully to the successful environmental performance.
- Developing JEs for the task they are planning to complete.
- Ensuring that the correct tools and equipment are used for all tasks.
- Knowing and implementing the environmental procedures and plans, as appropriate.
- Actively participating in the implementation of all Project environmental initiatives including hazard reporting and elimination.
- Reporting to their Supervisor, any defects or concerns in equipment that could result in an adverse environmental effect.
- Immediately reporting any issues, changes or concerns noted with respect to environmental mitigation (e.g., buffer zones, silt fences, dust levels) and instituting temporary corrective action until a more permanent solution can be administered.
- Immediately reporting any spills to their Supervisor or appropriate party. Implementing Contingency Plans in the event of an emergency or spill.
- Immediately reporting to their Supervisor or appropriate party any environmental compliance issue, failed mitigation, and changes to the schedule that may affect the implementation or monitoring of mitigation measures.



- Immediately reporting any identification of any species at risk to the EPCM Construction Manager and CFI's HSE Manager.
- Immediately reporting to the EPCM Construction Manager and CFI's HSE Manager any identification of cultural heritage artifacts.
- Notifying their Supervisor of any incident or near miss that occurs and supporting the investigation into the same.
- Intervening and correcting at-risk behaviour and correcting inappropriate environmental performance.
- Avoiding any improvising that entails additional risk to the environment.
- Warning other personnel of known hazards or environmentally sensitive areas.
- Participating in emergency response exercises, as required.
- Disposing of all waste materials in the correct manner.
- Reporting to their Supervisor, all health, safety and environmental incidents and near misses at the time of their occurrence.

2.8 Provincial, Federal, and Municipal Government Representatives

Provincial, federal, and municipal government representatives will be invited to visit the Project site periodically to ensure compliance with applicable government regulations and permits, as per the mandates of their respective agencies. They will be asked to provide information and advice directly to CFI and the EPCM Construction Manager.



3.0 DEVELOPMENT AND IMPLEMENTATION

The *EPP for the Construction Phase* may need to be revised and expanded as engineering design and work methods for the Project are further refined. Furthermore, as additional approvals and permits for the Project are issued, their conditions will be reviewed to determine if a revision to the EPP is warranted.

3.1 Maintenance of the EPP

Subsequent to the filing of the *EPP for the Construction Phase* with NL DOEC, CFI will maintain and keep the EPP current. This will be the responsibility of the HSE Manager. CFI will provide the most current and comprehensive version of the EPP to Project personnel, applicable regulatory agency representatives, stakeholders, interested parties and others as listed on the distribution list (Section 3.1.1). CFI is responsible for implementing the following actions:

- Provide a training course for relevant Project personnel, including contractors, to ensure proper implementation of the best management practices (BMPs) and mitigation measures contained in the EPP.
- Distribute copies of the EPP to appropriate Project site locations and Project personnel, including contractors.
- Implement EPP revisions and issue approved revision pages of the EPP to those listed on the distribution list (i.e., control copy holders).
- Review applicable sections of the EPP as warranted ensuring that the BMPs and mitigation measures contained therein are current and comprehensive.

3.1.1 Distribution List

The following distribution list provides the name, contact information and member organization of the EPP control copy holders. All revisions and updates to the EPP will be distributed to every party on this list.

Table 1: EPP for the Construction Phase Distribution List

Control Copy Number	Name	Organization	Contact Information
00	Callie Andrews, Environmental Assessment Specialist	Golder Associates Ltd.	11 Austin Street- Suite 101 St. John's, NL A1B 4C1 (709) 722-2695
01	Lindsay Gorrill, President and CEO	Canada Fluorspar (NL) Inc.	PO Box 337 St. Lawrence, NL, Canada A0E 2V0 (709) 873-3331
02	Frank Pitman, Construction Manager	Canada Fluorspar (NL) Inc.	PO Box 337 St. Lawrence, NL, Canada A0E 2V0 (709) 873-3331
03	Steve Cole, Project Manager	Canada Fluorspar (NL) Inc.	PO Box 337 St. Lawrence, NL, Canada A0E 2V0 (709) 873-3331



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Control Copy Number	Name	Organization	Contact Information
04	Engineering, Procurement, Construction Management (EPCM) Project Manager: TBD	TBD	TBD
05	EPCM Construction Manager: TBD	TBD	TBD
06	TBD, Health, Safety, Environment (HSE) Manager	Canada Fluorspar (NL) Inc.	PO Box 337 St. Lawrence, NL, Canada A0E 2V0 (709) 873-3331
07	Darryl Walsh, Fisheries Officer St. Lawrence Area	DFO	(709) 279-7850
08	Glen Rowe, Navigable Waters Protection Officer	Transport Canada	(709) 582-3241
09	Dr. Abdel-Zaher Kamal Abdel-Razek, Manager – Water Rights and Investigation Section	Newfoundland Department of Environment and Conservation (NL DOEC)	(709) 729-4795
10	Dexter Pittman, Manager - Industrial Compliance Section, Pollution Prevention Division	NL DOEC	(709) 729-6771
11	Alex Smith, Director – Mines / Mineral Development	Newfoundland Department of Natural Resources (NL DNR)	(709) 729-6379

Additional copies of the EPP are circulated as dated and will include distribution to all regulatory permit providers listed in Table 1 and any additional interested parties as requested. If the EPP has been updated, control copy holders will provide updated copies to those circulation copy holders to whom they had originally provided a copy.

3.1.2 Revision Notice

Circumstances may arise in which it may be appropriate to edit or change sections of the EPP during the course of Project construction. If it is determined that a revision to the EPP is warranted, the following guidelines and internal process will apply. EPP revisions will be initiated by Project (CFI and EPCM) personnel only.

Project personnel may initiate revisions by forwarding suggested changes or additions to the HSE Manager on the Revision Request Initiation Form which is provided in Section 9.0. All revision requests must be approved by the HSE Manager. When a revision request is received by the HSE Manager, a draft (yellow paper with change in bold type) will be issued to all control copy holders for review. After the draft is reviewed and deemed acceptable by all parties, a final version will be issued (blue paper). If a revision request is not approved, the HSE Manager will forward a letter to the originator explaining the rationale for the decision.

Each revision will be accompanied by the Revision Control Sheet provided at the beginning of the EPP that provides the revision instructions, and lists the sections and specific pages being superseded.

An updated EPP Table of Contents and Revision Control Table (provided at the beginning of the EPP) will be included as required with each revision.

The Revision Control Table will be kept current by control copy holders to track any revisions made to each section and sub-section of the EPP. The EPP Table of Contents will indicate the current revision status of each section.



Within two working days of receiving a revision, control copy holders are required to:

- Read the text of the revision.
- Check the Revision Control Sheet to ensure that all listed pages have been received.
- Remove and destroy the superseded pages.
- Insert the revised pages in the proper place in the EPP.
- Page check the EPP, using the updated Table of Contents, to ensure that the EPP is complete.
- Enter the revision number and date on the Revision Control Table.
- Ensure that any circulated copies of the EPP under their direction are updated.
- Take appropriate actions to incorporate the revision into practice.

3.2 Procurement Requirements

Contractors invited to bid on work for the construction of the Project will receive a copy of the EPP as part of the bid package. This will provide potential contractors with clarity on the requirements of the EPP and entrench the contractual obligation to following the requirements of the EPP within the procurement process. Changes to the EPP may occur between the time of the bidding process and the time when the work is completed. The contractor will be responsible for ensuring that they have and follow the most up-to-date version of the EPP.

3.3 Competency

Achievement of environmental protection, and health and safety objectives requires the selection of people who share CFI's values, beliefs and commitment to environmental leadership. All Project personnel must demonstrate the expected behaviours and performance associated with their role and task.

All Project personnel must be adequately qualified, suitably trained and supported with sufficient experience to conduct their work activities safely and in a socially and environmentally responsible manner.

3.3.1 Expectations

Project personnel and contractor management are expected to ensure:

- Recruitment and selection criteria may include a subjective evaluation of the applicant's environmental values.
- Commitment to developing a culture that reflects the EPP is communicated during the recruitment and selection process.
- Skill, knowledge and experience requirements relative to the responsibilities of the job must be assessed and verified prior to performing any activities unassisted.
- Appropriate to their function, location and activities, all Project personnel must be oriented, trained, and accredited where necessary in:
 - Their roles and responsibilities in meeting requirements of the EPP, including work and emergency response procedures appropriate to the risks to which they are exposed, or which they may create.
 - The significant risks associated with their activities and the benefits of working in an environmentally responsible manner.
 - The potential consequences of deviation from plans and procedures.



3.3.2 Training Records

Records of environmental training will need to be available on-site. Training attendance shall be recorded for all internal and external training and awareness sessions.

3.3.3 Licenses and Certificates of Competency

All Project personnel performing activities or tasks on Project sites that require statutory licenses or certificates of competency (e.g., Transportation of Dangerous Goods [TDG]) shall submit a current copy of the appropriate license or certificate to the EPCM Project Manager prior to starting work on the site.

Details of all licenses and certificates of competency will be held in the person's file at site by the individual's employer. Statutory records are jointly held, as required, by both the EPCM Managers and contractors.

Verification of competency will be demonstrated, as required.

3.4 Mechanisms for Implementation

The effectiveness of this EPP relies heavily on good communication between construction personnel and CFI's team, as represented on-site by CFI's General Manager, Construction Manager, and Site HSE Manager. Mechanisms to be used to ensure compliance with this EPP include: annual environmental performance reviews, JEAs for new work tasks, and weekly environmental and toolbox meetings.

3.4.1 Annual Environmental Performance Review

At the end of each construction year, CFI's managers, the EPCM Managers, the HSE Manager and site contractors will gather for an environmental performance meeting to review all work activities that relate to environmental concerns, issues and / or mitigation. The review process will provide all parties a chance to evaluate overall environmental performance and compliance with government regulations, permits, and the EPP.

3.4.2 Job Environment Analysis

For a new construction package that has the potential to cause an adverse environmental effect, a JEA will be conducted prior to the work commencing. The intent of the JEA is to identify potential environmental hazards and appropriate mitigation measures as provided in the EPP. The initial development of JEA documentation will be the responsibility of the individual company or contractor performing the work. Each JEA document shall be formally reviewed by CFI's HSE Manager, General and Construction Managers, other Project supervisors and Project design / field engineers. The JEA document review will integrate scientific principles, technological practices, and construction methods to arrive at appropriate mitigation measures for environmental protection. The review also provides a forum for discussing and agreeing upon improved methods and practices, and may prompt a revision to the EPP.

3.4.3 Weekly Environmental Meetings

Weekly environmental meetings involving CFI's HSE Manager, HSE technician, EPCM Managers, and contractors will be held to review any environmental issues and / or EPP implementation items. These meetings serve to anticipate and resolve environmental concerns before they arise, or to effectively deal with them should they occur. Non-compliance items identified during routine monitoring activities are tabled for discussion and resolution. In addition, the meetings provide an opportunity to keep all onsite Project personnel informed of upcoming work activities.



3.4.4 Toolbox Meetings

Toolbox or 'tailgate' meetings are short, informal meetings that are held with field crews and supervisors at the beginning of each work shift. Discussion involves the work task assignment for the day and any associated safety concerns or hazards. These meetings also provide the opportunity to discuss environmental concerns and applicable mitigation measures that apply.

3.5 Training

The site orientation training of all Project personnel and vendors that require access to the site will include discussion on environmental policies and familiarization with protection measures as detailed in the EPP. Project personnel and contractors will undergo regular training and refreshers to ensure that they are familiar with potential environmental issues, roles and responsibilities, mitigation requirements, communication of concerns, and emergency response procedures.

Records of all employees trained and the dates will be maintained.

3.5.1 Employee Orientation

A site orientation will be developed and presented to all Project personnel involved in construction activities on the site. New workers at the Project site are presented with general information, rules and procedures to assist them in performing their work safely and with minimal adverse effect on the environment. This site orientation will include elements of the EPP such as: spill response and reporting, environmental protection procedures, proper storage and handling of materials, encounters with wildlife and listed species, waste management, and emergency response.

3.5.2 Visitor Orientation

A site orientation shall be provided to those persons who have arrived at the Project site but will not be completing any field construction work (e.g., meetings, office work, deliveries). The visitor orientation shall cover relevant environmental protection measures, Project emergency procedures, environmental incident reporting requirements, and other general Project environmental requirements.

Any person who has not taken the full orientation program shall be supervised by a designated, oriented Project person at all times, and shall abide by the EPP.

3.5.3 Contractor Orientation

Contractors may develop and deliver additional environmental orientations to their workforces, visitors, consultants and inspectors on the details of the EPP, and / or corporate requirements. The Contractor orientations are subject to review and acceptance by CFI's HSE Manager.

3.6 Environmental Monitoring

Environmental monitoring is an essential component of Project site activities. This monitoring occurs on a daily basis by the HSE technician, and construction contractors. Every aspect of the operation is subject to inspection.

The basis for environmental monitoring at the Project site is embodied in the EPP. As an important component of the EPP, conditions of regulatory permits and approvals also define the scope of monitoring activities. The EEMP should also be used in conjunction with the EPP to ensure all monitoring requirements are achieved.

Non-conformance defined as a deviation from the EPP, other CFI policies or legislative requirements shall be documented and addressed during weekly meetings with the contractor responsible for mitigation measures. Non-conformance environmental issues will also be reported to the appropriate regulatory authority.



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Corrective action shall be identified to prevent the non-conformance from reoccurring, target dates shall be agreed upon, and responsibilities shall be assigned to appropriate personnel. This documentation shall be distributed to other members of the Project team and written notice of agreed corrective action will be forwarded to the contractor so that issues are appropriately resolved. If serious non-conformance items (as defined by CFI) are noted that require immediate attention, the HSE Manager, HSE technician, and construction contractors will have authority to temporarily halt Project activities, until such time as corrective actions can be implemented.

If serious non-conformance items are noted that require immediate attention and resources are not immediately available, or if agreed corrective action is not implemented in a timely and effective manner, then appropriate resources shall be contracted by the EPCM Construction Manager to immediately undertake the required action.



4.0 REFERENCE INFORMATION

This section summarizes relevant legislation, regulatory requirements, authorizations, permits and approvals required for the construction phase of the Project.

4.1 Relevant Legislation, Permits, Approvals and Authorizations

Work within the Project site will be initiated only after the required regulatory approvals have been obtained. The location of Project components and other features discussed in the following sections can be found on Figure 1 in Section 6.0. A registry of all permits required for the Project is located in a separate CFI database. This registry will be updated as permit requirements change over the course of site development.

4.1.1 Federal

Federal approvals and authorizations that have been acquired or will potentially be required are outlined in Table 2

Table 2: Potentially Applicable Federal Permits, Approvals and Authorizations

Agency	Permit, Authorization, Approval	Act / Regulation
Transport Canada	Transportation of Dangerous Goods – Explosives	<i>Canada Transportation Act</i>
Natural Resources Canada	Magazine Licence Application	<i>Explosives Act</i>
	Application for Permit to Transport using a Flatbed Trailer	<i>Explosives Act</i>
	Application for Authorization of Explosives	<i>Explosives Act</i>
Fisheries and Oceans Canada	Request for Project Review	<i>Fisheries Act</i>
	Application for Authorization	<i>Fisheries Act</i>
	Compliance with Section 36 (3) of the <i>Fisheries Act</i>	<i>Fisheries Act</i>
Environment Canada	Compliance to <i>Canadian Environmental Protection Act</i>	<i>Canadian Environmental Protection Act</i>
	Compliance with the <i>Wastewater Systems Effluent Regulations</i>	<i>Fisheries Act</i>
Canadian Wildlife Service	Scientific Permit	<i>Migratory Birds Convention Act</i>
Industry Canada	Communications Licence	<i>Radiocommunication Act</i>
	Radio Station Licence	<i>Radiocommunication Act</i>
Canadian Nuclear Safety Commission	Nuclear Substances and Radiation Devices License	<i>Nuclear Substances and Radiation Devices Regulations</i>

4.1.2 Provincial

On June 12, 2015, CFI filed an Environment Assessment (EA) Registration with the NL Department of Environment and Conservation (DOEC). Following the determination that additional information was required, CFI submitted an Environmental Preview Report (EPR) on September 23, 2015. The Project was released from further EA by the Minister of Environment and Conservation on November 5, 2015 and the EA release conditions stipulate that the following approvals and documents must be acquired, or submitted and approved, prior to start of construction:

- Certificate of Approval (NL DOEC) for the construction associated with re-activation of mine and mill facility;
- EPP;



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- EEMP;
- Gender Equity and Diversity Plan; and,
- Closure Plan.

Other provincial permits and approvals that may be required prior to start of construction are listed in Table 3.

Table 3: Potentially Applicable Provincial Permits and Approvals

Agency	Permit, Authorization, Approval	Act / Regulation
NL Department of Environment and Conservation (NL DOEC) - Water Resources Division	Alteration to a Body of Water	<i>Water Resources Act</i>
	Application for Permit for Constructing a Non-Domestic Well	<i>Water Resources Act</i>
	Water and Sewage Works	<i>Water Resources Act</i>
	Application for Water Use Licence	<i>Water Resources Act</i>
NL DOEC - Pollution Prevention Division	Certificate of Approval for Construction and Operation (Approval No. AA-04537)	<i>Environmental Protection Act</i>
	Certificate of Approval –Waste Disposal Facility	<i>Environmental Protection Act</i>
NL DOEC – Wildlife Division	Permit to destroy problem animals	<i>Wildlife Act</i>
	Compliance standard	<i>Endangered Species Act</i>
NL Department of Natural Resources (NL DNR) - Forestry Resources Branch	Commercial Cutting / Operating Permit	<i>Forestry Act</i>
NL Department of Natural Resources (NL DNR) - Mineral Lands Division	Approval for Development Plan, Closure Plan and Financial Assurance	<i>Mining Act</i>
	Surface Lease	<i>Mining Act</i>
	Mining Lease	<i>Mining Act</i>
	Quarry Permit	<i>Quarry Materials Act</i>
NL Municipal and Intergovernmental Affairs	License to Occupy Crown Lands	<i>Crown Lands Act</i>
Service NL	Certificate of Approval- Storage and Handling of Gasoline and associated products	<i>Environmental Protection Act</i>
	Permit for Flammable and Combustible Liquid Storing and Dispensing (Above or Below Ground) and for Bulk Storage (Above Ground Only)	<i>Environmental Protection Act</i>
	Storage Tank System	<i>Environmental Protection Act</i>
	Building Accessibility Exemption	<i>Buildings Accessibility Act</i>
	Statutory Declaration for Registration of Boiler and pressure Vessel Fittings Fabricated in NL	<i>Public Safety Act</i>
	Certificate of Plant Registration for Power, Heat, Refrigeration, Compressed Gas or Combined Plant	<i>Public Safety Act</i>



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	Contractor's Licence- Pressure Piping System	<i>Public Safety Act</i>
	Examination and Certification of Propane System Installers	<i>Public Safety Act</i>
NL Transportation and Works	Compliance Standard- Storing, handling and transporting dangerous goods	<i>Dangerous Goods Transportation Act</i>
Service NL	Notice of Project The Occupational Health & Safety Act and Regulations	<i>Occupational Health and Safety Regulations</i>
NL Tourism, Culture and Recreation	Compliance Standard- <i>Historic Resources Act</i>	<i>Historic Resources Act</i>

4.1.3 Municipal

The Project is located within the municipal boundaries of the Town of St. Lawrence and as such will abide by all the bylaws and regulations of the town. The Project site is within land use zones reserved for mining, as outlined in the Town of St. Lawrence Municipal Plan (Town of St. Lawrence 2012).

The potential municipal approval required for the Project is a Development Permit for Site Development-Quarry and Soil Removal. In addition, CFI will comply with the following municipal regulations, and any other applicable bylaws and regulations:

- Schedule C - Mixed Development Zone - Town of St. Lawrence Development Regulations 2012.
- Schedule C - Mining - Town of St. Lawrence Development Regulations 2012.

4.2 Reference Documents

Information and documents referenced in this EPP can be found with the HSE Manager at the Project site or in CFI's Project office in St. Lawrence. Guidance Documents are included in Appendix B of this EPP, and a list of NL DOEC Species at Risk Information Sheets and Environmental Guidelines are provided in Appendices C and E. A list of the key reference material is provided in the following subsections.

4.2.1 Relevant Provincial / Federal Government Publications

Appendix B – Guidance:

- Measures to Avoid Causing Harm to Fish and Fish Habitat (Fisheries and Oceans Canada [DFO] 2013; <http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html>).
- Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans Canada, St. John's, NF (Gosse et al. 1998; <http://www.dfo-mpo.gc.ca/Library/240270.pdf>).
- Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky 1998; <http://www.dfo-mpo.gc.ca/Library/232046.pdf>).

Appendix E – Environmental Guidelines:

- Environmental Guidelines for Watercourse Crossings (Water Resources Division, NL DOEC 1992a; http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter3_2.pdf).
- Environmental Guidelines for Stream Crossings by All-Terrain Vehicles (Water Resources Division, NL DOEC 1994; http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter3a_2.pdf).



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- Environmental Guidelines for Bridges (Water Resources Division, NL DOEC 1989; <http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter4.pdf>).
- Environmental Guidelines for Culverts (Water Resources Division, NL DOEC 1992b; <http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter5.pdf>).
- Environmental Guidelines for Fording (Water Resources Division, NL DOEC 1988; <http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter6.pdf>).
- Environmental Guidelines for Diversions, New Channels, Major Alterations (Water Resources Division, NL DOEC 1997a; http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter7_2.pdf).
- Environmental Guidelines for Pipe Crossings (Water Resources Division, NL DOEC 1997b; http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter9_2.pdf).
- Environmental Guidelines for General Construction Practices (Water Resources Division, NL DOEC 1997c; http://www.env.gov.nl.ca/env/waterres/regulations/appforms/chapter13_2.pdf).

Other:

- Freshwater Intake End-of-Pipe Fish Screen Guidelines (DFO 1995; <http://www.dfo-mpo.gc.ca/Library/223669.pdf>).
- Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador (Scruton et al. 1997).
- Standard Methods Guide for the Classification / Quantification of Lacustrine Habitat in Newfoundland and Labrador (Bradbury et al. 2001; <http://www.dfo-mpo.gc.ca/Library/263764.pdf>).
- Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador Rivers & Streams (Sooley et al. 1998; <http://www.dfo-mpo.gc.ca/Library/242052.pdf>).
- Environmental Policy for Infilling Bodies of Water (W.R. 91-1) (NL DOEC 1991; http://www.env.gov.nl.ca/env/waterres/regulations/policies/bodies_of_water.html).
- Environmental Guidelines for Construction and Mineral Exploration Companies (NL DOEC and NL DNR Undated; <http://www.nr.gov.nl.ca/mines&en/mqrights/environment.pdf>).
- Accredited Laboratory Policy, PD: PP2001-01.2 (Pollution Prevention Division, NL DOEC 2011; http://www.env.gov.nl.ca/env/publications/env_protection/policy_directive_pd_pp.pdf).

4.2.2 CFI's Technical Data Reports

CFI's technical reports formed the documentation to support the Project's EA Registration and prefeasibility study. Such information is useful as a key source of information for measuring environmental performance throughout the Project's construction phase. This documentation consists of:

- Technical Report on the AGS Vein Deposit, St. Lawrence Property, Newfoundland and Labrador (Agnerian 2015).
- AGS Fluorspar Mine, Environmental Assessment Registration Pursuant to the Newfoundland and Labrador *Environmental Protection Act* (CFI 2015a).
- AGS Fluorspar Mine, Environmental Preview Report Pursuant to the Newfoundland and Labrador *Environmental Protection Act* (CFI 2015b).



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- Phase I Hydrogeology Study, Canada Fluorspar Inc. St. Lawrence, NL for the Proposed AGS Mine Project (Golder 2015a).
- Geochemistry Testing Report, Canada Fluorspar Inc. St. Lawrence, NL for the Proposed AGS Mine Project (Golder 2015b).
- AGS Project Preliminary Water Quality Baseline Report. Report Submitted to Canada Fluorspar (NL) Inc (Golder 2015c).
- St. Lawrence Mine Historic Resources Impact Assessment (Gerald Penney Associated Limited [GPA] 2015).
- Proposed AGS Fluorspar Mine, St. Lawrence, NL Aquatic Studies Field Report (Sikumiut Environmental Management Ltd. [SEM] 2015).



5.0 GENERAL ENVIRONMENTAL PROTECTION PROCEDURES

Appendix D of this EPP contains a comprehensive suite of general Environmental Protection Procedures to be used. These procedures are brief and offer clear instruction to the reader.

These Environmental Protection Procedures will be invaluable to bidders at the tender stage because they provide guidance for standard mitigation measures proposed for the Project. This EPP will be part of each tender package, and contractors must include with their tender an Environmental Plan to show how they will achieve compliance with the EPP. Given that all contractors will be required by contract to comply with the EPP, this document will ensure that CFI's expectations for environmental performance are communicated and met throughout all aspects of the Project construction phase.

This EPP links general Environmental Protection Procedures (Appendix D) with specific work areas (Section 6.0). The procedures in Appendix D may need to be modified in the future to address new activities, unforeseen site conditions, changes in engineering design and / or construction work methods, or new environmental performance levels related to the Project.



6.0 AREA SPECIFIC ENVIRONMENTAL GUIDANCE

Environmental guidance specific to certain areas of the site are outlined in the following subsections. These areas include the linear developments (e.g., roads, pipelines, conveyors) the TMF, Mine and Mill.

6.1 Project Work Scope

The Project components and construction activities are outlined in the following subsections.

6.1.1 Project Components

Construction activities will occur in the following general areas:

- Linear developments (Section 6.2);
- TMF (Section 6.3); and
- Mine and Mill (Section 6.4)

See Figure 1 for the Project site plan. For each of these areas, environmental guidance is provided for the activities that are anticipated during construction. This EPP will be revised, as required, to reflect the evolving nature of engineering design and construction methods development during the construction phase. Revisions will be reviewed and approved, for issue to the EPP control copy holders prior to the start of these activities. CFI's HSE Manager will take the lead on EPP review and revisions.

Other areas may be identified later, such as off-site storage, marshalling and forwarding areas, and will be added to this EPP, as required.



LEGEND:

- EXISTING BUILDINGS
- EXISTING ROAD
- PROPOSED ROAD
- PROPOSED POWERLINE
- WATER
- WETLAND
- PRE-DEVELOPMENT WATER EXTENT
- EMBANKMENT
- PIT
- MINE DUMP
- TAILINGS
- MILL

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NOTES:

- COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 21N.
- BASE MAP: © HER MAJESTY THE QUEEN IN RIGHT OF CANADA DEPARTMENT OF NATURAL RESOURCES (2009). ALL RIGHTS RESERVED.
- CONTOUR INTERVAL IS 20 METRES.
- PLAN BASED ON INFORMATION PROVIDED BY LYCOPODIUM, DECEMBER 2, 2015. PLANT SITE, PORT LOCATIONS, PROPOSED ROADS BASED ON INFORMATION PROVIDED BY LYCOPODIUM, DECEMBER 30, 2015. DUMPS AND PITS BASED ON INFORMATION PROVIDED BY AGP JANUARY 15, 2016.

CANADA FLUORSPAR (NL) INC.

ST. LAWRENCE FLUORSPAR PROJECT

OVERALL GENERAL ARRANGEMENT

Knight Piésold
CONSULTING

FIGURE 1 | REV 0
P/A NO. NB101-642/6 | REF NO. NB16-00223



6.1.2 Construction Activities

The main activities to be completed during the construction phase for the Project include:

- site preparation;
- open pit development;
- construction of infrastructure;
- installation of utilities;
- restoration of temporary work areas; and
- commissioning

CFI will execute the proposed works in an environmentally responsible and safe manner, and will obtain all necessary regulatory approvals and permits prior to initiating construction.

6.1.2.1 Site Preparation

Site preparation activities include vegetation clearing, grubbing, topsoil salvage, site grading and excavation (Appendices D.1, D.2, D.9). The general areas requiring site preparation will be the Mine site, including the overburden, topsoil, and waste rock disposal areas, the Mill site, and the TMF. Land to be occupied by linear features, such as roads, pipelines, water diversion ditches, and power lines will also require site preparation. Site preparation is essential to support the safe installation of Project infrastructure. This work will be completed with all necessary sedimentation and erosion control measures (Appendix D.8). Cleared wood will be cut and stockpiled next to roads for access by the public for firewood once the proper internal process is followed and a permit is issued. Any residual slash will be stockpiled in windrows. Other early site preparation activities include levelling / infilling and installation of temporary offices with associated services (i.e., power, potable water cooler / storage systems, and temporary sanitary facilities) that will commence following upgrades to existing roads to allow equipment and personnel to safely access the site.

Temporary Sewage Facilities

Sewage generated during site preparation and construction will be collected and transported off-site for treatment and disposal at approved facilities. Portable washrooms and toilets will be used onsite until permanent facilities are completed. Where possible, permanent sewage systems will be installed and maintained to prevent the release of hazardous substances, pathogens and excess nutrients to the environment. All sewage and other wastewaters will be adequately treated prior to release to the environment (Appendix D.4), in accordance with the Waste Management Plan developed for the Project.

Stripping

Grubbing of the organic vegetation mat and / or the upper soil horizons, although they will be kept to a minimum, will be necessary in some areas within the Project footprint (Appendix D.2). Erosion control techniques and devices will be used to stabilize erosion prone areas (Appendix D.8).

Topsoil and excavated overburden will be stored in separate stockpiles for later use during reclamation. Any material unsuitable for construction purposes will be placed in an approved stockpile area. Runoff of sediment-laden water during grubbing will be minimized by using measures such as settling ponds, ditch blocks, interception ditches and filter fabrics. Erosion control measures such as rip-rap, filter fabrics, drainage channels, and gravel or wood chip mulches will be implemented in areas prone to erosion, as appropriate.



Excavation and Blasting

Excavation and blasting will be required related to the TMF, Mine and Mill site development, and access roads, (Appendices D.9, D.16).

Standard earthmoving procedures will be employed at the site, including drilling and blasting, and mechanical excavation (Appendices D.16, D.17). A large portion of the material to be moved on the site consists of rock. There are lesser amounts of till that also need to be excavated. Hard, sound igneous and metamorphic rock, which typically lies beneath the overburden, will require blasting and mechanical force to free it for excavation. Till is typically excavated using conventional mechanical means including excavators, loaders and dozers.

During construction, blasting operations are only required during the site preparation work phase of the Project. Blasting will be undertaken by licensed contractors. They will be responsible for maintaining current permitting with the regulatory agencies for the duration of construction. Explosives and auxiliary materials will be stored by the contractor as stipulated in relevant legislation, CFI Occupational Health and Safety (OH&S) standards, and in compliance with the construction permits.

Blasting activities will be coordinated and scheduled to minimize the number of blasts required per week. To reduce the seismic effect, blasting procedures will be developed. Time-delay blasting may be used as necessary to control debris scatter. Prior to any blast, the site will be surveyed to identify the presence of any wildlife; blasting will be delayed until such time as wildlife will not be affected by the blast.

Buildings and Service Roads

Site preparation for building construction will involve the use of compaction equipment, including conventional vibratory rollers (Appendix D.22). Final site levelling, and service and access road levelling will be done using graders. Concrete trucks will be used to transport concrete to the Project site. Cranes will be used throughout the site for assembling various Project components. Pit Development

Pit development will occur soon after the start of construction, including some overburden stripping and topsoil removal and salvage (Appendices D.2, D.9). In addition, small quantities of ore will be mined on the surface of the OCP to accommodate Mill commissioning (Appendix D.6). Small quantities of waste rock will also be excavated to use as road construction material, and to support construction of the TMF. Appropriate buffers will be maintained between the pit and environmental receptors, where necessary (Appendix D.7).

Grebes Nest Pond will be dewatered to allow the excavation of a portion of the GNP (Appendix D.13). Water quantity to be removed from Grebes Nest Pond is estimated at 0.3 million cubic metres (m^3). While most of that water is expected to be suitable for discharge into John Fitzpatrick Pond, disturbance of the pond bottom is expected to re-suspend sediment, and therefore, the water will be pumped through the nearby settling pond to the north (Appendices D.13, D.14). Prior to proceeding with dewatering of Grebes Nest Pond, fish will be captured and relocated in compliance with regulatory requirements and the Freshwater Fish Offset Plan to be approved by DFO (Appendix D.23).

6.1.2.2 Construction of the Mill

Construction of support buildings at the Mill site will include the water supply system that will be constructed after a suitable source of freshwater has been identified that will provide sufficient water quantity and quality for Mill processes, and following receipt of all required permits and approvals.

A tailings pipeline will also be constructed from the Mill to the TMF following an alignment that meets the technical, financial, and environmental requirements of the Project (Appendices D.12, D.19). The tailings pipeline will likely be built preferentially along road rights-of-way.



6.1.2.3 *Construction of Tailings Management Facility*

TMF construction activities will focus on the impervious tailings and polishing pond dams. The TMF design concept is based on a staged development of the tailings dam. The dam height will be raised as the life of Mine progresses, in step with the facility's need for increased storage capacity. Dam raises will follow the "Downstream Method" of dam development. Initially, a starter dam will provide a storage capacity of about 0.4 million m³ of tailings. At the end of the mining operations, the main dam will have reached its full design height to accommodate 2.0 million m³ of tailings. The TMF will be designed to contain a 1 in 200 year Environmental Design Flood. An emergency spillway will be constructed in order to convey the Inflow Design Flood as per the Canadian Dam Association (CDA) guidelines. Flow over the spillway would not occur unless the TMF is at its maximum operating level and a storm event in excess of the 1 in 200 year was to occur.

The tailings embankment dam will be constructed primarily of mine rock fill with 2H:1V upstream and downstream slopes and a 15 m wide crest. The upstream face of the embankment dam will be lined with a geosynthetic liner. The proposed maximum crest height for the dam is 26 metres (m), which would provide a capacity for 10 years of Mine operation. The initial dam will be constructed with a crest height of 15 m (elevation 111 m above sea level [masl]).

The water in the tailings pond will be transferred via an excess water transfer pump and pipeline to the polishing pond.

The polishing pond is located downstream (to the southeast) of the main TMF dam. Water will be discharged to the polishing pond prior to being released into the environment after applicable effluent discharge limits have been met, including the limit of 30 milligrams per litre (mg/L) for suspended solids, as stipulated in the NL Environmental Control Water and Sewage Regulations (2003) and in accordance with NL DOEC.

6.1.2.4 *Construction of Access and Haul Roads*

The Town of St. Lawrence is accessible from the provincial highway system along Route 220. A bypass road will be constructed to allow vehicle traffic to access the Mine site to the west of the town. Access between the Mill and Mine site entrance will be along a combination of existing and new roads (Appendix D.19). For the purposes of the Project, it is assumed that the existing roadways will require upgrading such as grading, widening, berthing and ditching. Each road will be upgraded to meet the loading and dimensional requirements of the largest design vehicle expected to use the road. Approximately 5.9 km of new access roads and 4.1 km of Mine roads will be constructed (Table 4).



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

Table 4: Mine Roads to be Built or Upgraded

Road Type	Road Location	Construction Type	Classification	Design vehicle	Width (m)	Length (m)
Mine and Haul Roads	In-pit	new	Dual Lane Heavy Vehicle	Caterpillar (CAT) 773G	20	1300
	In-pit	new	Dual Lane Heavy Vehicle	CAT 740B Articulated Dump Truck (ADT)	16	500
	In-pit	new	Single Lane Heavy Vehicle	CAT 740B ADT	11	900
	Surface- Haul road pit exit to dumps and Mill	new	Dual Lane Heavy Vehicle	CAT 773G	20	4000
	Surface- Haul road upgrade existing road to Mill	upgraded	Dual Lane Heavy Vehicle	CAT 773G	20	890
Access Roads	Around the Open Pits	new	Dual Lane Light Vehicle	Light Vehicle	7.35	2000
	Road Around TMF	new	Dual Lane Light Vehicle	Road Truck	8.75	3000
	Bypass Past Director Mill and Tarefare Shortcut	new	Dual Lane Light Vehicle	Road Truck	8.75	2500
	Road to Explosives Warehouse	new	Dual Lane Light Vehicle	Light Vehicle	7.35	1000
	Road From Pit Exit to Dumps	new	Dual Lane Heavy Vehicle	CAT 773G	19.845	4000
	From AGS Site Mill to Existing Mill Site	upgraded	Dual Lane Light Vehicle	Road Truck	8.75	3500
	From Mine to AGS Mill	upgraded	Dual Lane Heavy Vehicle	CAT 773G	19.845	390

Main Access Road

There are two main access roads to the Mill site and Mine site. Both are existing roadways and commence within the Town of St. Lawrence. The roads will temporarily be used during the construction period to bring heavy equipment, construction materials, supplies, and employees to the Project site. A permanent 6.7 km access road will be constructed to connect the site to Route 220 west of the Town.

Mine Roads

Approximately 7 km of Mine roads will be developed. Roads at the Mine site include surface haul roads, site roads and in-pit haul roads.

Surface haul roads will be developed to fit 773G mine trucks or similar and to allow for dual lane traffic with a width of 20 m. Haul roads will connect the pit exits with the waste dumps and the crusher at the Mill site.



A site perimeter road will run along the North edge of the pits for light vehicle traffic. The width and length of the various Mine roads is presented in Table 4.

The primary crusher feeding the Mill is located approximately 500 m from the Mine open pits to shorten the distance the haul trucks need to travel with the ore. Access from the Mine site to the Mill will be along a combination of existing roadways, which will be upgraded, and new Mine roads that will be built specifically for the Project. Upgrades to the existing roadways including ditching, grading, berthing and widening to 20 m will be required on this road to accommodate the large ore haul trucks.

6.1.2.5 Power

Marystow is the largest town on the Burin Peninsula, with a population of 5,900. It is located approximately 45 km northeast of the Town of St. Lawrence. Electrical power for local operations and the Town of St. Lawrence is obtained from the Newfoundland Power electrical grid, and emergency power is provided by a diesel generator located in the nearby community of Burin. A Newfoundland Power substation is situated on the north side of the Project area. Newfoundland Power has confirmed sufficient power will be available to supply the Project during both construction and operation.

Power requirements during the construction phase are estimated at 1,100 kV. The proposed transmission line will run from Newfoundland Power's existing substation in St. Lawrence to the Mill site. A new substation and metering station will be constructed at the Mill site to obtain the required voltage for the Mill.

6.1.2.6 Restoration of Temporary Works Areas

Restoration of temporary work areas will be undertaken during the construction phase to rehabilitate sites to a land use capability similar to that which existed prior to disturbance when the work in a given area has been completed.

Temporary facilities required for construction will be removed following completion of construction activities. Portable trailers for office space and for use by workers for dining and sanitation will be removed from service and relocated by contractors for reuse at other Project sites. Portable water supply equipment and portable sanitary toilets will also be removed and relocated to other CFI project sites.

Temporary oil and fuel storage tanks (Appendix D.3) will be decommissioned and relocated for use at other CFI contractors project sites. All product and vapours will be removed from the storage tanks, which will then be dismantled and removed from site by the supplier / contractor. Any contaminated material that may exist under or around the tanks will be excavated and removed for treatment and disposal following regulatory processes. The site will then be returned to a condition that is compliant with regulatory requirements, such as the Storage and Handling of Gasoline and Associated Products Regulations under the provincial EPA.

All construction equipment will be demobilized and removed from the site by the respective contractors for storage or reuse on other projects.

6.2 Linear Development (Roads, Pipelines, Conveyors)

For the purposes of the Project, it is assumed that the existing roadways will require upgrading such as grading, widening, berthing and ditching. Each road will be upgraded to meet the loading and dimensional requirements of the largest design vehicle expected to use the road. Approximately 5.9 km of new access roads and 4.1 km of Mine roads will be constructed (see Section 6.1.2.5).

Dry material will be moisture conditioned or covered to prevent blowing dust. Dust control will be provided for temporary roads and construction activities, primarily by using water when required. Fish bearing stream crossings



will be designed and constructed to allow fish passage and to preserve aquatic habitat. All bridge and culvert installations will be sized to meet design flood conditions. Watercourse crossings (by bridge or culvert) will be in accordance with permit requirements. Fish bearing streams will be crossed in accordance with DFO guidelines and standards (DFO 1995, 2013 and Grosse et al. 1998).

There will be no new power plants required for this Project; all power will be provided by Newfoundland Power from the provincial energy grid. There will be an overhead, single pole distribution system established by NL Power to the various facilities throughout the site.

Pipelines will also be required for the Project to serve various functions: delivery of process water needed for the Mill, and delivery of tailings to the TMF. Some of these structures may need to be installed beneath the ground surface to maintain grades required for gravity drainage or to ensure frost protection.

6.2.1 Construction Activities

Key activities associated with road and transmission line development include:

- stripping along the road and transmission line rights-of-way;
- excavation and blasting;
- construction activities and equipment mobilization;
- waste management;
- water management;
- energy consumption;
- transportation;
- staging and storage of construction-related equipment and materials;
- installing watercourse crossings (e.g. culverts, modular bridges, permanent bridges) along the road route;
- bridge and culvert maintenance;
- dewatering and erosion and sediment control; and
- fuel and other hazardous material storage and handling

6.2.2 Environmental Issues

General

General environmental issues associated with road, transmission line, and pipeline construction may include:

- sedimentation of waterbodies;
- alteration or loss of terrestrial habitat;
- loss or disturbance of wildlife;
- noise, dust and emissions;
- potential leakage or spills of fuel or other hazardous materials; and
- incidental events



Sensitive Areas / Periods

Freshwater: Stream crossings will generally be across existing roadways with existing culverts and bridges. New stream crossings may be required when constructing new access roads and Project infrastructure. All such stream crossings will be constructed in accordance with the procedures outlined in the EPP and will meet requirements of NL DOEC, DFO and any other applicable legislation.

Terrestrial: Construction of linear Project components may disturb migratory birds during the bird breeding season, which occurs from April 1 to September 1 in the region (Environment Canada 2014a). Any sightings or indications of nesting migratory birds will be reported immediately to the CWS, and work within an appropriate species-specific buffer of active nests will be halted until the HSE Manager advises otherwise. Additionally, to reduce potential adverse effects on nesting birds, clearing activities will take place outside of the bird breeding season for most bird species (April 1 to September 1), to the extent practical.

6.2.3 Environmental Protection Procedures

General Measures

General Environmental Protection Procedures relevant to linear developments are listed in Table 5, and presented in detail in Appendix D.

Table 5: Relevant Environmental Protection Procedures - Linear Development

General Environmental Protection Procedures (Appendix D)	Relevance to Linear Developments
D.1 Clearing of Vegetation	•
D.2 Grubbing, Stripping and Disposal of Related Debris	•
D.3 Storage, Handling and Transfer of Fuel and Other Hazardous Materials	•
D.4 Sewage Disposal	•
D.5 Solid Waste Disposal	•
D.6 Quarrying and Aggregate Removal	•
D.7 Buffer Zones	•
D.8 Erosion Prevention	•
D.9 Excavations, Embankment and Grading	•
D.10 Stream Crossings	•
D.11 Dust Control	•
D.12 Trenching	•
D.13 Dewatering – Work Areas	•
D.14 Pumps and Generators	•
D.15 Noise Control	•
D.16 Blasting	•
D.17 Drilling – Geotechnical	
D.18 Concrete Production	•
D.19 Linear Developments	•
D.20 Vehicular Traffic	•
D.21 Surveying	•
D.22 Equipment Operations	•
D.23 Fish Relocation	
D.24 Historic Resources	•



Sections 5.0, 6.0 and 7.0 and Appendices B, C, D and E of this EPP provide further information for preventing pollution, and avoid or reduce potential adverse effects on the environment during linear development construction.

6.2.4 Area Specific Measures

In addition to the Environmental Protection Procedures listed in Table 5 the following will be required during linear development construction:

- Requirements listed in all government permits, approvals, and authorizations.
- Proper installation or upgrading of culverts and / or bridges across a number of watercourses in the various watersheds. CFM will apply to NL DOEC for approvals for Alteration of a Body of Water pursuant to the provincial *Water Resources Act* for the installation of new structures and upgrading of existing structures. These activities will comply with terms and conditions of approval and guidance materials provided by NL DOEC with respect to the design, construction, and maintenance of the crossing structures to avoid or minimize the potential adverse effects on water quality and fish habitat.

6.2.5 Monitoring Requirements

Monitoring during linear development construction includes:

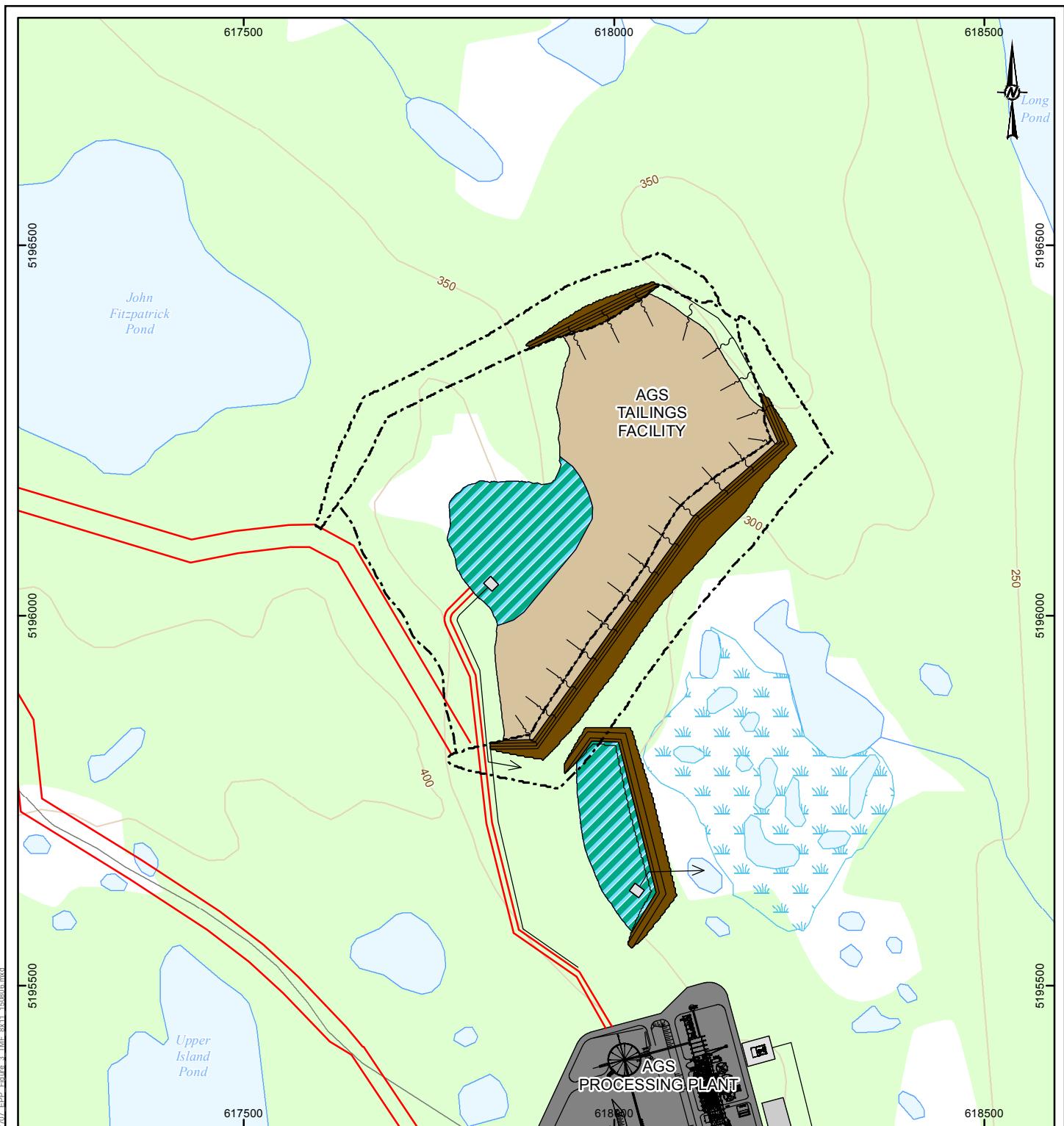
- Water quality and quantity monitoring will be undertaken in accordance with conditions of approval. In addition, water quality monitoring at other locations will be undertaken at the discretion of the HSE Manager and the HSE technician to ensure that natural freshwater bodies are not adversely affected by construction activity.
- Environmental monitoring to reduce potential adverse effects on federally or provincially protected species that may occur in, or in close proximity to, the Project footprint.

Detailed monitoring requirements during the Project construction phase are outlined in the EEMP (Golder 2016). Other monitoring requirements may be added as determined by regulatory conditions of approval.

6.3 Tailings Management Facility (TMF)

Construction of the TMF is described in Section 6.1.2.3. The general layout of the TMF is shown on Figure 2.

TMF construction activities will focus on the impervious tailings and polishing pond dams. The TMF design concept is based on a staged development of the tailings dam. The dam height will be raised as the life of Mine progresses, in step with the facility's need for increased storage capacity. Dam raises will follow the "Downstream Method" of dam development. Initially, a starter dam will provide a storage capacity of about 0.4 million m³ of tailings. At the end of the mining operations, the main dam will have reached its full design height to accommodate 2.0 million m³ of tailings.



LEGEND

- Existing Road
- Proposed Road
- Contour Line (interval: 50 ft/15.2m)
- Watercourse
- Waterbody
- Wetland
- Processing Plant
- AGS Tailings Facility
- AGS Tailings Pond
- Dam

0 125 250
Metres
1:7,500

REFERENCE

SOURCE(S): VARIOUS DRG, WORLEYPARSONS; CANVEC & CANVEC+, 1: 50 000 SCALE, NRCAN
PROJECTION: NAD 1983 UTM ZONE 21N

CLIENT

CANADA FLUORSPAR INC.

PROJECT

ST. LAWRENCE FLUORSPAR PROJECT
ENVIRONMENTAL PROTECTION PLAN

TITLE

TAILINGS MANAGEMENT FACILITY

CONSULTANT



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14-07707

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FIGURE

2



6.3.1 Construction Activities

Important activities in the TMF area during construction include:

- stripping;
- excavation and blasting;
- construction activities and equipment mobilization;
- waste management;
- water management;
- transportation;
- staging and storage of construction-related equipment and materials;
- dewatering and erosion and sediment control; and
- fuel and other hazardous material storage and handling

6.3.2 Environmental Issues

General

General environmental issues that may be associated with developing and working within the TMF area during construction include:

- sedimentation of waterbodies;
- alteration or loss of terrestrial habitat;
- loss or disturbance of wildlife;
- noise, dust and emissions;
- potential leakage or spills of fuel or other hazardous materials; and
- incidental events

Sensitive Areas / Periods

Terrestrial: Construction of the TMF may disturb migratory birds during the bird breeding season, which occurs from April 1 to September 1 in the region (Environment Canada 2014a). Any sightings or indications of nesting migratory birds will be reported immediately to the CWS, and work within an appropriate species-specific buffer of active nests will be halted until the HSE Manager advises otherwise. Additionally, to reduce potential adverse effects on nesting birds, clearing activities will take place outside of the bird breeding season for most bird species (April 1 to September 1), to the extent practical.

6.3.3 Environmental Protection Procedures

General Measures

Environmental Protection Procedures relevant to the construction of the TMF are listed in Table 6 and presented in detail in Appendix D.



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Table 6: Relevant Environmental Protection Procedures – Tailings Management Facility

General Environmental Protection Procedures (Appendix D)	Relevance to Tailings Management Facility (TMF) Construction
D.1 Clearing of Vegetation	•
D.2 Grubbing, Stripping and Disposal of Related Debris	•
D.3 Storage, Handling and Transfer of Fuel and Other Hazardous Materials	•
D.4 Sewage Disposal	•
D.5 Solid Waste Disposal	•
D.6 Quarrying and Aggregate Removal	•
D.7 Buffer Zones	•
D.8 Erosion Prevention	•
D.9 Excavations, Embankment and Grading	•
D.10 Stream Crossings	
D.11 Dust Control	•
D.12 Trenching	•
D.13 Dewatering – Work Areas	•
D.14 Pumps and Generators	•
D.15 Noise Control	•
D.16 Blasting	•
D.17 Drilling – Geotechnical	•
D.18 Concrete Production	•
D.19 Linear Developments	•
D.20 Vehicular Traffic	•
D.21 Surveying	•
D.22 Equipment Operations	•
D.23 Fish Relocation	
D.24 Historic Resources	•

Sections 5.0, 6.0 and 7.0 and Appendices B, C, D, and E of this EPP provide information to be used to prevent pollution, and avoid or reduce potential adverse environmental effects during construction of the TMF.

6.3.4 Area Specific Measures

In addition to the Environmental Protection Procedures listed in Table 6, the following will or may be required during TMF construction:

- Requirements listed in all government permits, approvals, and authorizations.
- A Water Management Plan will be prepared for the Project, in consultation with the provincial WRMD of NL DOEC that will describe the use and flow of water through and around the Mine during all Project phases, and the mitigation measures to be implemented to maintain water quality and quantity within each watershed.



6.3.5 Monitoring Requirements

- Environmental monitoring to reduce potential adverse effects on federally or provincially protected species that may occur in, or in close proximity to, the Project footprint.
- Water quality and quantity monitoring will be undertaken in accordance with conditions of approval. In addition, water quality monitoring at other locations will be undertaken at the discretion of HSE Manager and the HSE technician to ensure that natural freshwater bodies are not adversely affected by construction activity.
- Real-time water quantity / quality station(s) will be established in the vicinity of the TMF. This network will provide near real-time water quality and quantity data to ensure that emerging issues associated with the TMF (from both the construction and operational phases) are detected, to allow the appropriate mitigative measures to be implemented in a timely manner, thus reducing any adverse effect on the downstream systems. This network will be established in partnership between CFI and the WRMD through a signed Memorandum of Agreement. The exact type, number, location of the station(s) and other logistical details will be determined through collaborative engagement between CFI and WRMD.
- Water monitoring requirements and procedures will be outlined in the Water Management Plan that is currently being developed by CFI in collaboration with NL DOEC - WRMD.

Detailed monitoring requirements during the construction phase of the Project are outlined in the EEMP (Golder 2015d). Other monitoring requirements may be added as determined by regulatory conditions of approval.

6.4 Mine and Mill Sites

Mine and Mill construction is described in Sections 6.1.2.2 and 6.1.2.3. The general layout of the Mine and Mill Sites is shown on Figure 1.

6.4.1 Construction Activities

Key activities associated with development of the Mine and Mill includes:

- fish relocation;
- stripping;
- excavation and blasting;
- construction activities and equipment mobilization;
- waste management;
- water management;
- transportation;
- staging and storage of construction-related equipment and materials;
- dewatering and erosion and sediment control; and
- fuel and other hazardous material storage and handling



6.4.2 Environmental Issues

General

General environmental issues that may be associated with construction of the Project at the Mine and Mill includes:

- sedimentation of waterbodies;
- surface and groundwater quality or quantity;
- alteration or loss of terrestrial habitat;
- loss of fish and fish habitat;
- loss or disturbance of wildlife;
- noise, dust and emissions;
- potential leakage or spills of fuel or other hazardous materials; and
- incidental events

Sensitive Areas / Periods

Terrestrial: Construction of the Mine and Mill sites may disturb migratory birds during the bird breeding season, which occurs from April 1 to September 1 in the region (Environment Canada 2014a). Any sightings or indications of nesting migratory birds will be reported immediately to the CWS, and work within an appropriate species-specific buffer of active nests will be halted until the HSE Manager advises otherwise. Additionally, to reduce potential adverse effects on nesting birds, clearing activities will take place outside of the bird breeding season for most bird species (April 1 to September 1), to the extent practical.

6.4.3 Environmental Protection Procedures

General Measures

General environmental protection procedures relevant to the development of the Mine and Mill are listed in Table 7, and presented in detail in Appendix D.

Table 7: Relevant Environmental Protection Procedures - Mine and Mill Site Development

General Environmental Protection Procedures (Appendix D)	Relevance to Mine and Mill Site Development
D.1 Clearing of Vegetation	•
D.2 Grubbing, Stripping and Disposal of Related Debris	•
D.3 Storage, Handling and Transfer of Fuel and Other Hazardous Materials	•
D.4 Sewage Disposal	•
D.5 Solid Waste Disposal	•
D.6 Quarrying and Aggregate Removal	•
D.7 Buffer Zones	•
D.8 Erosion Prevention	•
D.9 Excavations, Embankment and Grading	•
D.10 Stream Crossings	•



General Environmental Protection Procedures (Appendix D)		Relevance to Mine and Mill Site Development
D.11	Dust Control	•
D.12	Trenching	•
D.13	Dewatering – Work Areas	•
D.14	Pumps and Generators	•
D.15	Noise Control	•
D.16	Blasting	•
D.17	Drilling – Geotechnical	•
D.18	Concrete Production	•
D.19	Linear Developments	•
D.20	Vehicular Traffic	•
D.21	Surveying	•
D.22	Equipment Operations	•
D.23	Fish Relocation	•
D.24	Historic Resources	•

Sections 5.0, 6.0 and 7.0 and Appendices B, C, D, and E of this EPP provide information to be used to prevent pollution, and avoid or reduce potential adverse environmental effects during Mine and Mill development.

6.4.4 Area Specific Measures

In addition to the general environmental protection measures listed above, the following specific measures will be implemented during construction:

- Additional specific conditions of approval will be implemented as per regulatory requirements.
- Use of manufacturer-recommended dust control equipment in the crushing plant, as defined in the Best Available Control Technology (BACT) analysis (to be developed).
- Covered-conveyor systems will be used to deliver crushed ore from the crusher building to the Mill stockpile, concentrate from the Mill to the storage building, and from the storage building to the ship loader and the ship. Where trucks are used to transport concentrate, covers will be used on the trucks.
- Proper building ventilation systems, complete with appropriate filters, will be used to reduce exhaust emissions.
- Indoor storage of fine Acid Grade concentrate and periodic moistening of concentrate to reduce dust dispersion by wind and over-drying in the storage building.
- Explosions at the Mill or Mine could result from an incident, failure of process equipment, over-pressure, sabotage, or as the result of a fire. A comprehensive leak and gas detection system will be in place to detect possible sources of ignition. A permit-to-work system will be implemented in all areas of the Mill and “hot work” will be strictly controlled in areas with a potential to have an ignition source. Site security will control access to the site (i.e., limited to approved personnel). The fire detection and alarm system will be monitored from the central control room to reduce response time so that small fires are detected and extinguished before developing into a major incident.



6.4.5 Monitoring Requirements

Monitoring applicable to the Mine and Mill construction includes:

- Environmental monitoring to reduce potential adverse effects on federally or provincially protected species that may occur in, or in close proximity to, the Project footprint.
- Water quality monitoring of surface water bodies and groundwater (including water pumped from the underground workings prior to discharging to surface water bodies).

Detailed monitoring requirements during the construction phase of the Project are outlined in the EEMP ([Golder 2016](#)). Other monitoring requirements may be added as determined by regulatory conditions of approval.



7.0 CONTINGENCY PLANS

CFI will establish an OHS Plan (to include radon and radon monitoring) and an Emergency Response Plan (ERP) that will include procedures that will be focused on avoiding workplace incidents. In the event of workplace emergency events, CFI will initiate the required response as outlined in the ERP. CFI is committed to providing the safest possible workforce for its employees through the strict enforcement of all safety related policies. It is the expectation of CFI that Employees will maintain constant vigilance, undergo regular safety training, and follow the procedures outlined in work execution plans to prevent and avoid workplace incidents.

7.1 Fuel and Hazardous Material Spills

Fuel and hazardous materials can be damaging to vegetation, soil, water (freshwater or marine), groundwater, wildlife, aquatic organisms, historic resources, and human health and safety. In the event of a fuel or hazardous material spill, the HSE Manager will be notified immediately. It is the responsibility of the supervisor / HSE technician to contact the appropriate agencies, if required.

An Emergency Response Team Coordinator (ERTC) will be identified at site. The ERTC will be trained in spill response procedures and how to mobilize the response equipment. The overall responsibility of co-ordinating a response and maintaining the contingency plan to ensure that it is current and up-to-date will be the ERTC's responsibility. The ERTC has full authority to take necessary and appropriate action without unnecessary delay. The ERTC will act in consultation with the HSE Manager and regulatory authorities.

Immediate action will be taken to stop the leak and contain the spilled material. All contaminated material will be collected and stored in an appropriate manner so as to not re-release to the environment until such time that it can be transported to an approved treatment/disposal facility.

The ERTC will be responsible for preparing a written report which will be submitted (as soon as possible and no later than 30 days after the spill) to the HSE Manager. It will be the responsibility of the HSE Manager to distribute the report to relevant government agencies, if required.

CFI's ERP will address fuel and hazardous materials spills.

7.2 Wildlife Encounters

Wildlife encounters pose a risk for stress and/or injury to both the wildlife and site personnel. Control measures and environmental protection procedures have been put in place to minimize the risk to wildlife and humans resulting from the construction of the Project. As a protection measure, hunting, trapping and fishing by Project personnel is not permitted on site.

The HSE technician is responsible to ensure that the site and working areas are kept clean of food scraps and garbage, waste is collected regularly and inspections are carried out to ensure cleanliness in accordance with the Waste Management Plan. No attempts to catch, chase or divert, follow, or otherwise harass any wildlife will be made by any Project personnel. Any encounters with wildlife shall be immediately reported to the HSE Manager.

To adequately document all worker / wildlife encounters, a wildlife encounter form shall be provided to all site contractors and completed when encounters are of a threatening nature or are of species at risk. These forms must be submitted to the HSE Manager.

CFI's ERP will address wildlife encounters.



7.3 Forest Fires

Construction of the Project may have activities that increase the risk of fire in the natural environment. To minimize the potential risk of fire, the HSE Manager will ensure that contractors take all precautions necessary to prevent fire hazards when working at the site. All waste materials of a flammable nature shall be disposed of in an appropriate manner, in the appropriate container. Personnel will be trained in fire prevention and response, and appropriate firefighting equipment will be readily available.

The Town of St. Lawrence has a dedicated emergency response team with fire-fighting equipment and emergency response vehicles equipped with fire-fighting equipment; it will be notified immediately. Evacuation of personnel from the area will be the highest priority. Meeting places for site workers will be established and headcounts taken to account for all personnel. The appropriate Forest Fire Protection Centre and RCMP office will also be notified immediately, and in the unlikely event of a large fire, local emergency response and fire-fighting capability will be called to respond, reducing the severity and extent of damage and to protect the safety of workers, visitors and the general public.

CFI's ERP will address forest fires.

8.0 COMMUNICATIONS PROTOCOL

Communication with various stakeholder groups is essential during the various Project phases to inform, engage, and obtain feedback. It is especially important during construction to allow CFI to be responsive to complaints and to provide timely, useful, and relevant information to local residents and other stakeholders to build positive relationships based on mutual respect. The Communications Protocol is outlined in the following subsections.

8.1 Objectives

The key objectives of the Communications Protocol for the Project are to:

- Provide timely and accurate Project information and updates, as required.
- Deliver information in a format that is clear and easy to understand.
- Identify issues of concern and respond in a timely and responsible manner.
- Improve the consultation process and the Project by incorporating stakeholder feedback and input, as well as public ideas and opinions.
- Adjust construction activities where possible, to avoid or mitigate adverse environmental effects.

8.2 Key Components of Communications Protocol

Under the direction of CFI, the following mechanisms and tools will be used to engage with stakeholder groups and the local community:

- open houses;
- stakeholder meetings (one on one meetings);
- project website;
- traditional media (newspaper and radio); and
- project toll free number and email address



Communication requirements and procedures will be incorporated into orientation training for all Project personnel and will include the following topics:

- emergency response / critical incident communications procedures;
- project activity notification procedures;
- complaints response procedures;
- stakeholder strategy awareness for employees and contractors; and
- monitoring, documenting and reporting requirements

During construction, communications material that may be used to provide updates and information to stakeholders could include:

- activity notices;
- Project information sheets;
- Project newsletters;
- local employment / business information;
- Project website updates;
- radio announcements; and
- press releases and advertisements

8.3 Project Personnel External Communication

It is important that all Project personnel understand that they represent the Project at all times, whether on or off the construction site. All personnel must conduct themselves appropriately and use the adequate communication procedures when communicating with other parties, such as regulatory agencies, inspectors, the media and the public.

8.3.1 Communication with Environmental Regulatory Agencies

All communication, verbal and written, to outside agencies regarding environmental issues shall require co-ordination through CFI's Managers.

CFI's Managers will act as primary contact for federal, provincial and local regulatory agencies that require compliance records and access to the Project site unless circumstances dictate otherwise. Submission of environmental reports to these agencies shall also be controlled by CFI's Managers.

8.3.2 Regulatory Inspectors

Provincial or federal regulatory officials may require access to the Project construction site to conduct an investigation or to complete an inspection. All visits, whether planned or unannounced, will be directed to the EPCM Construction Manager. The overall responsibility for co-ordinating these visits will be that of the EPCM Construction Manager. Where the inspection is environment related, the HSE Manager, or designate, must be contacted immediately and must be in attendance for any tours or meetings.



During site visits, regulatory officials will be requested to attend a pre-inspection meeting and a post-inspection meeting with the EPCM Construction Manager, HSE Manager and other personnel, as designated. The HSE Manager will prepare a report summarizing the environment related visit, findings and the actions that are required. Corrective action will be completed promptly, regulatory officials will be kept informed, and copies of the report will be issued to the EPCM Project Director and CFI's Managers.

8.3.3 Communications with Media

No Project personnel are authorized to speak with the media. Any media requests must be sent to CFI's Community Relations Liaison who will respond to the request according to corporate policies.

8.3.4 Communications with Public

No Project personnel are authorized to speak with the public regarding details of the Project construction.

In the event that construction personnel are approached by a visitor on-site, the visitor should be directed to the main construction office. In the event that the construction office is not practical, the visitor should be directed to the closest of the following: EPCM Construction Manager or HSE Manager. These representatives will direct the visitor appropriately.

8.4 Complaints Management

An effective and well-functioning complaints mechanism is an essential part of managing community relations. For local communities, Project effects such as noise, dust, traffic and influx of workers associated with construction can result in disturbances.

A procedure will be implemented for managing complaints from stakeholders. The objectives of the procedure will be to:

- Provide affected people with straightforward and accessible ways for making a complaint.
- Ensure that appropriate and mutually acceptable corrective actions are identified and implemented.
- Verify that complainants are appropriately addressed with outcomes of corrective actions.

CFI will respond to inquiries and complaints received from the public. When a complaint is made, all contractors will immediately communicate it to an appropriate CFI representative. CFI will identify a person responsible to manage responses to complaints and will establish a defined timeline for responding to complaints. All complaints received will be communicated to this manager, who will be responsible to log, track and respond to inquiries within a defined timeline.

A register of complaints and responses will be maintained by CFI to document how issues have been resolved. The register of inquiries will include:

- source;
- time and nature of the complaint;
- work activities being conducted at the time of the complaint;
- weather conditions at the time of the complaint; and
- complainant's name, address and contact number



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An investigation of each complaint will be completed. Where required, corrective action(s) will be implemented, as appropriate, including the possible modification of construction technique and / or equipment to avoid recurrence, or reduce adverse effects. CFI will inform the stakeholder of the response to their complaint, including details on implementation of corrective action(s), if applicable. Follow-up monitoring will be implemented, if necessary, to evaluate the effectiveness of the corrective action(s).

All contractors will be required to be familiar with, and abide by the complaints procedure. This will include:

- Providing Project schedule and activity updates to CFI to allow sufficient time for any potential effects to the local community to be included in Project updates and notifications.
- Ensuring contractor personnel participate in orientation training, including code of conduct and communications training, and abide by the procedures and expectations outlined in the training.
- Participating in investigations of complaints or other incidents that could lead to complaints.
- Making resources available to undertake immediate and appropriate corrective action to resolve issues.
- Providing follow-up monitoring and reporting as necessary.



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9.0 FORMS

9.1 Environmental Meeting Record Form

Date and Time: _____ Project: _____

Location: _____ Weather: _____

Type of Environmental Meeting: Toolbox Meeting Job Environment Analysis [JEA] Weekly Meeting

Brief Description of Job / Task:

Special EPP Measures for the Job / Task:

For more information, contact the Office of the Vice President for Research and Economic Development at 319-273-2500 or research@uiowa.edu.

Other Issues:

For more information, contact the Office of the Vice President for Research and Economic Development at 515-294-6450 or research@iastate.edu.

Resolutions:

For more information, contact the Office of the Vice President for Research and Economic Development at 319-273-2500 or research@uiowa.edu.

HSE Manager Comments:

For more information, contact the Office of the Vice President for Research and Economic Development at 515-294-6450 or research@iastate.edu.

Signatures of Project Personnel

[Signatures]

[Signatures]

[Signatures]



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9.2 Spill Report Form

Date: _____

Project: _____

Substance Spilled: _____

Time of Spill: _____

Time Personnel Learned of Spill: _____

Time Clean-up Commenced: _____

Approximate Volume of Spill: _____

Spill Location: _____

Description of Source / Cause: _____

Nature, Extent, Duration and Environmental Effect:

Remediation Plan and Follow-up:

Disposal Receipt Attached or to Follow? Yes / No

Date Report Sent to Regulators: _____

[OPTIONAL – COMPLETE PORTION BELOW IF SPILL WAS AN EMERGENCY]

Time Environmental Emergencies Notification: _____

Name of Emergency Personnel: _____

Any Resulting Injuries? Yes / No [If yes, please describe]

Signatures:

HSE Manager: _____
[Signature]

EPCM Construction Manager: _____
[Signature]

Others: _____
[Signatures]



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9.3 Non-Compliance Form

Name of Personnel: _____

Role or Title: _____

Date of Non-Compliance: _____

Location of Non-Compliance: _____

Weather: _____

Ground Conditions: _____

Photos Attached? Yes / No

Photo Numbers: _____

Issues of Non-Compliance:

Resolution:

Follow-up Required:

Signatures

Project Personnel: _____
[Signature]

HSE Manager: _____
[Signature]

EPCM Construction Manager: _____
[Signature]



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9.4 EPP Revision Request Initiation Form

Section to be revised:

Section	Page #

Nature of Revision:

Rationale for Revision:

Submission Date: _____

Signatures

Project Personnel: _____
[Signature]

HSE Manager: _____
[Signature]

EPCM Construction Manager: _____
[Signature]



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Report Signature Page

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APPENDIX A

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To Be Determined

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Project Manager

To Be Determined

Construction Manager

To Be Determined

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Environmental Protection - Environmental Emergencies Coordinator

National Environment Emergency Centre

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Canadian Wildlife Service - Environmental Conservation Branch



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Fisheries Protection Program

Triage and Planning

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Marine Pollution (24 hour)

1-800-563-9089

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Marysville, NL A0E 2M0

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APPENDIX B

Guidance Documents



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

Document #	Title
1	DFO. 2013. Measures to Avoid Causing Harm to Fish and Fish Habitat. Available at: http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html . Accessed: September 2015.
2	Gosse, M.M., Power, A.S., Hyslop, D. E. and S.L. Pierce. 1998. Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans Canada, St. John's, NF. Available at: http://www.dfo-mpo.gc.ca/Library/240270.pdf . Accessed: September 2015.
3	Wright, D.G. and G.E. Hopky. 1998. Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters. Available at: http://www.dfo-mpo.gc.ca/Library/232046.pdf . Accessed: September 2015.

Measures to Avoid Causing Harm to Fish and Fish Habitat

If you are conducting a project near water, it is your responsibility to ensure you avoid causing [serious harm to fish](#) in compliance with the [Fisheries Act](#). The following advice will help you avoid causing harm and comply with the Act.

PLEASE NOTE: This advice applies to all project types and replaces all “Operational Statements” previously produced by DFO for different project types in all regions.

Measures

Project Planning Timing

- Time work in water to respect [timing windows](#) to protect fish, including their eggs, juveniles, spawning adults and/or the organisms upon which they feed.
- Minimize duration of in-water work.
- Conduct instream work during periods of low flow, or at low tide, to further reduce the risk to fish and their habitat or to allow work in water to be isolated from flows.
- Schedule work to avoid wet, windy and rainy periods that may increase erosion and sedimentation.

Site Selection

- Design and plan activities and works in waterbody such that loss or disturbance to aquatic habitat is minimized and sensitive spawning habitats are avoided.
- Design and construct approaches to the waterbody such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
- Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.

Contaminant and Spill Management

- Plan activities near water such that materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.
- Develop a response plan that is to be implemented immediately in the event of a sediment release or spill of a deleterious substance and keep an emergency spill kit on site.
- Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

Erosion and Sediment Control

- Develop and implement an Erosion and Sediment Control Plan for the site that minimizes risk of sedimentation of the waterbody during all phases of the project. Erosion and sediment control

measures should be maintained until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the waterbody or settling basin and runoff water is clear. The plan should, where applicable, include:

- Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the water body.
- Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site such that sediment is filtered out prior to the water entering a waterbody. For example, pumping/diversion of water to a vegetated area, construction of a settling basin or other filtration system.
- Site isolation measures (e.g., silt boom or silt curtain) for containing suspended sediment where in-water work is required (e.g., dredging, underwater cable installation).
- Measures for containing and stabilizing waste material (e.g., dredging spoils, construction waste and materials, commercial logging waste, uprooted or cut aquatic plants, accumulated debris) above the high water mark of nearby waterbodies to prevent re-entry.
- Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction.
- Repairs to erosion and sediment control measures and structures if damage occurs.
- Removal of non-biodegradable erosion and sediment control materials once site is stabilized.

Shoreline Re-vegetation and Stabilization

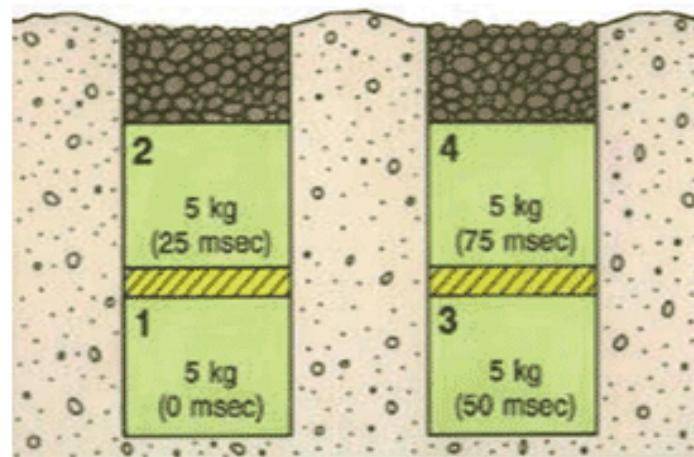
- Clearing of riparian vegetation should be kept to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction. When practicable, prune or top the vegetation instead of grubbing/uprooting.
- Minimize the removal of natural woody debris, rocks, sand or other materials from the banks, the shoreline or the bed of the waterbody below the ordinary high water mark. If material is removed from the waterbody, set it aside and return it to the original location once construction activities are completed.
- Immediately stabilize shoreline or banks disturbed by any activity associated with the project to prevent erosion and/or sedimentation, preferably through re-vegetation with native species suitable for the site.
- Restore bed and banks of the waterbody to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage should be restored.
- If replacement rock reinforcement/armouring is required to stabilize eroding or exposed areas, then ensure that appropriately-sized, clean rock is used; and that rock is installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.
- Remove all construction materials from site upon project completion.

Fish Protection

- Ensure that all in-water activities, or associated in-water structures, do not interfere with fish passage, constrict the channel width, or reduce flows.
- Retain a qualified environmental professional to ensure applicable permits for relocating fish are obtained and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters. Fish may need to be relocated again, should flooding occur on the site.
- Screen any water intakes or outlet pipes to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.
 - In freshwater, follow these measures for design and installation of intake end of pipe fish screens to protect fish where water is extracted from fish-bearing waters:
 - Screens should be located in areas and depths of water with low concentrations of fish throughout the year.
 - Screens should be located away from natural or artificial structures that may attract fish that are migrating, spawning, or in rearing habitat.
 - The screen face should be oriented in the same direction as the flow.
 - Ensure openings in the guides and seals are less than the opening criteria to make “fish tight”.
 - Screens should be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area.
 - Structural support should be provided to the screen panels to prevent sagging and collapse of the screen.
 - Large cylindrical and box-type screens should have a manifold installed in them to ensure even water velocity distribution across the screen surface. The ends of the structure should be made out of solid materials and the end of the manifold capped.
 - Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.). A 150 mm (6 in.) spacing between bars is typical.
 - Provision should be made for the removal, inspection, and cleaning of screens.
 - Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.
 - Pumps should be shut down when fish screens are removed for inspection and cleaning.

- Avoid using explosives in or near water. Use of explosives in or near water produces shock waves that can damage a fish swim bladder and rupture internal organs. Blasting vibrations may also kill or damage fish eggs or larvae.
 - If explosives are required as part of a project (e.g., removal of structures such as piers, pilings, footings; removal of obstructions such as beaver dams; or preparation of a river or lake bottom for installation of a structure such as a dam or water intake), the potential for impacts to fish and fish habitat should be minimized by implementing the following measures:
 - Time in-water work requiring the use of explosives to prevent disruption of vulnerable fish life stages, including eggs and larvae, by adhering to appropriate fisheries [timing windows](#).
 - Isolate the work site to exclude fish from within the blast area by using bubble/air curtains (i.e., a column of bubbled water extending from the substrate to the water surface as generated by forcing large volumes of air through a perforated pipe/hose), cofferdams or aquadams.
 - Remove any fish trapped within the isolated area and release unharmed beyond the blast area prior to initiating blasting
 - Minimize blast charge weights used and subdivide each charge into a series of smaller charges in blast holes (i.e., decking) with a minimum 25 millisecond (1/1000 seconds) delay between charge detonations (see Figure 1).
 - Back-fill blast holes (stemmed) with sand or gravel to grade or to streambed/water interface to confine the blast.
 - Place blasting mats over top of holes to minimize scattering of blast debris around the area.
 - Do not use ammonium nitrate based explosives in or near water due to the production of toxic by-products.
 - Remove all blasting debris and other associated equipment/products from the blast area.

Figure 1: Sample Blasting Arrangement



Per Fig. 1: 20 kg total weight of charge; 25 msecs delay between charges and blast holes; and decking of charges within holes.

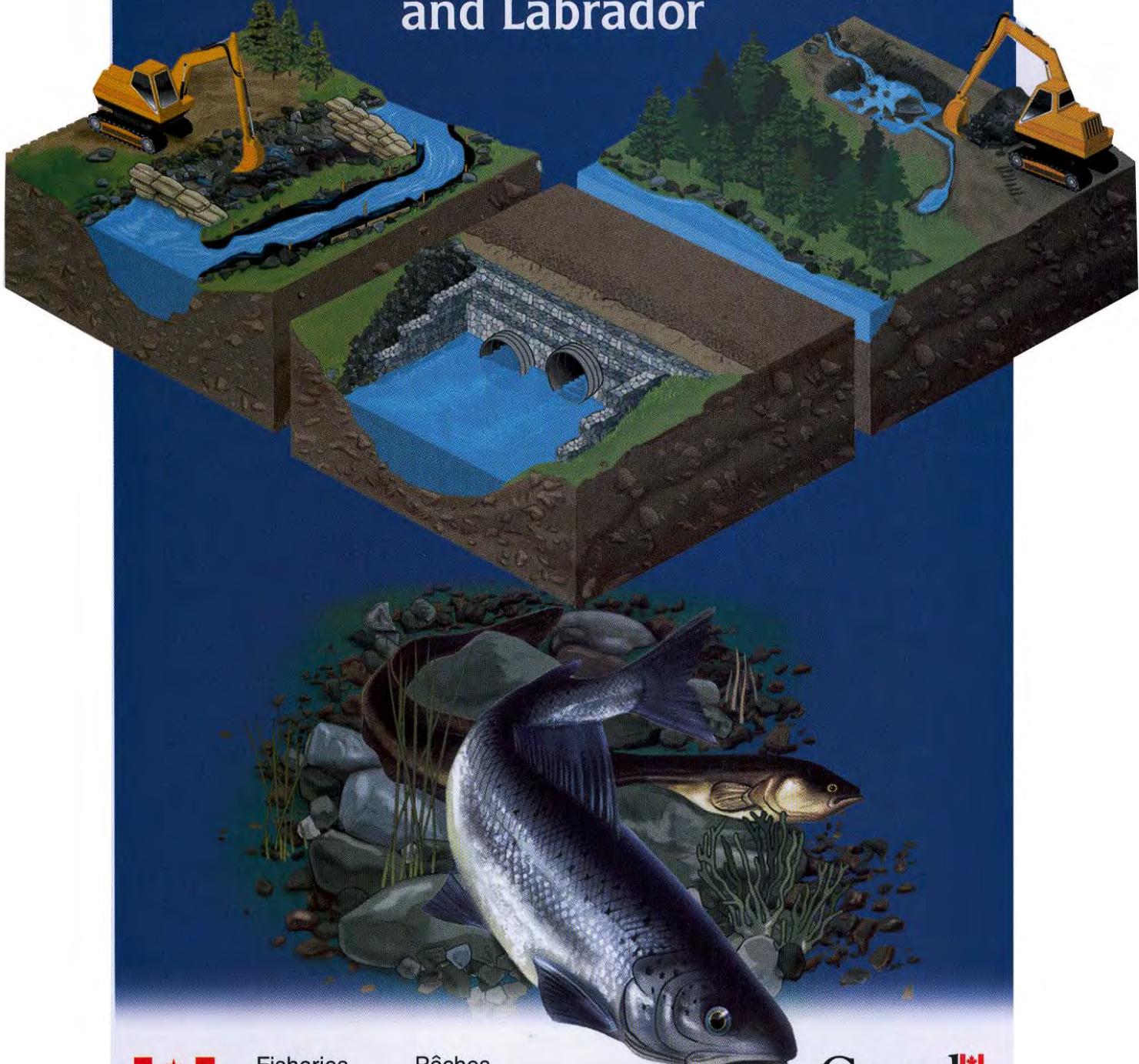
Operation of Machinery

- Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.
- Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbance to the banks and bed of the waterbody.
- Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.
- Use temporary crossing structures or other practices to cross streams or waterbodies with steep and highly erodible (e.g., dominated by organic materials and silts) banks and beds. For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g., swamp mats, pads) if minor rutting is likely to occur during fording.
- Wash, refuel and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.

Date modified:

2013-11-25

Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador



Fisheries
and Oceans

Pêches
et Océans

Canada

Department of Fisheries & Oceans
Marine Environment and Habitat Management Division
Science Branch

*Guidelines for Protection of Freshwater Fish Habitat
in Newfoundland and Labrador*

by

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March 1998

The correct citation for this document is:
Gosse, M.M., A.S. Power, D.E. Hyslop, and S.L. Pierce. 1998. Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans, St. John's, NF. x + 105 pp., 2 appendices.

Published by:

Department of Fisheries and Oceans
Science Branch
P.O. Box 5667
St. Johns, NF
A1C 5X1

ISBN 0-662-26714-1

Catalogue No. Fs 53-4/1998E



Printed on Recycled Paper

PREFACE

Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador has been developed to serve as a reference for planners, developers, contractors and regulatory agencies in addressing freshwater fish and fish habitat protection issues arising as a result of proposed project development activities. This document has been generated following reviews of existing guidelines from local and other jurisdictions, field observations and recommendations from experts in both the environmental and construction fields. This guideline updates and combines the information contained in the previous Department of Fisheries & Oceans (DFO) guideline documents entitled *Resource Road Construction Fish Habitat Protection Guidelines* (McCubbin et al. 1990) and *Urban Development Guidelines for Protection of Fish Habitat in Insular Newfoundland* (DFO and LGL Ltd. 1990). Guidance provided in this document is intended to assist planners, developers and contractors in providing appropriate fish and fish habitat information to regulators for use in the comprehensive review of project development proposals.

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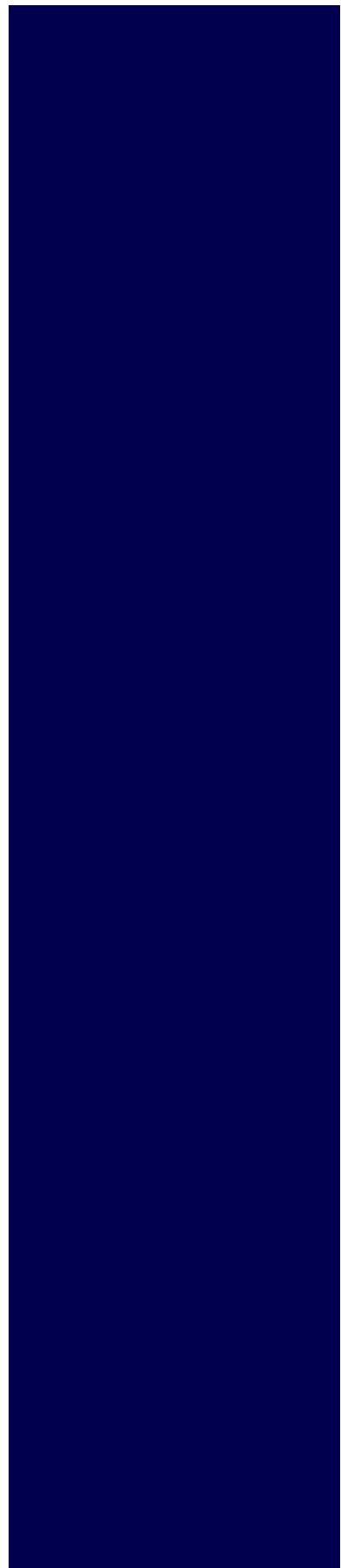
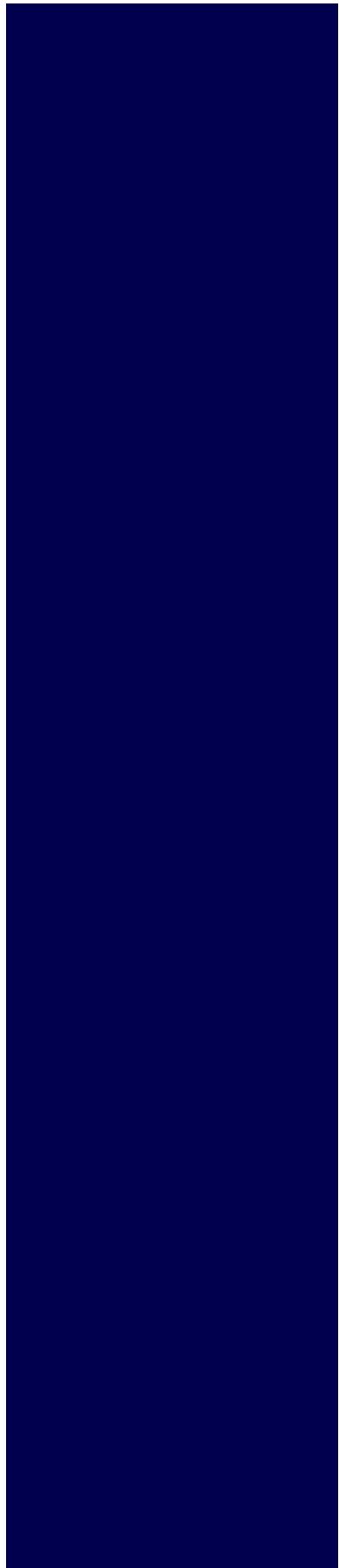


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1.O INTRODUCTION

Canada's *Fisheries Act* provides for the protection of fish and fish habitat.

These guidelines have been developed to serve as a reference for planners, developers, contractors, and regulatory agencies in addressing freshwater fish and fish habitat protection issues arising as a result of proposed project development activities. This document has been generated following reviews of existing guidelines from local and other jurisdictions, field observations, and recommendations from experts in both the environmental and construction fields. This guideline updates and combines the information contained in the previous Department of Fisheries and Oceans (DFO) guideline documents entitled *Resource Road Construction Fish Habitat Protection Guidelines* (McCubbin et al. 1990) and *Urban Development Guidelines for Protection of Fish Habitat in Insular Newfoundland* (DFO and LGL Ltd. 1990).

Protection is an essential step in maintaining the productivity of fish habitat. Habitat protection contributes to the conservation and enhancement of commercial, recreational, and subsistence fisheries resources. Specific requirements for protection of fish habitat are set out in Canada's *Fisheries Act* and its associated regulations. Other federal, provincial, or municipal legislation addressing fish and fish habitat protection may also apply to proposed developments.

Most problems associated with development-related activities, regardless of scale, are often the result of poor planning and design, improper site location, and inappropriate construction practices. This document identifies common project development activities that have the potential to adversely impact the aquatic environment and offers guidance on measures to reduce or eliminate these harmful impacts. The proper implementation of appropriate mitigative techniques can prevent or minimize impacts on productive fish habitat and fish populations.

1.1 PURPOSE AND SCOPE

The purpose of these guidelines is to provide direction to planners, developers, contractors, and regulatory agencies in addressing freshwater fish and fish habitat protection issues arising from proposed project development activities. The following highlights the format of this document:

- Section One outlines the purpose of this document within the context of fish habitat management in Newfoundland and Labrador. A description of key fish habitat requirements is provided to illustrate the linkage between fish and fish habitat and to emphasize the importance of habitat protection.
- Section Two provides an overview of the DFO's legislative responsibilities under the *Fisheries Act* and the *Policy for the Management of Fish Habitat*.
- Section Three outlines the general information requirements of DFO that enable the review and evaluation of the predicted impacts of a proposed development on fish and fish habitat and the mitigative measures that should be incorporated into the development plan to protect fish and fish habitat.
- Section Four outlines mitigative techniques aimed at reducing or eliminating the potential harmful impacts of project development and operation activities on fish and fish habitat.

1.2 FISH AND FISH HABITAT

The freshwater fishery resource of Newfoundland and Labrador is unique among areas of comparable latitude in North America since salmonids are predominant in virtually all waterbodies. Salmonid species include Atlantic salmon, brook trout, brown trout, rainbow trout, lake trout, and white fish. Other freshwater fish found in the province include eel, stickleback, smelts, northern pike, and others.

In order for fish populations to thrive and reproduce, fish habitat should provide shelter, security and nourishment. All salmonids have similar freshwater habitat requirements: clear, clean water; cool water temperatures; a high oxygen supply; shelter; food from both aquatic and terrestrial sources; a combination of appropriate habitat types; suitable substrates; adequate stream flow; and access to a variety of habitats for various life processes (Figure 1.1).



Figure 1.1 Freshwater habitat requirements for salmonids.

Fish require a healthy habitat to survive and reproduce.

Water clarity is important for various reasons. Suspended sediment reduces visibility, making it difficult for fish to locate and capture prey. Suspended sediment (Figure 1.2) can also damage fish gills causing injury, mortality, and increased susceptibility to disease and predation. Settled sediments can infill pools and riffles, reducing the availability and quality of spawning and rearing habitat for fish (Figure 1.3). Infilling occurring during spawning, incubation, or hatching periods can smother eggs and alevins. Sediment deposits can also reduce the food supply by displacing insect larvae that reside on the stream bottom.



Figure 1.2 Development activities can introduce suspended sediment into watercourses.

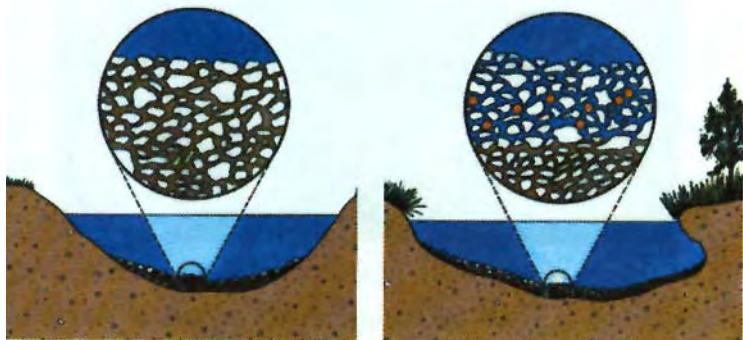


Figure 1.3 Suspended sediment can settle on the bottom of water-courses, filling interstitial spaces in gravel substrate used for spawning and incubation.

Clean water, free of toxins and pollutants, is essential for healthy and productive fish populations. The introduction of pollutants into the aquatic environment can seriously affect plants, animals, and micro-organisms, thereby altering the structure of the aquatic ecosystem. Pollutants can be directly lethal to fish, can make fish more susceptible to other stressors, or can accumulate in fish tissues making them unsafe for human consumption.

Water temperature is a critical factor in salmonid survival. Fish may display signs of stress at temperatures above 22°C and mortalities have been recorded at 27°C. Developing eggs also have strict cool temperature requirements and hatching success can be greatly affected by increases in temperature. Factors that help to maintain cool water temperatures include deep, flowing steadies and pools, shading by streamside vegetation, and intact groundwater sources.

Dissolved oxygen in the water is absorbed by fish through the gills and transported around the body in the blood. Aquatic plants and algae introduce oxygen into the water as a product of photosynthesis. Turbulence is also important for oxygenating water. Dissolved oxygen levels are reduced in warm water, another important reason for cool water maintenance.

Shelter is necessary for avoiding predators and accessing shaded areas during periods of warm temperatures. Stumps, logs, and other instream debris make excellent hiding places. Fish rest behind instream boulders or in undercut streambanks, and dart out into the current to catch drifting food. These areas are also velocity shelters that enable fish to conserve energy.

Food supply in the aquatic environment must be plentiful and diverse to sustain the productivity of a watershed. A healthy pond or stream contains hundreds of varieties of plant and animal life, much of which is microscopic. Leaf litter and woody debris that fall into a stream are broken down and decomposed by microorganisms and insect larvae. These insect larvae, in turn, may be eaten by juvenile fish. Larger fish may prey upon worms, amphipods, and smaller fish.

Habitat variety is important for providing key habitat components to all life stages within a fish population. Salmonids use different sections of a stream at different life cycle stages. The usefulness of

these sections is determined by substrate size, water depth, and flow.

Suitable substrate is essential for fish productivity. Fish need well-aerated, gravel-bottomed areas for spawning. Rearing areas require larger substrates, which provide young fish with resting areas and shelter from predators

Adequate stream flow is required by fish to ensure that habitat is accessible. Stream flow also influences other habitat factors such as water temperature and dissolved oxygen levels. Flow is required to provide oxygen to developing eggs and remove wastes. Deeper, slow-moving stream sections make good nursery and rearing areas for newly-hatched and growing salmonids. Excessive flow and high water velocities can displace fish from habitat and create migration barriers. Pools and ponds are used for overwintering. Flow ultimately determines the available space (wetted area) for fish.

Access to habitat is crucial in maintaining fish populations. Obstructions to fish passage can alienate large areas of productive spawning and rearing habitat.

2.0 LEGISLATION AND POLICY

In Newfoundland and Labrador, fish habitat protection falls under the jurisdiction of the Department of Fisheries and Oceans (DFO). It is recommended that DFO be consulted early in the planning stages of any development that has the potential to affect freshwater fish and fish habitat. The following provides an overview of relevant federal fish and fish habitat legislation and policy. Other federal (e.g. *Navigable Waters Protection Act*), provincial or municipal legislation and policy may also apply to proposed developments. Proponents, developers and contractors are advised to contact the appropriate regulatory agencies regarding approvals and permits.

2.1 FISHERIES ACT

The Habitat provisions of the *Fisheries Act* apply to all projects and activities that have the potential to alter, disrupt or destroy marine or freshwater fish or fish habitat through chemical, biological, or physical means. Under the *Fisheries Act* there are sections specific to fish habitat that address such aspects as physical disruption of fish habitat, discharge of pollutants (or deleterious substances), fish passage, fishways, explosives, and intake screens, among others.

The *Fishery (General) Regulations*, as made pursuant to the *Fisheries Act*, also have habitat provisions. Section 58 of the Regulations addresses the harmful alteration, disruption, or destruction of fish habitats as a result of developments. It is in this Section of the Regulations that the Department of Fisheries and Oceans (DFO) Authorizations For Works or Undertakings Affecting Fish Habitat is identified and Authorization is given under Sub-Section 35(2) of the *Fisheries Act*.

For project developments or activities that have the potential to impact on freshwater (or marine) fish or fish habitat, it is recommended that the Department of Fisheries and Oceans be contacted. Recommendations, via a Letter of Advice, are provided where any

potential harmful alteration, disruption, or destruction of fish habitats can be properly mitigated. In cases where harmful alteration, disruption, or destruction of fish habitats cannot be appropriately mitigated, then a Section 35(2) Authorization under the *Fisheries Act* may be issued with any associated fish habitat compensation, as required. Project developments may include: general in-stream work, stream crossings, blasting in or near waterbodies, quarries in proximity to waterbodies, water withdrawal, onland site development activities potentially resulting in siltation, infilling or other freshwater (or marine) project activities to name a few.

The *Policy for the Management of Fish Habitat* applies to habitats supporting fish stocks or populations that sustain commercial, recreational, or subsistence fisheries. The Policy is not a statutory requirement to be met at all costs, rather it is a guide for DFO officials and other interested individuals (eg., proponents/developers).

The Marine Environment and Habitat Management Division of DFO has many documents /pamphlets available addressing legislation and policy, and identifying types of mitigative measures that may be applicable to project activities involving freshwater (or marine) fish or fish habitat. Referrals should be forwarded to the appropriate Area Habitat Biologist (See Appendix A).

For information and reporting of environmental emergencies and chemical or hydrocarbon spills see Appendix B.

DFO should be contacted regarding activities in or near aquatic environments.

2.2 POLICY FOR THE MANAGEMENT OF FISH HABITAT

The Department of Fisheries and Oceans' *Policy for the Management of Fish Habitat* provides a comprehensive framework for the conservation, restoration, and development of fish habitats and strategies for the implementation of policy components.

The overall objective of the Policy (as outlined in Figure 2.1) is a **net gain** of the productive capacity of fish habitats for Canada's fisheries resources. The policy is intended to:

Increase the natural productive capacity of habitats for the nation's fisheries resources to benefit present and future generations of Canadians.

No Net Loss is a key element in DFO's *Policy for the Management of Fish Habitat*.

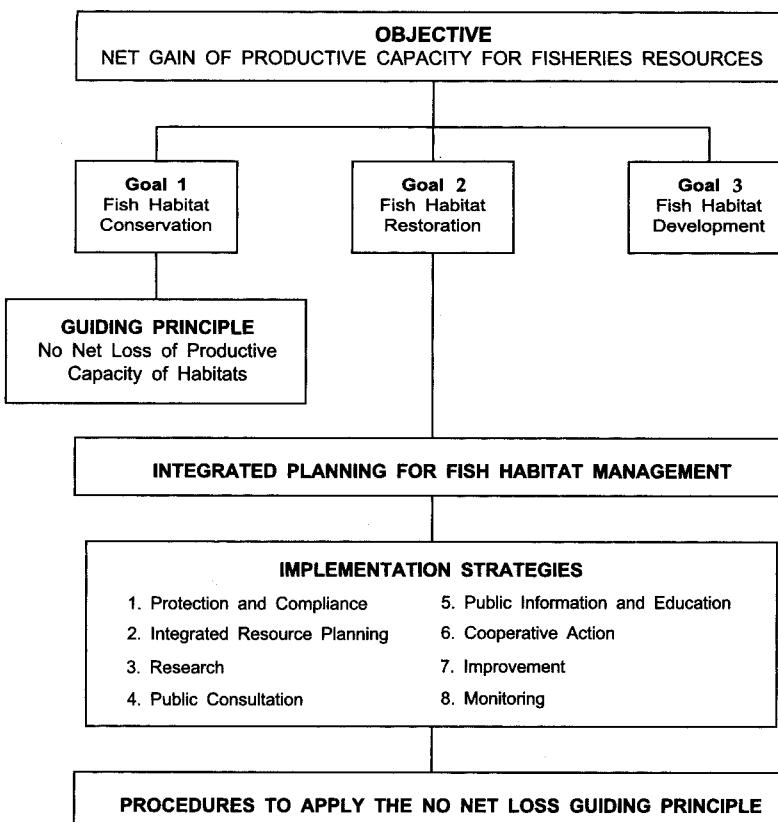


Figure 2.1 Schematic diagram of the Department of Fisheries and Oceans Policy for the Management of Fish Habitat

This objective is supported by three goals covering the conservation, restoration, and development of fish habitat. Specifically, the three goals are:

- 1) **Conservation** - Maintain the current productive capacity of fish habitats supporting Canada's fisheries resources, so that fish suitable for consumption may be produced (This goal is implemented using a no net loss guiding principle).
- 2) **Restoration** - Rehabilitate the productive capacity of fish habitats in selected areas where economic or social benefits can be achieved through the fisheries resource.
- 3) **Development** - Create and improve fish habitats in selected areas where the production of fisheries resources can be increased for the social or economic benefit of Canadians.

The **no net loss** guiding principle of the conservation goal is applied in terms of a hierarchy of preferences. This goal can be achieved by avoiding any habitat loss or alteration at the site of a proposed project or activity through project redesign, selection of alternate sites or the implementation of measures to mitigate potential damage. Only after it proves impossible or impractical to maintain the same level of habitat productive capacity using the forementioned approaches will compensatory options (like-for-like compensation, off-site replacement habitat, or an increase in the productivity of existing habitat for the affected stock) be considered.

3.0 INFORMATION REQUIREMENTS

Provision of comprehensive project information is necessary to facilitate review.

Project-specific information is required to address the potential impacts of a proposed development on fish and fish habitat. The types of information that may be required by DFO are highlighted in the following section. While this listing is not intended to be all inclusive, it indicates information that may be necessary to enable DFO and other regulatory agencies to review a proposed project development. Note the level of detail to be provided may vary with the complexity of the proposed project and site-specific characteristics.

3.1 TYPES OF INFORMATION

Project Specific Information

- project rationale/ purpose
- detailed description of the project, project structures and any associated construction, operation or decommissioning activities
- project/ activity schedule (time of year, duration, frequency, magnitude, and extent of activities)
- site plans/sketches indicating the location of project development activities (detailed on a 1:50,000 topographic map)
- engineering design details (when applicable)

General Site Information

- type of watercourse (e.g. pond or stream)
- gazetted or common name of watercourse
- location of the watercourse (preferably latitude and longitude or military grid reference)
- general photographs / video of the site

Biophysical Information

- fish presence, species, size(s) and type of fish habitat at the project site
- physical description of the watercourse at the project site (e.g. channel width and depth, direction and velocity of water movement, variations in water levels, flow regime at various times of the year, debris loading, etc.)
- location, orientation, and proximity of the development in relation to surrounding watercourses
- description of natural site features and characteristics
- commercial, recreational and/or subsistence fisheries (or potential fisheries) in the area

Water Withdrawal Information (where applicable)

- purpose of the water withdrawal;
- average rate, or ranges of rates, of withdrawal from the water course;
- duration and time of the withdrawal; estimates of ranges of flow (e.g. daily, weekly, monthly) in the watercourse during times of withdrawal with dates and times of the year (with particular consideration to periods of low flow);
- expected effects of withdrawal on existing conditions in the water course (e.g. drawdown, downstream dewatering, etc.);
- description and location of structures or activities associated with the development of the intake;
- whether the application is for a new intake, or re-development or upgrading of an existing structure;
- screen area (both open and effective areas); physical screen parameters with respect to the intake and the watercourse;
- screen material, method of installation, and supporting structures; and
- screen maintenance, clearing, or other special requirements.

Blasting/Explosives Information (where applicable)

- total quantity of and type of explosives;
- cross-section of blast hole detail;
- individual weight of charge(s);
- magnitude of charge weight to be detonated instantaneously;
- any decking of charges (e.g. several charges within a hole);
- amount of millisecond delay between charges;
- information on the type of material requiring blasting (e.g. rock, saturated soil, unsaturated soil);
- proposed blasting methodology;
- location of blasting;
- proposed time of year for undertaking; and
- biophysical information on fish habitat and fishery resources in the area.

Other Information

- potential impacts of the proposed development and associated activities on freshwater fish and fish habitat in the area
- details of proposed mitigation
- need for, adequacy of, or design of proposed monitoring (e.g. environmental effects monitoring, etc.) programs to be implemented to address the impacts of the proposed development and associated activities on fish and fish habitat

Note: *A Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador: Rivers and Streams* (Sooley et al. 1998) is available from DFO. The document details the types of information that may be required by DFO in the project review process as well as a guide to the standard methods for the collection of required fish and fish habitat information.

3.2 HOW THIS INFORMATION WILL BE USED

The above information is used by DFO to assist in the review of the proposed project development. Based on the information provided, DFO determines the accuracy of a proponent's assessment of potential impacts, and the adequacy of proposed mitigative measures and monitoring programs. It is essential that potential environmental impacts, mitigative measures, and monitoring programs that will be in place throughout the life of a project be fully identified/addressed to enable a comprehensive understanding of the implications of the project on fish and fish habitat.

4.0 HABITAT PROTECTION MITIGATION TECHNIQUES

Silt is harmful to fish and fish habitat.

For many project developments and associated activities there are issues that typically have to be addressed with respect to freshwater fish and fish habitat protection. Issues such as erosion/sedimentation control, site stabilization, site clearing, buffer zones, watercourse crossings, and fish passage are common to many project developments regardless of overall project scale (i.e. small or large). The following section presents both general construction activity related and project specific mitigative techniques aimed at reducing or eliminating potentially harmful impacts on fish and fish habitat; these techniques are often used most effectively in combination.

4.1 EROSION/SEDIMENTATION CONTROL

Land development activities, such as clearing land, grading slopes, road building, and excavating and stockpiling materials, can lead to the erosion of soils into nearby watercourses that contain fish and fish habitat (Figure 4.1). Sedimentation of watercourses can have detrimental effects on fish and fish habitat. Suspended sediment reduces water clarity and can cause damage to gills. Sediment can also settle onto the bottom of watercourses, smothering eggs and/or rendering gravel substrate unsuitable for spawning. Even after the replacement and compaction of slopes and surfaces, gully and channel formation can occur and lead to subsequent erosion. Therefore, on- and off-site runoff management is a key factor in erosion and sediment control. Management techniques, such as preparing and covering disturbed soils, revegetating slopes, and lining runoff ditches early in the project assist in reducing the potential for erosion.



Figure 4.1 Development activities can lead to the erosion of soils into nearby watercourses.

In general, provision of appropriate erosion and sedimentation control should consider the following:

- Plan the development to suit the existing terrain and site conditions.
- Schedule development to minimize potential impacts associated with erosion.
- Retain existing vegetation where possible (Figure 4.2).
- Re-vegetate/protect denuded areas and bare soils, and divert runoff away from denuded areas.
- Minimize the length and steepness of slopes, where possible, and provide erosion protection for temporary and longterm/permanent slopes.
- Minimize runoff velocities and erosive energies by utilizing interceptor ditches, minimizing gradients, and maximizing lengths of conveyance ditches.
- Design development to minimize or control runoff associated with project construction, operation, and decommissioning or abandonment activities.
- Retain eroded sediments on site with erosion and sediment control structures.

Avoid deposition of silt into fish bearing water.

- Plan, inspect, and maintain erosion and sediment control structures to ensure effective and efficient operation.



Figure 4.2 Existing vegetation should be retained around watercourses whenever possible. Riparian (streamside) vegetation provides bank stabilization, thereby reducing the potential for erosion.

In addition to the above general guidelines, Sections 4.1.1 through 4.1.8 provide details on some specific erosion/ sedimentation control mitigative techniques (i.e. silt fence, filter fabric dam, rock check dam, settling ponds, ditches, stabilized access to site, straw barrier/ bale structure, matting and vegetation, and grading). When using manufactured erosion control materials, manufacturer's specifications should also be consulted. Further, appropriate and timely stabilization of disturbed areas, as presented in Section 4.2, can facilitate sedimentation and erosion control. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments.

4.1.1 Silt Fence/Filter Fabric Dam

Silt fences and filter fabric dams are temporary barriers that provide an effective filter for sediment-laden runoff from disturbed slopes and surfaces. Silt fences are constructed with filter fabric

and posts or stakes, and are typically installed at the bottom of slopes in development areas. Silt fences surround a disturbed site or contoured exposed slope (maximum steepness 2:1), effectively trapping the sediment close to the erosion source and preventing sedimentation of the aquatic environment via site runoff. Filter fabric dams are used in ditches to remove sediment from collected water prior to the release of this water into a natural watercourse. Silt fences and filter fabric dams have a limited retention capacity and are not designed for long term control of sedimentation. These structures also require ongoing maintenance. To use filter fabric structures effectively, the following guidance is provided:

- a. Filter fabric structures are designed for temporary use only.
- b. More than one filter fabric dam should be installed to ensure maximum removal of sediment prior to the entry of collected water into the receiving watercourse and filter fabric dams should be installed in series (Figure 4.3).



Figure 4.3 Filter fabric dams used in series maximize the effectiveness of the removal of suspended sediment from collected water.

- c. Filter fabric structures should not be used in natural watercourses and have minimal effectiveness when placed in locations of continuous flow and/or moderate to high water velocities.

Filter Fabric fences are only temporary siltation control structures.

- d. Use should be limited to situations in which only surface runoff is expected.
- e. Filter fabric/silt fences should be installed on the lower perimeter of slopes (lower 1 /3 to 1 /2 of site) and in areas where the erodibility is high and/or it is desirable to contain waterborne movement of eroded soils (i.e. the bottom of cut or fill slopes, material stockpiles, and disturbed natural areas).
- f. For ditch installations, the filter fabric dam should be appropriately embedded in the ditch bottom and sides (e.g. 100 mm minimum) to prevent the movement of fines under or around the dam (Figure 4.4). Wooden stakes should be installed on the downstream side of the trench and filter fabric attached to the upstream side of the stakes. Adjoinments of sections of filter fabric should be sufficiently overlapped (e.g. minimum 150 mm) to prevent the movement of fines around or through the seam area.

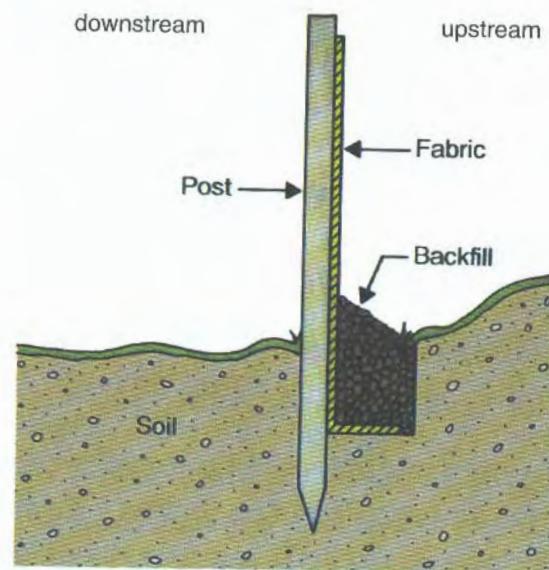


Figure 4.4 Filter fabric should be embedded in the ditch bottom and sides. Fabric should be supported by wooden posts/stakes.

- g. Accumulated sediment should be removed regularly from the silt fence or filter fabric dam and disposed of in a manner that prevents subsequent entry into any watercourses (e.g. material should be disposed of at a landfill approved by the appropriate regulatory agency).

- h. Damaged sections of fabric should be repaired or replaced. Dams should be inspected to ensure that water is not flowing under or around the filter fabric and that the structure is appropriately functioning to retain sediment.
- j. Filter fabric dams and silt fences should not be removed until all site work has been completed and disturbed areas stabilized. All accumulated sediment should be removed and disposed of in an appropriate manner (e.g. at a landfill approved by the appropriate regulatory agency) prior to removing the filter fabric structure.

4.1.2 Check Dam

Check dams (Figure 4.5) can be temporary or permanent and are used to prevent erosion and control sedimentation arising from roadside ditches. Check dams are structures used to prevent the erosion of ditch bottoms by slowing the velocity of concentrated runoff and by collecting and holding moisture and sediment in the ditch bottom. These structures are generally constructed with consideration for the availability of materials and whether the check dams are to be permanent or temporary. Check dams can be constructed of locally available materials and are relatively easy and economical to construct. Materials typically used include: brush, rock, gabion baskets, planks, sodded earth fill, or sandbags. When utilizing check dams, the following guidance is provided:

- a. Check dams are typically limited to treating runoff from small drainage areas and should not be used in natural watercourses. Therefore, several small check dams may be preferable to a few larger dams to reduce runoff and maximize the sediment-trapping capacity.

Rock check dams can be constructed of locally available materials.



Figure 4.5 Check dams can be constructed from a variety of readily available materials, including rocks.

- b. Check dams should be constructed to provide an impermeable structure, including lining with impermeable material, such as plastic or polyethylene sheeting, if only larger stones are available. The center of the check dam should be lower than the sides to enable the movement of accumulated water over the dam, while settled sediment is retained by the sides and lower portion of the dam (Figure 4.6).
- c. The check dam and ditch should be stabilized with riprap or other non-erodible material.
- d. The check dam should be regularly inspected and accumulated sediment removed. Material removed from the check dam should be disposed of in an appropriate manner (e.g. at a landfill approved by the appropriate regulatory agency) to ensure that sediment does not enter the aquatic environment. Ensure that accumulated sediment is removed and disposed of prior to the removal of a temporary check dam.

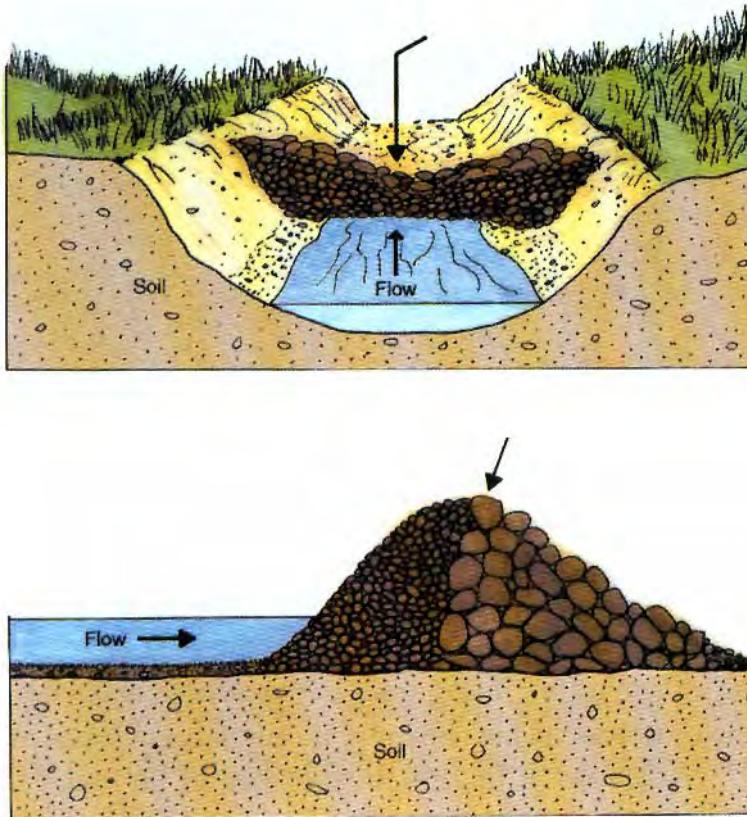


Figure 4.6 Side and oblique views of a well-constructed rock check dam.

4.1.3 Settling Ponds

Settling ponds/basins (Figure 4.7) are used to intercept and retain sediment-laden runoff. These structures allow sediment to settle out, thereby reducing the amount of sediment leaving the disturbed area and protecting fish habitat into which runoff is flowing. The effectiveness of settling ponds is influenced by particle size, settling characteristics, settling time, and surface area. Settling ponds should be installed at the development area prior to any excavation or other construction related activities. These ponds are most effective for sedimentation control on a relatively short-term basis. When using settling ponds, the following guidance is provided:

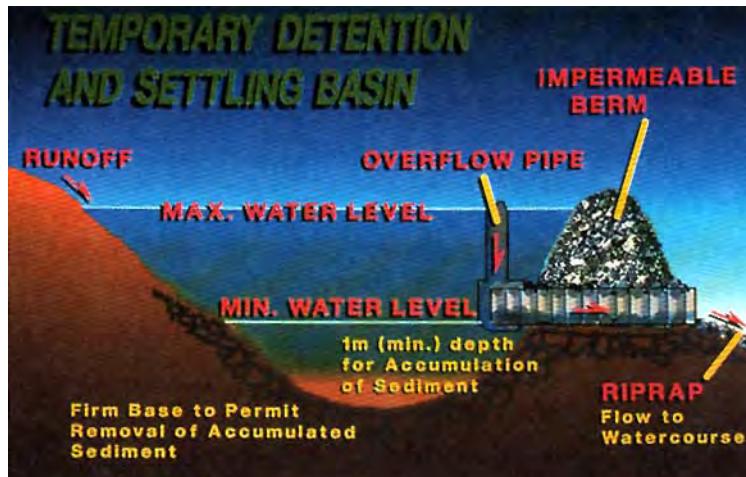


Figure 4.7 Features of a well-constructed settling pond/basin.

Settling ponds should be used in series.

- a. Settling ponds should be installed during initial site development before any grubbing of the area occurs.
- b. Settling ponds should be constructed so that the length is at least four times the width.
- c. Settling ponds are most effective when several are used in series, particularly if long-term activity of several weeks or more is planned. A minimum of two ponds should be provided.
- d. The bottoms of settling ponds should be lined with a material, such as plastic, to retain sediment and water (Figure 4.8).
- e. A pipe should be installed near the top of a settling pond in such a manner that water is discharged from the top of the water column. There are a number of alternatives to this method of settling pond construction involving the use of various detention devices such as pre-cast manholes and using natural topographic features.
- f. A chemical additive, known as flocculant, may increase the rate at which sediment particles settle out of the water column. Any questions regarding the use of chemicals should be directed to the appropriate regulatory agencies.

- g. It may be necessary to remove and dispose of accumulated sediment from settling ponds in order to maintain operating capacity.
- h. Settling ponds should be filled in and stabilized when no longer required. Impermeable liners, such as plastic, should be removed and appropriately disposed of.



Figure 4.8 Settling ponds should be lined with an impermeable material, such as plastic, to prevent the generation of silt from the excavated settling pond.

4.1.4 Ditches

Ditches collect runoff from roads, development sites, or slopes. Roadside ditching allows drainage of the roadbed, restricts vegetative growth, and corrects for deficiencies such as: erosion; non-conformity in grade, line, or cross section; and water ponding on the roadway. Interceptor ditches are temporary or permanent structures designed to intercept and carry clean surface runoff away from erodible slopes, reducing potential surface erosion and limiting the amount of runoff requiring treatment. Alternatively, these ditches can collect sediment laden runoff from slopes and carry it, without further erosion, to treatment areas or settling ponds.

Ditches should be stabilized and not discharge open ended into aquatic environments.

Interceptor ditches usually have to be excavated and should be stabilized to prevent erosion and sedimentation.

Ditches, particularly new ditches, can transport large volumes of sediment. Sediment discharged into watercourses can adversely affect fish habitat and aquatic life. When using ditches, the following guidance is provided:

- a. Ditches should be stabilized and should not discharge open ended into a watercourse. Ditches should flow into vegetated areas located upslope of watercourses to allow the trapping of sediment prior to the entry of the runoff into the watercourse (Figure 4.9).

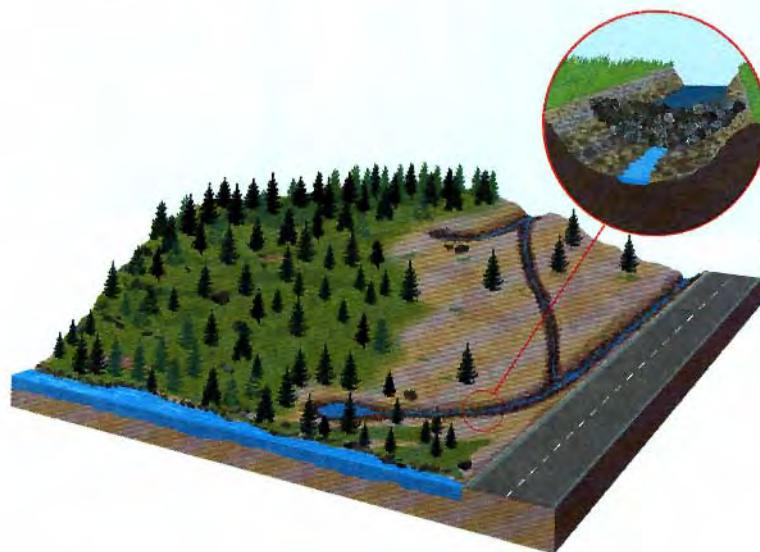


Figure 4.9 Features of a well-designed ditch system.

- b. The location of and access to ditches should be determined following review of the topography, the existing or planned drainage pattern, and subgrade conditions. Ditches should be laid out following the site contours, if possible, and constructed during the initial site clearing.
- c. In sidehills or similar areas, ditches should be installed on uphill sides of roads to intercept seepage and runoff.

- d. Where ditches have been excavated in areas with erosion-prone soils, the ditches should be immediately lined with non-erodible material.
- e. Cross drainage culverts and take-off ditches (Figure 4.10) should be incorporated to carry water away from the road and into the surrounding vegetation, where sediments can be filtered.



Figure 4.10 Cross drainage culverts and take-off ditches carry water away from the road and into surrounding vegetation.

- f. In addition to take-off ditches, road side ditches with long slopes may require rock check dams to reduce water velocity in the ditch, control erosion, and prevent sedimentation of nearby watercourses.
- g. Where the topography does not permit the construction of take-off ditches, settling ponds should be used to trap sediment and prevent sedimentation of nearby watercourses.
- h. A regular maintenance program is necessary to keep ditches in good working order. Sediment has to be removed from rock check or filter fabric dams; these structures may have to be adjusted or repaired; and additional stabilization may be necessary. In addition to regular inspections, all ditches and structures should be inspected after heavy rainfall or during periods of sustained precipitation.

- i. Temporary ditches should be filled and vegetated when no longer required.

4.1.5 Stabilized Site Access

Significant releases of sediments to drainage systems and receiving waters can be caused by site access development. Site access road construction requires the removal of vegetation, which exposes soils to erosion. Improperly designed drainage ditches can aid in transporting sediments to nearby watercourses. When addressing potential erosion/ sedimentation control issues associated with site access, the following guidance is provided:

- a. Construction of site accesses should be restricted in number and to locations that will serve as permanent access after development.
- b. Access to a construction/ development site should be covered with a layer of clean stone/granular material.
- c. When transporting excavated materials from the site, care should be taken to minimize the dropping of loose soils in the form of dust or mud from wheels, tracks, and undercarriages of equipment.

4.1.6 Straw Barrier/Bale Structure

Straw barrier/bale structures should be installed in runoff paths and other possible locations of concentrated flow to inhibit the migration of erodible soils. The number and spacing of bales will depend upon the nature of the construction operations; however, these structures are effective at controlling sediment close to the source. When utilizing straw barrier/bale structures, the following guidance is provided:

- a. Straw barriers should not be used in natural watercourses.
- b. These barriers are short-term measures and are effective only when treating runoff from very small drainage areas (less than 1 ha).

- c. Straw barriers can be used in shallow ditches or along the side of waterways or property boundaries during construction of other erosion control measures.
- d. Straw barriers should be staked into the ground to ensure stability.
- e. The maximum life is approximately 3 months, and may be considerably less under wetter conditions and successive storms.
- f. Accumulated sediment should be removed regularly and disposed of in an appropriate manner (e.g. a landfill approved by the appropriate regulatory agency) to prevent entry into the aquatic environment.

4.1.7 Matting and Vegetation

Temporary matting, such as jute mat, glass fibre mat, polyethylene sheeting, woven paper mat, and vegetative mat (commonly called erosion control blankets), is used to provide stabilization for the surface of steep slopes and ditches, and to protect newly-seeded soil from erosion. These mats act as mulch to hold moisture in and allow grass to grow through (Figure 4.11). The mats absorb raindrop impact, reduce runoff velocity, improve infiltration, bind soil particles with roots, and provide immediate erosion control until permanent vegetation can be established.

The rapid establishment of a vegetation cover is generally recognized as the most effective form of surface erosion control. Seeding, hydro-seeding, sodding, shrubs, and/or small trees or vegetative mats are some natural forms of stabilization methods that offer permanent surface protection.

When utilizing matting and vegetation as forms of erosion control, the following guidance is provided:

- a. When immediate protection is required or other protective measures are not feasible, polyethylene sheeting or tarps can

Vegetative matting prevents erosion.

be used. Sheeting or tarps should be well anchored and repaired immediately if maintenance is required.

- b. If a biodegradable pre-seeded erosion control mat is used, the mat should be stapled to the soil surface and anchored at the top.



Figure 4.11 Temporary matting provides erosion protection for newly-seeded areas. Moisture is held in and grass grows through the mat.

- c. When seeding, soil surfaces should be rough. Areas should be covered with mulch immediately after seeding.
- d. Selection of the type of vegetative cover depends upon the amount of surface water runoff across the disturbed area. Vegetative protection may be ineffective unless seepage is controlled. Site conditions and time of year should also be considered when selecting the most appropriate type of vegetative cover.
- e. Hydro seeding should be carried out as soon as possible after completion of the surface preparation. Final preparation of slopes and other exposed earth should be done as cut and fill

areas are completed, to enable seeding to be done in stages as work progresses.

- f. Sods should be appropriately staked in.

4.1.8 Grading

Temporary graded areas should be protected from erosion through the use of straw mulch and/or polyethylene tarps in non-traffic areas and a gravel cap in zones of construction traffic. Final graded or landscaped areas should have the appropriate permanent surface protection or landscaping in place as soon as possible. Guidance on grading is provided below:

- a. Grading work and disturbed/ exposed soil should be stabilized and completed as early during site development as possible.
- b. To the extent possible, cuts and fills should be kept on as flat a slope as possible (e.g. less than 2 horizontal to 1 vertical).
- c. Terraces can be used to form a series of diversions down a slope or to change a steep slope to a series of smaller ones.

4.2 STREAMBANK STABILIZATION

Streambanks are composed of a variety of materials (such as sand, soil and gravel) that are easily erodible when exposed or disturbed by construction activities (Figure 4.12). Streambank erosion can result in the deposition of large amounts of sediment into the freshwater environment. Sedimentation can have a variety of negative effects on fish and fish habitat, such as damaging fish gills, smothering eggs and infilling important spawning habitat. Streambank stability is maintained in a natural state by the living network of roots and vegetation. Disturbed areas require additional stabilization measures to ensure that bank slopes are stable and resist erosion.

Stabilization prevents
erosion and
sedimentation.



Figure 4.12 Development activities can de-stabilize streambanks, resulting in streambank erosion and considerable sedimentation of watercourses.

In general, efforts to stabilize streambanks should consider the following:

- Stabilize or rebuild disrupted streambanks as quickly as possible after disturbance. Shape streambanks so that the bank slope is stable and conforms to the existing topography.
- Streambank stabilization should not result in a decrease in the cross sectional width of streams. Place stabilization materials outside the wetted perimeter of the stream, from the toe of the bank slope to a height on the streambank equal to the anticipated high water level (or to the top of the bank slope, as appropriate).
- The effectiveness of stabilization can be increased if bank slopes are supplemented with the planting of vegetation such as grasses, corduroy and brushmats, small shrubs, etc. together with the placement of stabilization materials.
- Exercise care when stabilizing the outside bends of meanders since such areas are subject to increased erosion pressures.

To protect against the potential impacts of sedimentation resulting from a disturbed streambank, stabilization techniques should be

used in combination with erosion/ sedimentation control measures. (Figure 4.13).

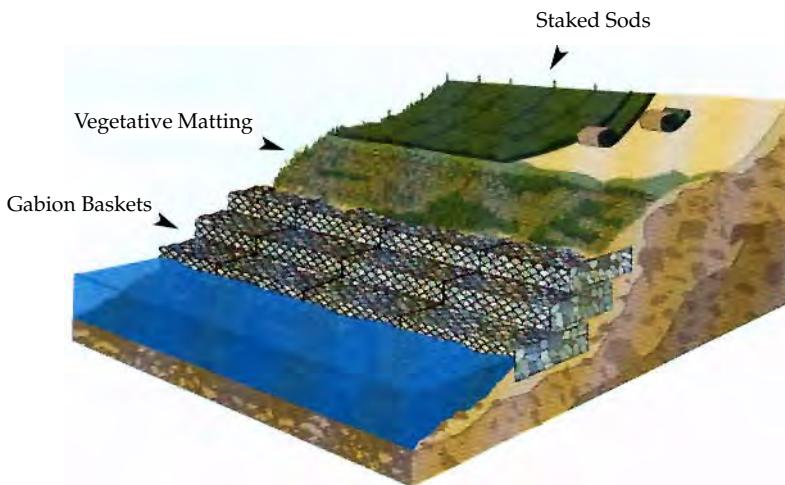


Figure 4.13 Examples of stabilization techniques.

Sections 4.2.1 through 4.2.4 provide guidance on streambank stabilization (i.e. riprap, gabions, geotextile and timber cribwork). When using manufactured stabilization materials, manufacturer's specifications should also be consulted. Further, some erosion control measures (e.g. matting) also provide stabilization. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments.

4.2.1 Riprap

Log and rock riprap are utilized to stabilize eroding streambanks. Riprap should be used only when vegetation cannot provide adequate bank support. The type of riprap used depends on the individual situation and the availability of materials (Figure 4.14).



Figure 4.14 Rock riprap prevents erosion.

When utilizing riprap for stabilization, the following guidance is provided:

- a. Rock riprap should be of a blocky, angular shape, rather than elongated or round.
- b. Rock riprap should be comprised of a mixed gradation so that smaller stones fill the voids between the larger ones to provide compaction and stability. A layer of filter stones may be required depending upon the type of underlying soil and the size of the protective riprap.
- c. Typical riprap stone sizes that may be used for various stream flow velocities are highlighted in Table 4.1. (Buchanan et. al. 1989).
- d. Rock riprap should not be used for banks exceeding 3 m high and a grade of more than 2:1. (Buchanan et. al. 1989).

Table 4.1 Riprap Stone Sizes for Various Stream Flow Velocities.

Stream Flow m/sec	Mean Stone Diameter (mm)
less than 3.0	200 - 460
3.0 - 4.0	200 - 770
4.0 - 4.60	500 - 1220

- e. Rock riprap should be clean, free of fine materials, and of sufficient size to resist displacement during peak flood events.
- f. Log riprap can be used in streams with a low to moderate gradient, with light to moderate flooding and where the bank requiring stabilization is not more than 1.0 m high.

4.2.2 Gabions

Gabions, gabion baskets, or gabion mats are pre-constructed steel wire type baskets filled with rocks. Gabions are used to protect streambanks from the erosive action of stream flow and to provide retaining wall support for an unstable soil bank. To prevent toe failure along a streambank, a line of gabion baskets built at the mean stream level can act as a protective apron or form a gabion mattress. This technique can be used when slopes are too steep for riprap stabilization techniques. When utilizing gabions for stabilization, the following guidance is provided:

- a. Gabions should be used for stabilization on streambanks less than 3 m high, with the flattest possible bank slope greater than 2:1 and when there are no suitable sizes and types of rock available for rock riprap.
- b. Gabions can be used as an alternative to riprap where bank slopes are not at a stable angle of repose.
- c. Gabions must be embedded or buried in the substrate to protect against anticipated scour.

- d. A seepage drain should be installed if there is a seepage problem. A filter fabric can be used if the existing bank material is not granular; however, granular material should be placed between the filter and the gabion basket or mat.
- e. Gabions should be tied into the streambank to ensure stability. Gabions should be terraced to form “steps” up the side of the streambank (refer to Figure 4.13).

4.2.3 Geotextiles

Geotextile filter fabrics are used to serve as a soil stabilizer, allowing water to flow through the lining, while preventing underlying soil from being washed away. The type of geotextile material used is site-specific and takes into consideration factors such as soil type, hydraulic conditions, and construction conditions and techniques. When choosing and installing geotextiles, professional advice (e.g. soils engineer or manufacturer’s representative) and manufacturer’s specifications should be considered. Guidance on the use of geotextiles is provided below:

- a. Geotextile should be laid by running up and down or across the slope to be stabilized. Adjacent rolls of geotextile should be overlapped (minimum 300 mm).
- b. Pins may be required to secure geotextile on steep slopes.
- c. Rips or tears in geotextile should be repaired by placing a new piece of geotextile over the torn area. The new piece of geotextile should extend beyond the rip or tear (minimum of 1m).
- d. When installing geotextile, care should be taken to ensure that material is laid or rolled into place, rather than dragged. When geotextile is dragged, exposed soil can smear the material and decrease filtering properties.

4.2.4 Timber Cribwork

Timber cribs are used as erosion control/ stabilization structures. When utilizing timber cribwork, the following guidance is provided.

- a. Material used to fill a submerged timber crib structure should be free of fines or sediment; suitable materials may include clean blasted rock or boulders (Figure 4.15).



Figure 4.15 Infill materials for timber cribs should be blocky, angular and free of fines or sediment.

- b. Material should never be removed directly from any watercourse, from any shoreline, or from any streambank area for use as ballast.
- c. Shoreline or streambank disturbance should be restricted to the immediate work area. Disturbed shorelines or streambanks should be stabilized.
- d. Untreated wood or pressure treated wood is recommended for use in or near freshwater environments (Figure 4.16). Manually applied wood treatments may also be used. Freshly treated preserved wood should be avoided. The appropriate regulatory agencies (Environment Canada) should be contacted regarding the use of wood treatment products, weathering,

and the location of treatment sites for manually applied preservatives.



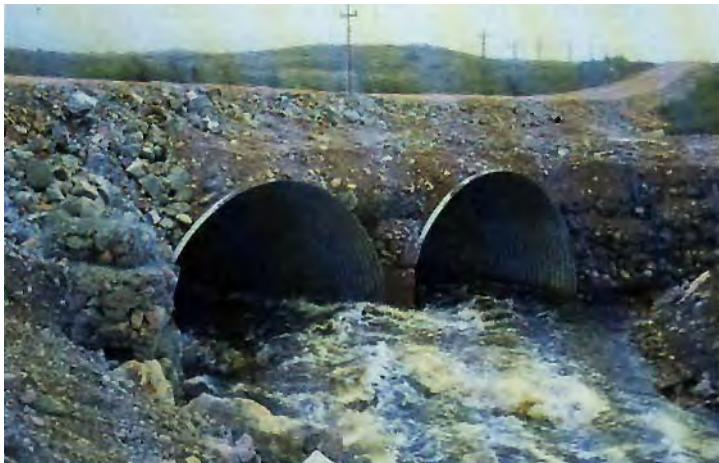
Figure 4.16 Untreated or pressure treated wood should be used for timber crib construction.

- e. Regular maintenance should be carried out on timber cribs to prevent collapsing and possible shifting of the crib or ballast. Any timber crib material moved by ice or wave action should be recovered.

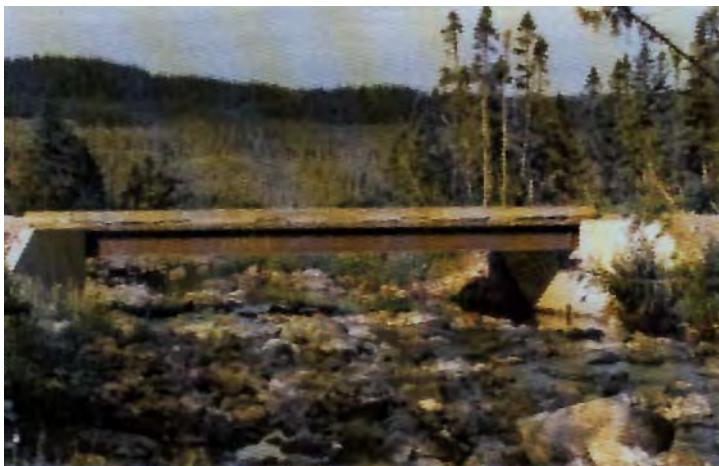
4.3 WATERCOURSE CROSSINGS

Stream crossings should be installed to ensure provision of fish passage and habitat protection.

During the course of projects such as exploratory drilling, forest harvesting, mining, hydroelectric developments, or works associated with linear development (e.g. transmission lines, road construction, etc.), it will often be necessary to cross watercourses (Figure 4.17). Any watercourse crossing has the potential to alter the existing natural flow regime for the entire range of flow conditions. Improperly installed crossings (i.e. culverts, bridges, etc.) can result in impeded fish passage and/or the alteration, disruption or destruction of fish habitat. In addition to addressing *Fisheries Act* related issues, other applicable legislation (eg. *Navigable Waters Protection Act*, etc.) should be addressed.



(a) Bottomless arch installation.



(b) Permanent bridge.



(c) Portable temporary bridge.



(d) Fording.

Figure 4.17 Methods of watercourse crossings. (a) bottomless arch installation; (b) permanent bridge; (c) portable temporary bridge; and (d) fording.

The preferred option for mitigation of the potential adverse effects of watercourse crossings is avoidance of crossing where possible. In general, with respect to watercourse crossings, the following guidance is provided:

- Plan linear development routes so as to minimize the number of crossings, avoid wetlands or floodplain areas, and maintain substantial buffer strips along watercourses.
- When selecting a site for a proposed watercourse crossing, examine the physical characteristics of the watercourse and associated drainage basin to identify the site that will provide the best features and conditions for the crossing.
- Crossing sites should be located where the stream is straight, unobstructed and well-defined.
- Where possible, crossings should be at right angles to streams. Watercourse crossing structures should be installed in advance of other road construction activities.

- Crossing sites should be placed where stable geological and soil conditions exist and a minimum of scour, deposition or displacement of sediments are expected to occur at or near a crossing.
- Crossings should be located away, and preferably downstream, from areas such as fish spawning sites or water use intakes. If a crossing must occur in the vicinity of sensitive fish habitat, a bridge with a high approach, rather than a culvert, should be used to limit disturbance to the channel.
- Crossings should be constructed where possible effects on other existing bridges and hydraulic structures can be avoided and where it is possible to minimize the risk of damage from environmental hazards such as floods or landslides.
- The type of crossing structure selected and the design of the crossing structure should consider natural site features, hydraulic conditions at the site, hydraulic performance needs and the relative amount of environmental disturbance with each type of installation.
- Construct approaches to watercourse crossings with erosion resistant materials, and keep approach grades to a minimum for at least 15 m on each side of a watercourse.
- Crossing structures that maintain natural watercourse bottom and hydraulic conditions (e.g. bridges, bottomless arch culverts) are preferred over structures that alter fish habitat, flow regime, and constrict watercourse width.
- All of the environmental considerations and mitigative efforts involved in watercourse crossings apply to watercourse crossings by all-terrain vehicles, or other such vehicles.

Sections 4.3.1 through 4.3.5 present specific guidance related to types of watercourse crossings (i.e. fording, bridges, culverts, underground watercourse crossings, and causeways). Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments.

4.3.1 Fording

Under certain circumstances, properly designed fords may be used as watercourse crossings. The use of a fording site is usually limited to periods when low flow conditions prevail and the number of crossings at the fording site is restricted. Fording must be kept to a minimum and if repeated fording at one site is anticipated then the use of temporary bridges or permanent crossing structures is required (Scruton et. al. 1997). The appropriateness of fording may depend upon the type of vehicle using the site. While vehicles with low pressure tires may ford a stream with little disruption, tracked machinery may result in considerable environmental damage and as such may not be generally suited for fording watercourses (Figure 4.17(d)). The appropriate Area Habitat Biologist should be contacted regarding sensitivities concerning the habitat and habitat utilization of various fish species in the proposed fording area (See Appendix A).

When fording, the following guidance is provided:

- a.** Fording must be avoided in potential spawning areas.
- b.** Fording sites should be situated where streambanks are stable and where approaches to the crossing have low slopes. Steep or unstable slopes should be stabilized to prevent erosion.
- c.** Fording sites should be selected on a site specific basis after a survey of the stream. Where possible, fording should be scheduled to avoid potential adverse impacts on spawning activities, spawning habitat, egg incubation, and fish migration.
- d.** Fording sites should be situated in areas of instream bedrock outcrop, or stable streambed substrate.
- e.** Crossings should be restricted to a single location and should occur at right angles to the stream to minimize disturbance.
- f.** Fording sites should be prepared and used during low flow conditions.

- g. Approaches to the fording site should be stabilized using non-erodible materials such as corduroy, brush mats, or clean stone materials.
- h. Equipment should be mechanically sound to avoid leaks of oil, gas, and/or hydraulic fluids.
- i. Fording sites should be monitored to ensure that approaches to the site are not eroding and substrate is not being disturbed to the extent that obstructions to fish passage are created.
- j. When a fording site is no longer required, the stream channel and banks should be restored to original condition. Any wheel ruts or other damage that may cause sedimentation in the stream should also be repaired.

4.3.2 Bridges

Bridges are the preferred crossing structure for all crossings, for areas where ice blockage or rapid runoff may cause the structural failure of a culverted crossing, as well as for any watercourses that support anadromous (sea-run) and/or resident fish populations. A well-designed bridge allows for a natural stream bottom at a crossing site and should not result in any increased water velocities that may impede fish passage or cause stream bed scour (Figure 4.18). When utilizing bridges for watercourse crossings, the following guidance is provided:

- a. Bridges should be located on straight sections of a stream, where the stream channel is narrow, having low banks and firm, non-erodible soils.
- b. Concrete aprons under bridges are not recommended since fish passage can be impeded at low flows.
- c. Bridge abutments should be located outside the wetted perimeter of the stream.
- d. Instream piers should be aligned with the stream flow; where necessary, streambank protection should be provided.

Bridges maintain natural stream habitat.



Figure 4.18 A well-designed bridge allows for a natural stream bottom at a crossing site.

- e. Equip bridges with wing-walls to prevent bank erosion.
- f. Instream work (i.e. abutment construction) should be scheduled to avoid potential adverse impacts on spawning activities, spawning habitat, egg incubation, and fish migration. The appropriate Area Habitat Biologist should be contacted regarding sensitivities concerning the habitat and activities of various fish species in the proposed work area.
- g. All instream works should be carried out in the dry and in such a manner that no harmful substance (e.g. lime, cement or fresh concrete) enters the water.
- h. Fill material for bridges should not be taken from stream beds, banks or riparian areas.
- i. To the extent possible, bridges should not be replaced with other structures (e.g. culverts).
- j. Where it becomes necessary to demolish or remove a bridge every effort should be made to avoid “dropping the bridge” into rivers/streams. This could be done by “sawing” appropriate sections of the bridge and using cranes to lift these sections or by constructing a platform onto which the bridge could be dropped. Disturbed areas should be stabilized to prevent erosion.

4.3.3 Culverts

Culverts are the most commonly used method for providing access over a watercourse, and particularly for small and medium sized streams. Several types of culverts are used including; open bottom/bottomless arch, pipe arch, box, and circular/ cylindrical. Box type culverts are generally made from wood or concrete while other types are made from plastic, concrete or, most commonly, corrugated steel. Figure 4.19 identifies culvert shapes and Figure 4.20 illustrates some culvert crossing related terms used in this guideline.

The following guidance concerning culvert installations is generic and has been developed to apply to a variety of different circumstances. In some site specific situations a professional engineer and/or biologist should be consulted. Where fish passage is required, sufficient depth of flow and appropriate water velocities for the fish species and size of fish at the site/area should be provided in culvert installations. Swimming performance of some fish species, relative to fish passage, is provided in Scruton et al., 1998.

Sufficient depth of flow and appropriate water velocities for fish passage should be provided in culvert installations.

When utilizing culverts, the following guidance is provided:

- a.** Improperly selected and sized culverts can become obstructions to fish migration and can cause upstream flooding. Culvert size should be based on the capacity to handle peak flows. It may be necessary to have a hydrologic and hydraulic analysis performed in order to determine the correct size culvert to be used. The hydrologic analysis is used to determine the peak flow and the hydraulic analysis is used to calculate the capacity of the culvert to adequately pass the peak flows.
- b.** Selection of the type of culvert should consider site specific characteristics such as: cross-section of watercourse at the crossing site (e.g. wide and shallow, narrow and deep, etc.), fish habitat characteristics/ substrate types (e.g. spawning habitat, boulders, gravels, etc.), hydrologic factors (e.g. flashy system, low flows and high flows, ice conditions, etc.). The type

Open bottom or bottomless arch culverts are the preferred type of culvert installation.

of culvert selected and installed should minimize potential impacts on fish habitat, maintain fish passage, and sufficiently accommodate watercourse flows. To the extent possible, natural stream conditions (i.e. widths, habitat, etc.) should be maintained.

- c. Open bottom / bottomless arch culverts are the preferred type of culvert installation. These culverts maintain the natural bottom substrate and hydraulic capacity of the watercourse when footings are installed outside the wetted perimeter of the stream.



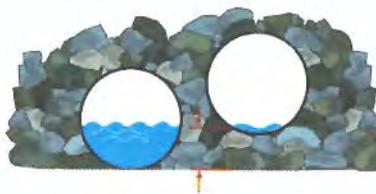
Open Bottom Culvert
Maintains natural bottom substrate and hydraulic capacity of a watercourse (i.e. minimal effects on natural water velocity)



Box Culvert
Can be designed to accommodate natural stream width.



Pipe Arch Culvert
Good for low clearance installations. Wide bottom area allows for retention of natural substrates.



Stacked/Multiple Culvert
Can provide fish passage over a wider range of flows, depths, and water velocities.



Cylindrical Culvert
If properly designed and installed does not limit fish passage. Can constrict stream width and create high velocities.

Figure 4.19 Culvert Shapes

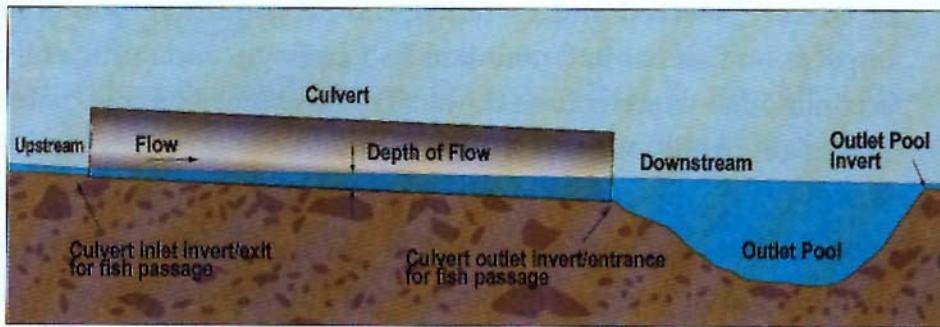


Figure 4.20 Illustration of General Culvert Terms.

- d. Footings for open bottom culverts should be installed outside the normal wetted perimeter of the watercourse and tied into the bedrock or sufficiently stabilized to prevent erosion around the footing or undermining.
- e. Pipe arch culverts often maintain the hydraulic capacity of the natural channel and are preferred over cylindrical culverts. Cylindrical culverts usually reduce the cross-sectional area of water entering the culvert which may result in: (1) an increase in water velocity which may make it difficult for upstream migration of fish; (2) undermining at the culvert inlet or streambed scouring at the culvert outlet; (3) an area where free flow of debris may be restricted which results in obstructing fish migration as well as flooding of upstream areas.
- f. To allow fish passage, cylindrical culverts should have a minimum diameter of 1000 mm and be designed/sized according to site specific, including hydrologic/ hydraulic, considerations.
- g. Cylindrical culverts should be installed to simulate open bottom or pipe arch culverts. Culverts up to 2000 mm in diameter should be countersunk a depth of 300 mm below the streambed elevation. Culverts having a diameter equal to or exceeding 2000 mm should be countersunk a minimum of 15% of the diameter below the streambed elevation (Figure 4.21).
- h. Countersinking reduces the hydraulic capacity of the culvert, therefore, the required diameter of the culvert must be adjusted for countersinking.

- i. Culverts should be aligned parallel to the existing natural channel and located on a straight stream section of uniform gradient.



Figure 4.21 Countersunk Culvert.

- j. The culvert should be placed on firm ground and be countersunk to the appropriate depth. In sites where a soft foundation is present it should be removed and replaced by clean granular material to prevent the culvert from sagging. Water movement under or around a culvert installation should be prevented through the use of headwalls, or other means, as necessary.
- k. A culvert should extend beyond the upstream and downstream toe of the fill (e.g., a minimum of 300mm).
- l. For multiple culvert installations, the culvert intended to provide fish passage should be placed in the deepest part of the channel and be countersunk to the required depth. The remaining culvert(s) should be placed 300 mm above the invert of the fish passage culvert (Figure 4.22).
- m. Culverts should be sufficiently sized and installed such that scouring of the outlet streambed does not occur as a result of increased water velocities in the culvert. Elevated culvert entrances may result in streambed scouring and can become an obstruction for migrating fish as illustrated in Figure 4.23.

In multiple culvert installations, the countersunk culvert should be designed to provide fish passage.



Figure 4.22 Multiple Culvert Installation

- n. A minimum water depth of 200 mm should be provided throughout the culvert length. To maintain this water depth at low flow periods an entrance/ downstream pool can be constructed. A downstream pool is of particular importance for long culverts or culverts to be installed on steep slopes, in some cases, an upstream pool may also be necessary.
- o. The invert of the pool outlet should be at an elevation that maintains a minimum of 200 mm of water depth up to the inlet or upstream end of the culvert (Figure 4.24).

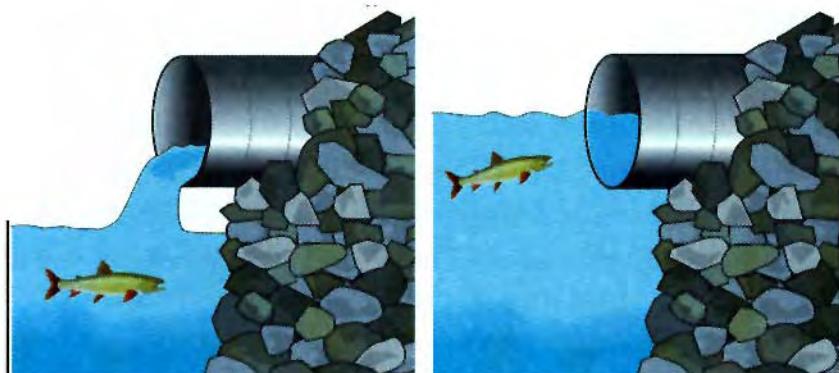


Figure 4.23 Perched Entrance and Properly Installed Culvert Entrance

p. The culvert slope should follow the existing stream gradient slope where possible. Increasing culvert slope, reduced culvert capacity due to countersinking and maintenance of the 200 mm minimum depth of flow, and back watering due to the creation of an outlet pool should be considered when selecting the required culvert diameter to meet fish passage and hydraulic criteria such as passing peak flows.

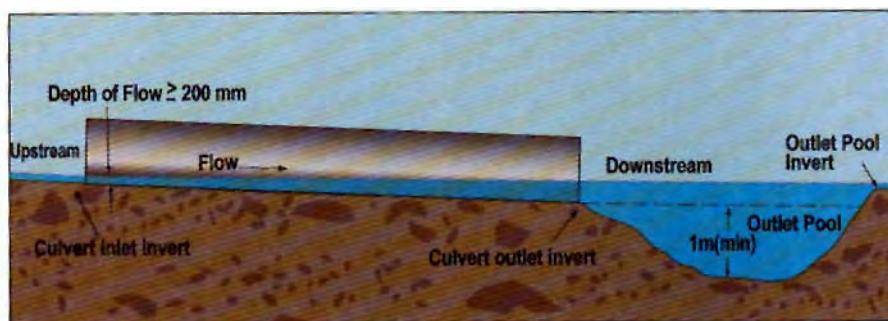


Figure 4.24 Culvert Installation Showing Downstream Pool to Maintain Minimum 200 mm Water Elevation Throughout Culvert.

q. Pools should be designed so that there is a smooth transition of flow from the culvert to the natural stream width.

r. The natural streambed elevation should be used as the pool outlet invert; however, depending on site specific conditions, a pool outlet may need to be constructed. It is essential that the invert elevation of the pool outlet be stable and, if necessary, well maintained to ensure a minimum water level in the culvert. Clean, non-erodible riprap or gabions should be used to stabilize the pool edges. If a pool outlet is constructed, care should be taken not to introduce blockage to fish passage. For example, the pool outlet may need to be v-notched to enable fish passage at low flow periods. Depending on site specific features (eg. gradient) more than one pool may be required.

s. Pools should be pear shaped and sized such that
 pool length = 2 to 4 times the fish passage culvert diameter;
 pool width = 2 to 3 times the fish passage culvert diameter;
 pool depth = 0.5 times the fish passage culvert diameter, 1 metre minimum. (Figure 4.25).

- t. For stacked/ multiple culverts, pools should be installed with the fish passage culvert orientated to the centre of the pool to allow for a smooth transition of water from the culvert to the watercourse.

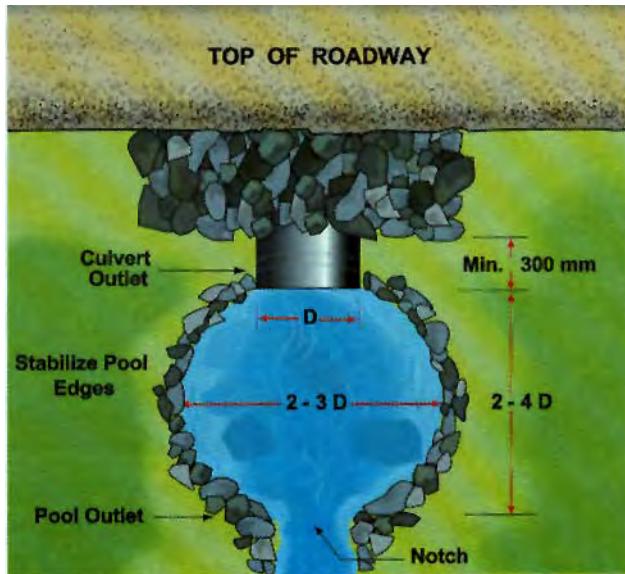


Figure 4.25 Recommended Pool Dimensions.

- u. Depending on site-specific conditions (e.g. steep slopes, long crossings, constricted streams resulting in high water velocities, etc.), baffles/weirs may need to be installed in the fish passage culvert. Baffles/weirs can provide an adequate depth of flow and reduce the water velocity in the culvert in order to facilitate fish passage. Baffle dimensions are provided as per Figure 4.26.
- v. A minimum depth of flow of 200 mm should be provided throughout the culvert and baffled sections. The drops between adjacent baffles should be a maximum of 200 mm.
- w. Baffles should be placed approximately 1 metre from the inlet and outlet ends of the culvert, the next baffles should be placed at 1 / 2 the baffle spacing. Baffle size and spacing should be determined by using the low flow (flow at the time of fish migration, i.e. lesser of flow at 90% exceedance via flow duration analysis or 7 day, 10 year low flow) as a basis for meeting the above depth of flow and drop between baffles criteria.

Baffle spacing should also provide a pool volume between baffles large enough to dissipate the kinetic energy produced by the water falling over the weir; and consider high flows (i.e. 10% exceedance based on flow duration) during the fish migration period. Baffle spacing is presented in Figure 4.27.

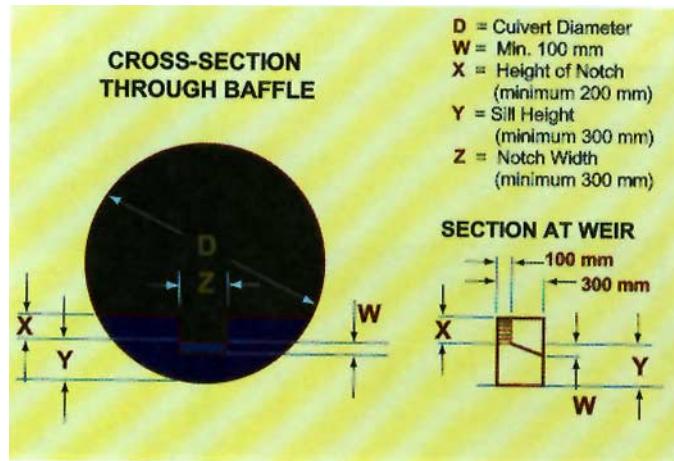


Figure 4.26 Baffle Sizing.

- x. The baffle culvert should be installed such that the invert elevation of the outlet pool backs water up to the top of the outlet baffle (i.e. entrance baffle); that is, set the elevation of the top of the entrance baffle to be the same as that of the pool outlet invert elevation. Baffled culverts should be countersunk approximately 100 mm below the streambed elevation. If countersinking exceeds 100 mm then the baffle system arrangement/ design may need to be adjusted accordingly.
- y. The upstream culvert invert can, in some site specific situations, be countersunk to facilitate depth of flow provided that the head differential is accounted for.
- z. Culvert installations should be suitably stabilized to prevent erosion, seepage, and undermining, and maintained in good operating condition. Headwalls or other appropriate means should be installed to ensure that all water is directed through the culvert system.

Note: Modifications of the above criteria in consultation with the Department of Fisheries and Oceans, may be required to address the passage of fish species other than salmon, brook trout, and brown trout in culvert installations. Further, site specific considerations may warrant modification of the above guidance, as deemed appropriate and in consultation with the appropriate Area Habitat Biologist (Appendix A).

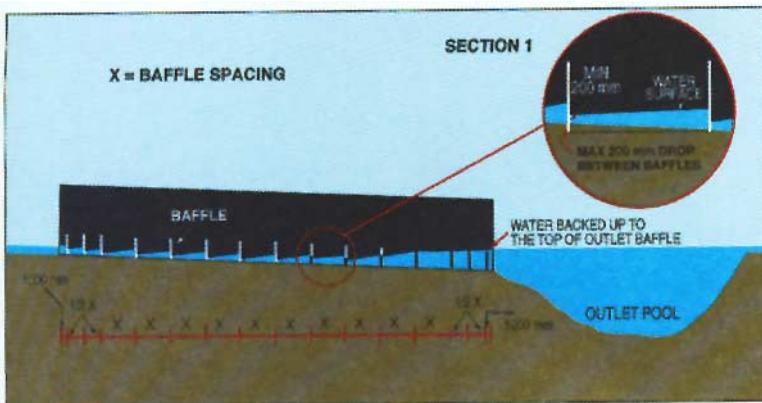


Figure 4.27 Culvert Baffle Spacing Requirements.

4.3.4 Underground Watercourse Crossings

Project developments sometimes require that streams be crossed by water pipes, sanitary sewers, underground cables, etc. The number of crossings should be minimized. Necessary crossings should follow roads, thereby reducing the overall impact on the stream. Construction of underground facilities results in disturbance to the stream bed and may produce downstream sedimentation. When undertaking developments beneath the streambed, the following guidance is provided:

- a. Instream works associated with underground stream crossings should be carried out in the dry.
- b. Once the pipe installation has been completed, the "trench" created in the stream bed should be partially filled with suitable materials; these materials can then be compacted and the stream bed brought back to its previous elevation and grade

using a topping of clean, non-erodible materials containing a minimum of fines (Figure 4.28).

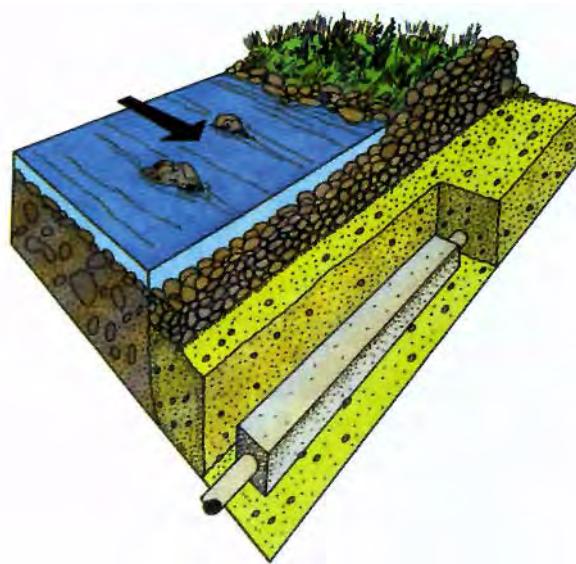


Figure 4.28 A properly installed underground stream crossing is constructed in the dry, backfilled and topped with appropriate substrate to retain the original characteristics of the stream bottom.

- c. The materials used for the “topping” in the crossing area should be consistent with the material substrate of the stream in this area and should be large enough to resist displacement by peak flows.
- d. Once the stream crossing has been properly completed and the crossing area sufficiently stabilized, regular maintenance is usually not required unless site specific problems arise; any subsequent requirements for excavation should be carried out as described above.
- e. Streambanks and approaches to or from crossing areas disturbed as a result of underground crossing construction activities should be stabilized immediately after the crossing has been completed.
- f. Excess materials resulting from stream bed/streambank excavation should be disposed of or stockpiled so as to prevent entry into any watercourse.

4.3.5 Causeways

A causeway for linear development should only be constructed when alternate routes prove to be unfeasible. If causeway installation is necessary, the causeway should cross the shortest possible length of the water body or wetland area.

When constructing a causeway, the following guidance is provided:

- a.** Avoid infilling small wetland areas.
- b.** Avoid causeway construction at the peak of fish migration and schedule construction so as not to interfere with sensitive periods of aquatic species life cycles.
- c.** Structures required for the maintenance of fish passage and flow of water (e.g. culverts) should be installed during, rather than after, causeway construction. This will eliminate the need for future construction activities in the area.
- d.** Design causeways and associated culverts to permit fish passage over the full range of natural flows. Causeway openings should have sufficient clearance to handle peak flows without interference to fish movement.
- e.** Causeways should be built in areas with a solid, stable bottom to prevent shifting of bottom substrate and subsequent lifting of the watercourse bottom in areas adjacent to the causeway.
- f.** Instream use of heavy equipment should be minimized. Equipment should be operated from dry, stable areas, such as the advancing causeway fill material.
- g.** Use causeway construction materials such as clean granular fill material, boulders, blasted rock, and armour stone.
- h.** Protect causeway embankments against erosion due to waves, ice and currents. Armour stone or rip-rap should be provided for in such areas.

Avoid causeway construction to the extent possible.

Buffer zones of undisturbed vegetation should be maintained around aquatic environments.

4.4 SITE PREPARATION, BUFFER ZONES AND ABANDONMENT

When carrying out activities associated with the preparation and abandonment of development sites, fish habitat protection should be considered. Site preparation activities, such as clearing and grubbing, can release sediment into nearby watercourses, resulting in damage to fish and fish habitat. Much of the impact of site preparation activities can be reduced or eliminated by a preliminary site visit, the development of an erosion control program and the implementation of proper site preparation procedures. Buffer zones should always be considered prior to the preparation of project sites, since these areas provide considerable protection to adjacent watercourses from the impacts of nearby activities. Upon abandoning a project site, consideration should be given to the provision of long-term erosion protection and the proper removal of roads, ditches and stream crossing structures. General considerations for site preparation, buffer zones and abandonment are:

- Site reconnaissance should be undertaken early in project planning stages to identify the location of watercourses and fish and fish habitat in relation to the proposed development.
- The activities to be carried out at the site should be identified in the project planning stages to ensure that adequate buffer zones are maintained between watercourses and the development site.
- Abandonment plans should be considered early in the project development. Planning of abandonment activities in these early development stages will ensure that the abandoned site is returned as closely as possible to pre-development conditions.

The project description and associated mitigation measures to be implemented should be discussed with DFO. Sections 4.4.1 through 4.4.4 provide detailed guidance on site preparation, buffer zones and abandonment. Section 3.0 of this document should be

consulted to determine the information required by DFO for review of proposed developments.

4.4.1 Stockpiling

Material stripped from a construction site during site preparation is often stockpiled. Stripping involves the removal of topsoil and overburden before the construction of an access road or facilities. Topsoil and organic material are often kept at the construction site for use in revegetation following the completion of construction activities. Stockpiled overburden material is often removed from the site and should be disposed of at a landfill approved by the appropriate regulatory agencies. Guidance on stockpiling is provided below:

- a.** All stockpiles should be easily accessible, located on well drained ground, and separated from watercourses by a minimum distance of 50 m.
- b.** A working space of at least 5 m around stockpiles is recommended.
- c.** Topsoil and organic material should be stored in low (e.g. 1 to 2 m high) stable piles to decrease compaction effects. When stored for extended periods, these materials should be vegetated to minimize nutrient loss and erosion of fines.

4.4.2 Buffer Zones

Buffer zones should be maintained along watercourses for erosion protection (Figures 4.29 and 4.30). The width of the buffer will depend on soil characteristics, the steepness of the slope leading to bodies of water, the type and quality of habitat being protected, and the type of activity being buffered. Table 4.2 outlines recommended buffer zone widths for a variety of activities when carried out near water bodies. For specific details regarding buffer zones with respect to forestry operations the *“Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador”* (Scruton et.

al. 1997) should be consulted. Despite differences in the design criteria, buffer zones generally function to:

- Protect riparian vegetation to provide shading, bank stability, food supply for fish, etc.
- Protect water quality by acting as a sediment trap between the watercourse and an area of significant land disturbance.
- Stop the erosion of soils, and dampen the impacts of excessive rainwater runoff and snow melt upon watercourses (i.e. reduces peak runoffs to watercourses, thereby decreasing instream erosion).

a)



b)



Figure 4.29 Buffer zones of undisturbed vegetation should be maintained between watercourses and development activities.



Figure 4.30 Illustration of a well-maintained buffer zone.

When planning and maintaining buffer zones, the following guidance is provided:

- a. The degree of protection required for a poorly defined watercourse should be determined early in the planning stage through consultation between the proponent and DFO.
- b. If a steep or unstable bank is present on one or both sides of the watercourse, the buffer zone should be measured from the top of the bank.
- c. Linear facilities (e.g. transmission lines, roads, pipelines, water and sewer lines) paralleling the watercourse should be outside the buffer zone, but under some circumstances the buffer zone may be utilized to access these facilities for infrequent maintenance. If facilities require frequent maintenance, an access road should be constructed outside the buffer zone.

Table 4.2 Recommended Minimum Buffer Zone Requirements for Activities Near Watercourses.

Activities	Recommended Buffer Widths
1. Development around watercourses in urban or other developed areas.	15m depending upon site specific considerations
2. Timber Harvesting 3. Silvicultural activities involving extensive land disturbance.	Minimum of 20 m no cut buffer zone with slopes <30%. For slopes >30% use formula: 20 m + 1.5 X slope (%).
4. Resource roads and highways running adjacent to water bodies.	20 m + 1.5 X slope (%).
5. Piling of wood and slash. 6. Sawdust storage (sawmills). 7. Grubbing. 8. Single recreation cottage lot development.	30m.
9. Construction of site camps. 10. Fuel storage. 11. Quarries/borrow pits.	100m

Note: Site specific considerations may warrant modification of the above guidance, as deemed appropriate and in consultation with the appropriate Area Habitat Biologist.

4.4.3 Right-of-way Clearing and Grubbing

The clearing, removal and disposal of vegetation (trees, logs and brush) is often accompanied by grubbing activities, which involve the removal and disposal of roots and stumps (Figure 4.31). These activities are common practices in many construction-related operations and are important issues to address when such developments are adjacent to a watercourse. The extent of clearing and grubbing associated with creating right-of-way widths depends upon the type of project and the vegetation cover present.



Avoid debris deposition in aquatic environments.

Figure 4.31 Right-of-way clearing and grubbing is commonly associated with many construction developments, including roads, pipelines and transmission lines.

Guidance on right-of-way clearing and grubbing is provided below:

- a. Keep right-of-way widths at water crossings to a minimum. Right-of-way widths at watercourse crossings should not exceed the minimum specified for that road class. Ground vegetation is essential to erosion control and care should be taken to minimize destruction of vegetation during right of way construction.

- b. Right-of-way boundaries should be clearly marked prior to the commencement of clearing operations, particularly no-grub (buffer) zones adjacent to watercourse crossings.
- c. Right-of-way cutting should not extend to the perimeter of watercourses; a buffer zone of undisturbed vegetation (Table 4.2) should be maintained for all activities adjacent to a watercourse.
- d. Fell trees away from all watercourses. Leaners should be removed; slash and debris should be piled above the high water mark so that this material cannot enter watercourses during periods of peak flow.

4.4.4 Site Reclamation and Abandonment

To ensure the protection of fish and fish habitat, site reclamation for any development activity is an issue that should be addressed during the planning stage. The following guidance is provided with respect to site reclamation and abandonment:

- a. All slopes of the site should be reduced as much as possible. Long slopes should be benched or terraced to interrupt the flow of water and minimize erosion.
- b. Vegetative growth should be restored on all denuded areas by seeding or laying sod.
- c. Once all decommissioning activity is completed and vegetation has been re-established, sediment traps (e.g. silt fences, filter fabric dams) and any accumulated sediment should be removed.
- d. Ditches, settling ponds and stream diversions should be filled in and stabilized when no longer in use.
- e. Fuel and hazardous materials should be removed from the area.
- f. When it is determined that an access road is to be abandoned the road surface should be scarified to promote the natural regeneration of a productive forest. Surface erosion can be controlled with ditching. These ditches intercept surface

runoff and redirect runoff away from the road surface and into surrounding vegetation.

- g. Upon road abandonment, bridges and culverts that require ongoing maintenance should be removed when the road is abandoned. Streambanks around the disturbed area should be stabilized to ensure erosion protection.

4.5 INSTREAM WORK IN THE DRY

Instream work should be avoided, where possible. Potential adverse effects of improperly conducted instream work include sedimentation of downstream habitat and alteration, disruption or destruction of habitat at the work site. However, it is recognized that at times it may be necessary to perform instream work as part of a project development. Work is defined as "instream" when it is performed anywhere within the high water mark. This includes work outside the wetted perimeter of a stream during periods of low flow. Some potential adverse impacts of improperly conducted instream work include entrapment of fish in dry work areas, increased erosion and sedimentation and obstruction of fish passage.

When conducting instream work in the dry, the following should be considered:

- Provision of fish passage should be maintained throughout the period of instream work.
- Any fish entrapped in the dry work area should be removed and relocated to an appropriate area of the stream.
- Instream work should be scheduled to avoid potential adverse impacts on spawning activities, egg incubation, spawning habitat and fish migration. The appropriate Area Habitat Biologist should be contacted regarding sensitivities concerning the habitat and habitat utilization of various fish species in the proposed work area.
- The duration of instream activities should be minimized.

Work areas should
be isolated from
stream flow.

- Substrate and/or bank material should not be removed from the stream or streambanks.
- It is preferable that instream work be carried out by heavy equipment working from dry land. Where it is necessary to have heavy equipment in waterways, such equipment should be rubber tired and free of leaks of fuel, oil and hydraulic fluids. Equipment should be steam cleaned prior to use instream. Equipment should not be serviced or washed in areas adjacent to watercourses.
- Frequent inspections of any instream structures, especially during periods of high runoff, are important to determine whether repairs or modifications are necessary to reduce any environmental impacts such as erosion and sedimentation.

Sections 4.5.1 through 4.5.3 provide guidance on specific methods of conducting instream work in the dry through the use of diversion channels or elevated piping in combination with cofferdams. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments.

4.5.1 Cofferdams

This technique is recommended for relatively short term projects on smaller streams or during low flow periods, but can also be applied in larger rivers, ponds or lakes. Essentially, a cofferdam extends from the shore, encircles the area of the stream to be closed off and then returns to the shore. Cofferdams can be used alone to isolate work areas along stream margins from stream flow (Figure 4.32), or in conjunction with temporary diversion channels or elevated piping to create a dry work area that spans the full width of a stream (Figure 4.33). A cofferdam usually consists of a double row of sand bags with plastic between the rows. Only clean, sediment free materials should be used as fill and all bags and materials must be removed after construction is completed.



Figure 4.32 Coffer dams can be used to isolate stream margin work areas from stream flow.



Figure 4.33 Coffer dams can be used in conjunction with temporary diversion channels to create a dry work area.

Guidance on cofferdams is provided below:

- a. Consideration should be given to maintaining fish passage and downstream flow throughout the area.
- b. Cofferdams should be sufficiently high to prevent overtopping in the event of sudden increases in water levels.

Coffer dams are usually constructed of a double wall of sand bags with plastic in between.

- c. To prevent sediment from entering the stream, a pump should be used to remove sediment-laden water from the work area inside the cofferdams. This water should be treated by discharging to settling ponds, vegetated areas or sediment traps (e.g. silt fences, filter fabric dams, etc.) prior to release to streams.
- d. If pumps are used to route streams around cofferdams for more than one day, the pump operation should be monitored during periods when no work is occurring at worksites.
- e. Care should be taken to seal leaks in cofferdams. Sand bags damaged during the course of work should be replaced.
- f. When the work is complete and the area fully stabilized, the downstream cofferdam should be removed first, followed by the upstream cofferdam.
- g. All cofferdam materials should be removed from the stream and disposed of at a landfill approved by the appropriate regulatory agency, or, if possible, reused or recycled.

4.5.2 Temporary Diversion Channel

A temporary diversion (Figure 4.34) is one method used to conduct instream work in the dry. This method is usually limited only by the availability of space within which to construct a diversion. The water is diverted into an excavated stream bypass lined with plastic and secured with crushed stone. These diversions should always be excavated in isolation from stream flow, starting from the bottom end of the diversion channel and working upstream to minimize sediment production.

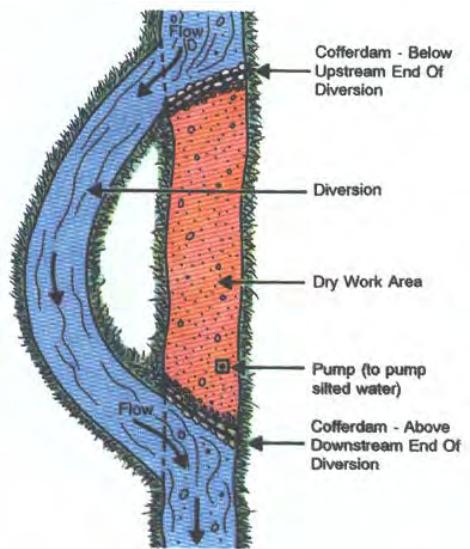


Figure 4.34 Features of a well-constructed temporary diversion.

Stream diversions should commence only after prior consultation with DFO and should be completed as quickly as possible, preferably within a single day during the low flow period. Upon completion of the instream work, the stream should be restored to original configuration and stabilized to prevent bank erosion around the temporary diversion. When utilizing temporary diversion channels, the following guidance is provided:

- a. Care should be exercised in the excavation of the diversion channel to ensure that the diversion is capable of accommodating peak flows from the stream that is being diverted.
- b. Temporary diversions should be excavated from the downstream end toward the upstream point of diversion, where a “plug” of earth should be left to prevent the entry of streamflow into the diversion before channelization. The channel should be lined with plastic that is weighted down with crushed stone and staked into the top of the channel slopes (Figure 4.35). Once the channel has been lined and the lining secured, the “plug” of earth referred to earlier can be removed.

Temporary diversions should be lined and stabilized

- c. Do not direct flow into diversion channels until construction is complete. DFO and other regulatory agencies, as appropriate, should be advised of such temporary diversions.



Figure 4.35 Temporary diversion channels should be lined with plastic that is weighted down with stone.

- d. To connect a diversion channel, a cofferdam should be placed immediately below the upstream point of diversion to reroute the flow of water into the diversion. Another cofferdam should then be placed immediately above the downstream point of diversion to isolate the work area and prevent sediment-laden water from escaping into the stream. In this manner the work area is effectively isolated from the stream and instream work can proceed in the dry.
- e. A pump is usually required to remove sediment-laden site water arising in dewatered work areas. This water should be treated to remove sediment (i.e. discharge to vegetated areas, settling ponds, filter fabric dams, etc.).
- f. The plastic lining the diversion should be kept in good state of repair to ensure that streamflow does not get under or behind the channel liner and cause erosion of the channel banks and

subsequent downstream sedimentation. At increased water levels and velocities it may be necessary to further secure the channel liner.

- g. Constant maintenance of temporary diversion channels may be required.
- h. The temporary diversion should be filled in and stabilized to prevent erosion when no longer in use and any construction materials may be disposed of appropriately.

4.5.3 Elevated Piping

Elevated pipes (Figure 4.36) can be used to carry out instream work in the dry as an alternative to the use of cofferdams and pumps or in circumstances where site constraints preclude the construction of a temporary diversion.

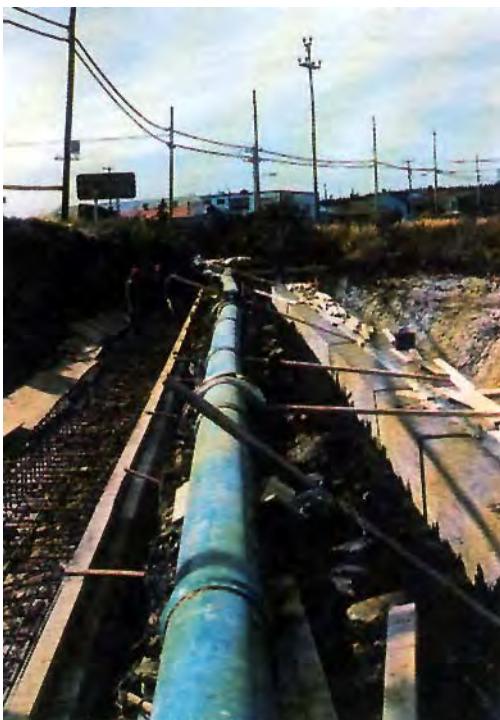


Figure 4.36 Elevated pipe.

Guidance on elevated piping is provided below.

- a. Use of elevated pipes should consider stream flows and the provision of fish passage. Low stream flows are most suitable for use of this technique. Further, elevated pipes may impede fish passage.
- b. The inlet and outlet of an elevated pipe are usually seated on cofferdams (e.g. double walls of sandbags with plastic placed between the walls). Upstream and downstream cofferdams should be placed into the stream and the pipe placed onto the cofferdams (Figure 4.37). Additional sandbags should then be placed on top of the pipe inlet and outlet to hold the pipe in place. If more than one pipe section is necessary to carry streamflow over the instream work area then consideration should be given to the impermeability of the area(s) where the pipe sections are coupled.

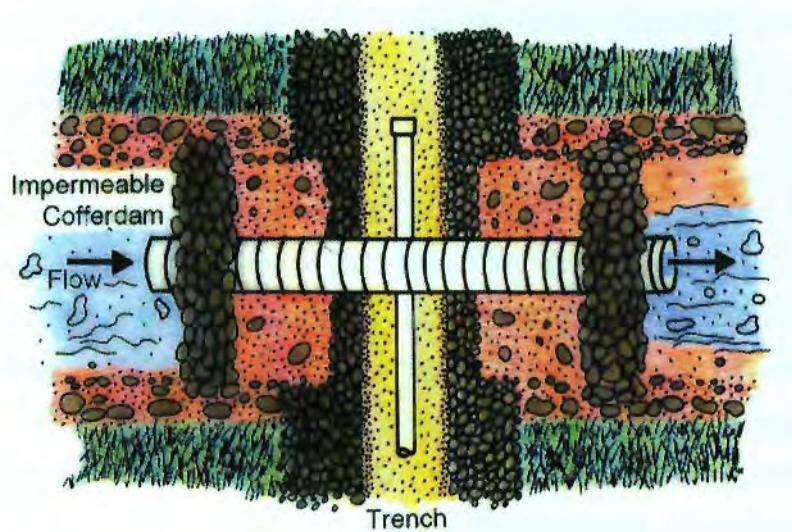


Figure 4.37 Stream crossing dewatered by means of an elevated pipe

- c. Cofferdams should be checked periodically to ensure that water is not leaking into the work area or from the work area into the stream. Any such leaks should be repaired as soon as possible.
- d. The instream work area should be fully stabilized and brought back to grade prior to removing the elevated pipe.

- e. Sand bags, pipe sections, etc. should be removed upon project completion.
- f. Sediment-laden water within the work area should be pumped out and treated by discharging to settling ponds, vegetated areas or sediment traps (e.g. silt fences, filter fabric dams, etc.) prior to release to streams.

4.6 DAMS

Dams are frequently constructed across streams or lake outlets to create larger or deeper waterbodies or to divert streamflow for other purposes. Dams are utilized for such project activities as the creation of reservoirs, flood control to protect downstream areas by controlling release from headwater areas, forming or deepening lakes or lagoons for water supply, and diverting streamflow for industrial or recreational use.

Dams may affect fish populations by preventing normal migration between feeding, rearing and spawning areas and may have a direct physical effect on habitat. In addition, the reservoir created behind the dam may inundate incoming streams, potentially resulting in the loss of important spawning or rearing habitat. In addition to addressing *Fisheries Act* related issues, other applicable legislation (eg. *Navigable Waters Protection Act*, etc.) should be addressed. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments. Guidance related to dam construction and the protection of fish and fish habitat is provided below:

- a. The location and design of a proposed dam should consider fish, fish habitat, fish passage, hydrology and hydraulic conditions, and the need for provision of downstream minimum flows. Each of these issues should be detailed.
- b. The extent of the flooded area and the potential for increased mercury levels should be considered.

Fish passage and
maintenance of
downstream flow
should be
addressed for dam
installations.

- c. Dams should be constructed in the dry with erosion and sedimentation control incorporated into construction activities.
- d. Dams and approaches to dams should be stabilized to prevent erosion.
- e. For systems directing or withdrawing water, a water balance of the area under varying flow regimes should be considered in terms of habitat protection, fish passage and provision of minimum downstream flows.

4.7 WATER WITHDRAWL

Improper design and/or construction of a water withdrawal structure can result in such adverse effects as dewatering of downstream areas, obstruction of fish passage and entrainment or impingement of fish on fish screens. Water withdrawal should be planned with consideration for maintenance of downstream flows and intakes should be equipped with fish screens (screening, netting or mesh) designed and installed in such a manner as to prevent potential losses of fish due to entrainment or impingement.

The installation and maintenance of a fish screen (Figure 4.38) at freshwater intakes is the responsibility of the proponent. This requirement is intended to limit the potential negative impacts that water extraction may have on a fishery resource, the severity of which depends upon the abundance, distribution, size, swimming ability, and behavior of fish in the vicinity of the intake. As well, water velocity, flow and depth, intake design, screen mesh size, installation and construction procedures and other physical factors need to be considered.

Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed water withdrawal. Guidance related to water withdrawal is provided below:

- a. Detailed guidelines for the provision of fish screens at small-scale water withdrawals up to 125 L/s (e.g. for small

Screens should be installed on water intakes

municipal, construction, irrigation and private water supply projects) can be found in the *Freshwater End-of-Pipe Fish Screen Guideline* (DFO 1995).

- b.** Fish screen requirements for larger-scale water withdrawals will be considered by DFO and other regulatory agencies on a site specific basis.
- c.** Flow regime and water balance in the area, as well as the need for provision of minimum downstream flows, when designing and constructing any water withdrawal system should be considered.

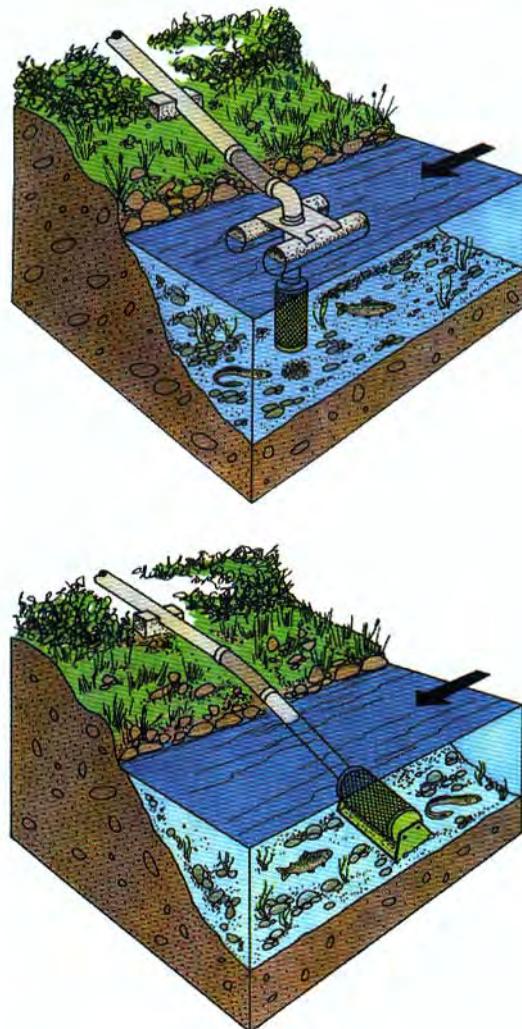


Figure 4.38 Examples of typical applications and features of end-of-pipe fish screens.

4.8 STORMWATER DRAINS

Storm drains are used to conduct storm water away from developed lots, buildings and housing developments, etc. Water enters storm sewers from impervious structures such as parking lots, roads and building roofs as well as through soil percolation and inflow. Storm sewers frequently directly discharge into the nearest watercourse without any treatment or storage.

Stormwater drainage can have implications on stream basin hydrology and water quality of the receiving watercourse. An inflow of storm sewer water can change stream basin hydrology both in the rate and the quality of runoff. Rapid runoff during storms may cause bank destabilization, erosion, sedimentation, and displacement of fish. Reduced base flow conditions between storm events may decrease the amount of usable fish habitat and may cause a reduction in the standing stock of fish within a watercourse. Urban runoff can contain many contaminants including bacteria, heavy metals, road salt, sediment, pesticides /herbicides, and a variety of organic compounds such as petroleum hydrocarbons. The introduction of such substances into the freshwater environment can negatively affect fish populations.

Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments. Guidance on the design, installation and maintenance of stormwater drains is provided below:

- a.** Stormwater drainage channels should be of sufficient size to accommodate peak storm events.
- b.** Storm drainage outlet structures should not be constructed directly on watercourse banks, but should be constructed some distance back and a channel excavated from the outlet structure to the watercourse. This channel should be constructed so that the general orientation of storm water discharge is parallel with stream flow (Figure 4.39).

- c. Sediment-laden water arising within work areas should be treated to remove sediment prior to release into a watercourse.
- d. During construction, the inlets of storm sewer and drainage systems should be blocked or equipped with sediment traps (e.g. rock check dams, filter fabric dams, etc.).



Figure 4.39 Storm drainage outlets should be connected to the receiving watercourse by a channel with orientation parallel to the flow of the receiving watercourse.

- e. All excess materials resulting from excavation of the storm drainage channel and construction of the storm water outlet should be removed and disposed of at a site approved by the appropriate regulatory agencies.
- f. The channel should be lined with clean stones to reduce the velocity of the water exiting the outlet structure. This will help to avoid streambed and streambank erosion.
- g. Storm drains should discharge onto riprap energy dissipators followed by a vegetated buffer zone rather than directly into a watercourse.
- h. Once storm drain outlets have been properly constructed and stabilized, regular maintenance should be provided as necessary. Storm drains should be kept free of debris to avoid blockage of flow.

Avoid release of silted water from sites into aquatic environments.

4.9 BORROW SITES/QUARRIES AND ASPHALT/CEMENT PLANTS

Gravel or other materials should not be removed from watercourses and watercourse banks due to potential negative effects on fish and fish habitat. Removal of stream bed materials can destroy fish habitat and create siltation that can have negative impacts downstream. Runoff from gravel removal sites on hillsides or near small feeder streams can contribute substantial quantities of sediment laden water into a watercourse.

The location of borrow sites/quarries and asphalt/cement plants should consider local drainage patterns, fish and fish habitat, and nearby watercourses. All proposed sources of borrow material should be approved by the appropriate regulatory agencies. Borrow sites/quarries and sites for asphalt/cement plant operations should allow for:

- controlled access in and out of the pit;
- working space in which to move equipment;
- storage areas for stockpiling topsoil and overburden separately;
- space to form a final grade;
- visual screening;
- dust control by washing, etc., when required;
- space for an acceptable settling pond system(s) to remove suspended solids from any water used; and
- maintenance of a buffer zone of undisturbed vegetation between activities and natural watercourses (see Table 4.2).

Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments. Guidance on borrow sites, quarries, and sites for asphalt/cement plant operations is provided below:

- a.** No gravel or other borrow materials should be removed from watercourse banks, stream beds, or within the buffer zone (buffer zones are discussed in Section 4.4.2).
- b.** Materials should not be quarried from active flood plains.
- c.** Aggregate quarrying operations should be limited to areas above the design flood high water mark and no closer than 100 m from all watercourses. The vegetation within this buffer zone should remain undisturbed.
- d.** No excavations should encroach within watercourse boundaries or result in slope failure.
- e.** Small drainage channels should be diverted around borrow sites to avoid sedimentation.
- f.** Where site access roads cross a watercourse, a bridge or culvert should be installed (see Sections 4.3.2 and 4.3.3).
- g.** Any water withdrawal requirements for the purpose of gravel washing should be reviewed by DFO (water withdrawal is discussed in Section 4.7).
- h.** Runoff control devices or sediment traps (e.g. filter fabric dams, settling ponds, ditches, etc.) should be used to prevent the entry of sediment laden water into nearby watercourses.
- i.** The site should be appropriately rehabilitated and stabilized upon completion of quarrying, borrowing and asphalt/cement plant operations.

4.10 BLASTING/EXPLOSIVES

Blasting in or near water produces shock waves that can damage fish swim bladders and rupture internal organs. Blasting vibrations may also kill or damage fish eggs or larvae. Chemical explosives may only be used when other, less detrimental methods are not feasible, and mitigation should be implemented to protect fish and fish habitat during blasting activities that occur in or near a watercourse. Section 3.0 of this document should be consulted to determine the information required by DFO for review of pro-

Blasting Plans should be developed to eliminate or minimize impacts on fish and fish habitat.

posed blasting activities. Guidance on blasting activities in or near the freshwater environment is provided below:

- a. Large charges should be subdivided into a series of smaller charges and time delayed to reduce the overall detonation to a series of smaller detonations.
- b. For multiple charges, time-delay (e.g. blasting caps) should be used to reduce the overall detonation to a series of single explosions separated by a minimum of 25 millisecond delay between charge detonations.
- c. The on-land set-back distance from the blast site to the watercourse and the set-back distance (zone) around the blast site in the watercourse are based on the maximum weight of the charge to be detonated at one instant in time and the type of fish and fish habitat in the area of the blast. Blasting activities are to take place at a minimum set distance from the watercourse as indicated in Table 4.3. A sample blasting arrangement is shown in Figure 4.40.

Table 4.3 Minimum Required Distances From a Watercourse for Blasting (Confined Charges).

Habitat	Weight of Explosive Charge (kg)					
	0.5	1	5	10	25	50
H1	7m	10m	15m	20m	35m	50m
H2	15m	20m	45m	65m	100m	143m

H1 = rearing/general fish habitat

H2 = spawning habitat where egg or early fish development is occurring.

- d. If on-land blasts are required nearer to the watercourse than indicated in Table 4.3, then additional mitigative measures should be initiated which include, but are not limited to, the following:
 - (i) installation of bubble/air curtains to disrupt the shock wave. When a bubble curtain is used, the curtain should

surround the blast site and be started up only after fish have been moved outside of the surrounded area;

- (ii) blasting should be undertaken at the time of least biological activity or biological sensitivity;
- (iii) isolation of the work area from fish movement;
- (iv) detonation of small scaring charges set off one minute prior to the main charge to scare fish away from the site; and
- (v) use of noise generators to move fish out of the area.

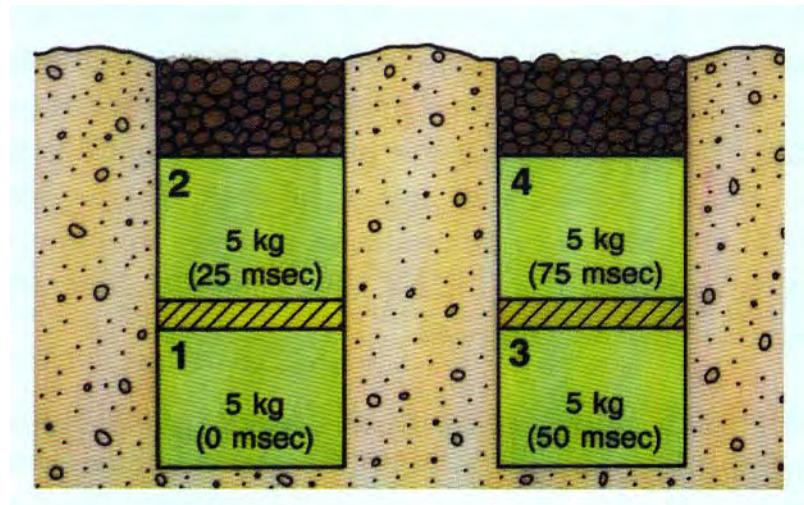


Figure 4.40 Sample blasting arrangement consisting of: 20 kg total weight of charge; 25 msecs delay between charges and blast holes; and decking of charges within holes. As per Table 4.3, for the 5 kg weight of charge shown here, a 15 m set-back from rearing habitat and a 45 m setback from spawning habitat should be provided.

- e. To confine the blast, sand or gravel should be used to backfill blast holes to grade or to streambed/water interface.
- f. Blasting mats should be placed atop the blasting holes to minimize the scattering of blast debris around the area.
- g. Ammonium nitrate based explosives (i.e. Ammonium Nitrate Fuel Oil mixtures, or ANFO) should not be used in or near water due to the production of toxic by-products (ammonia).

- h. All blasting and other associated equipment and products are to be removed from the blast area, including any debris that may have entered the aquatic environment.

4.11 SEISMIC ACTIVITIES

Seismic activities are associated with petroleum exploration and ground geophysical operations in mineral exploration. As with other project developments, activities associated with seismic exploration (such as watercourse crossings, cuttings, etc.) should include the implementation of mitigative measures to address fish and fish habitat protection. Sections 4.3 and 4.10 of this document, which discuss watercourse crossings and blasting, respectively may be applicable to seismic activities. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed development activities. Guidance on seismic activities is provided below:

- a. Geophysical operations should be conducted so as to avoid sensitive or important fish habitat.
- b. Proponents should plan seismic programs well in advance and take advantage of winter freeze-up, whenever possible.
- c. When commencing operations, the energy level of the output should begin at low levels and gradually increase to the operating range to permit fish to move away from the source of the sound without being unduly startled.
- d. Appropriate buffer zones, stream crossings and erosion/sedimentation control should be provided. Any disturbed areas should be stabilized.

4.12 DREDGING

Dredging requires the removal of material from the bed of a watercourse by mechanical means and has the potential to harmfully impact fish and fish habitat. Dredging often occurs in areas where the water depth precludes working in the dry. Section 3.0 of this

document should be consulted to determine the information required by DFO for review of proposed development activities.

In order to minimize the effects of dredging in standing freshwater, the following guidance is provided.

- a.** Time dredging activities to avoid periods where fish may be migrating through or near the work area. Dredging at low flow periods reduce the amount of sedimentation.
- b.** A floating silt barrier should be installed to control sedimentation. These are impervious, floating barriers orientated vertically from the water surface to the substrate and restrict the spread of siltation from the work area to the surrounding water. The barrier should be anchored / weighted to the substrate bottom profile, be appropriately floated at the surface, and, as necessary, be fastened into the shoreline.
- c.** Sensitive or important fish habitat should be avoided.

Depending on the time of year, dredging activities in estuaries could interfere with the seaward or return migration of anadromous (sea-run) salmonid species. This could have implications on fish survival or on spawning success (if the dredging activities interfere with return spawning migration). Guidance on dredging in estuary regions of rivers is provided below

- a.** Time activities to avoid periods when migrating fish are passing through the area to be dredged.
- b.** Dredge on a receding tide only.
- c.** Dredging activities should cease when migrating fish (eg. salmon, trout) are in the dredge area in significant numbers.
- d.** Sensitive or important fish habitat should be avoided.

Note: An ocean dumping permit may be required if dredged material is to be disposed of in the marine environment. Environment Canada should be contacted before carrying out any dredging activities in estuaries, in order to determine if a permit is required.

4.13 FOREST HARVESTING AND RELATED ACTIVITIES

The growing mechanization of the logging/timber harvesting sector and the accelerated construction of access roads has increased the potential for these activities to negatively impact fish and fish habitat.

Potential adverse impacts of forestry activities on fish and fish habitat include: sedimentation resulting from erosion of exposed soils on watercourse banks; obstruction of fish movements in watercourses by deposition of logs and slash; depletion of the oxygen supply due to decomposition of organic material such as sawdust, bark, slash and sunken logs; destruction of spawning and rearing areas by the instream use of heavy equipment; leaching of fertilizers and herbicides; and destruction of streambank vegetation.

The Forestry Guidelines for the Protection of Fish Habitat in Newfoundland and Labrador (Scruton et al. 1997) should be consulted for detailed forestry-related guidelines. General guidance for forest harvesting is provided below:

- A buffer zone of undisturbed vegetation should be maintained between harvesting activities and watercourses.
- Slash, tops or any other logging debris should not be left within the high water mark of any watercourse.
- Skid trails and landings should not be located in or adjacent to watercourses.
- Watercourses should not be used for the driving or towing of logs.
- Bridges are preferred for watercourse crossings. Portable bridges can be constructed using two sections of poles and two hard-wood bedlogs. The poles are lashed together at both ends with a section of chain and then placed on the bedlogs.

- Scarification of silviculture plots should be carried out parallel to the natural contours of the land. Scarification at right angles to the land will lead to erosion of unstable soils.
- Prescribed burning treatments should be carried out so as to ensure that riparian (streamside) vegetation is not burned as part of the treatment.
- In areas where fertilizers are prescribed, treatment zones should be located outside of buffer zones to prevent direct entry of fertilizers into fish habitat.

Section 4.13.1 provides guidance on fish and fish habitat protection measures that should be incorporated into the use of forwarder trails. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed development activities.

4.13.1 Forwarder Trails

Forwarder trails are used to transport timber to roadside. When the forest floor is compacted by machinery operating on trails, the natural filtering action of the soil is destroyed. Surface water is no longer absorbed, but is collected by wheel ruts, which act as drainage ditches (Figure 4.41). As the water flows into these ruts, soil is eroded and large volumes of sediment can be discharged into nearby watercourses, damaging fish habitat and aquatic life. A forwarder trail that has been left unprotected may continue to wash out and create sedimentation problems long after the harvesting operation has been completed.

Guidance on forwarder trails is provided below:

- a. The location of forwarder trails should be planned to minimize the number of watercourse crossings. Where watercourse crossings are necessary, temporary bridges should be installed.



Figure 4.41 Wheel ruts in forwarder trails can facilitate the movement of sediment-laden water into nearby watercourses.

- b. To ensure that sediment laden water does not collect in wheel ruts and discharge into watercourses, mudlogs should be installed across trails before ruts develop. Mudlogs divert water and mud out of the forwarder track and onto the forest floor
- c. Mudlogs (Figure 4.42) should be installed close to where the water is entering the forwarder trail and where the ground slopes to one side. A small earthen dam is pushed up with the forwarder blade on an angle across the trail, and a 30 cm diameter log is placed immediately in front of the dam, on the uphill side. If conditions are extremely wet, several of these logs may have to be placed along the trail.
- d. If mudlogs become compacted into the ground and are no longer effective, new mudlogs should be installed.



Figure 4.42 Mudlogs divert water off of the trail and onto the forest floor.

- e. Mudlogs should be maintained in place to ensure that surface water is intercepted and deflected into surrounding vegetation.

4.14 LINEAR DEVELOPMENT

The construction of linear developments (e.g. highways, resource roads, transmission lines, pipelines, and fibre optics cable development) involves a variety of activities. Earlier sections of this document have presented fish and fish habitat protection measures for several activities that are often associated with linear developments (i.e. ditching, watercourse crossings, right-of-way clearing, stormwater drains, borrow sites/quarries and blasting/explosives). All of these sections should be consulted when planning and designing a proposed linear development.

Due to the large number of activities involved in linear development, there are a variety of potential adverse effects that may result from poor design and construction of these facilities. Failure to consider fish and fish habitat protection measures during activities associated with linear developments can result in sedimentation of fish habitat. Blasting operations require mitigation to protect fish

Fish and fish habitat protection measures should be implemented for linear developments.

from injury. Inadequately designed watercourse crossings and stormwater drains can have implications on stream hydraulic characteristics and fish passage.

When designing and constructing linear developments, the following general guidelines should be considered:

- A buffer zone of undisturbed vegetation should be maintained between linear developments and watercourses (see Table 4.2).
- Design watercourse crossings and storm drainage systems with consideration for flow regime and water balance in the area of the crossing.
- Developments should incorporate erosion and sediment control plans and all disturbed areas should be stabilized.

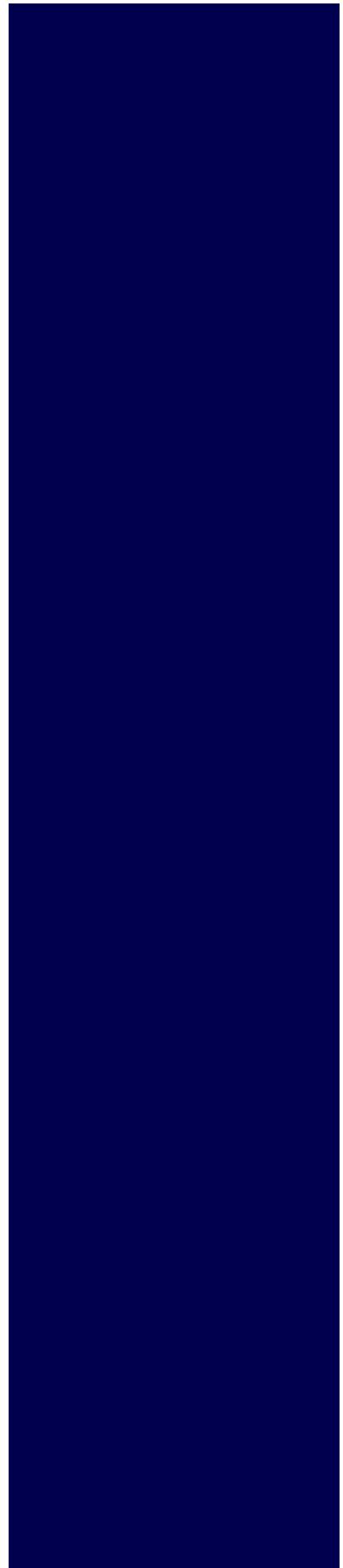
Sections 4.14.1 through 4.14.3 present general guidance for various types of linear development. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments.

4.14.1 Highways/Resource Roads

Roads can cause negative environmental effects that degrade rather than enhance the natural environment. Unless roads are properly designed and planned, and care is exercised in construction, undesirable disturbances to aquatic environments are likely to occur (McCubbin et. al. 1990). Guidance on road construction is provided below:

- a. Determine road locations during the spring when seeps and springs are most noticeable.
- b. Plan the road network layout so that the number of watercourse crossings is minimized.
- c. Work should not be undertaken on easily erodible materials, during or immediately following heavy rainfalls.

- d. Aggregate (fill) materials for road construction should not be removed from watercourses. This includes any area within the historical floodplain of a watercourse.
- e. Where road construction or associated activities (e.g. grubbing, right-of-ways, etc.) take place adjacent to a watercourse, appropriate buffer zones of undisturbed vegetation should be maintained between the road or activities and the watercourse.
- f. Roads should be adequately ditched to allow for good drainage. Roadside ditches should not open directly into a watercourse but should end blindly in vegetated or forested areas. Planning and construction of ditches should be carried out early in the road development process to ensure proper drainage throughout road construction.
- g. Keep ditches at the same gradient as the road, wherever possible, and design to convey peak flows.
- h. Prevent ditch flow into watercourses by constructing ditch run-outs or takeoff ditches on road approaches a minimum of 30 m from watercourses.
- i. Prevent flooding in wetland areas through the use of collector ditches and culverts to provide cross-drainage.
- j. Frequently divert ditch flows into cross-drainage culverts to prevent erosion or overflow.
- k. Provide appropriate watercourse crossing structures that consider protection of fish habitat and maintain fish passage. Bridges and culverts that require ongoing maintenance should be removed when the road is abandoned. Permanent maintenance-free structures should be left in place.
- l. Inspect watercourse crossing structures prior to and during spring ice breakup. Debris caught on piers and at the entrance to culverts should be promptly removed to prevent obstruction to fish passage and upstream flooding. These regular inspections will also ensure that culverts and take off ditches are maintaining proper drainage.
- m. Check watercourse crossing sites after the first heavy rain subsequent to installation to ensure that no erosion or sedimentation problems are developing.



- n. Consideration should be given to regeneration of the right-of-way to make the area productive for growing trees and to prevent erosion.
- o. Stabilize erosion prone cuts and fills with vegetation or other suitable material.
- p. Siltation control structures, such as silt fences, filter fabric dams and rock check dams, should be installed.
- q. Clean and provide regular maintenance for areas designated for sediment trapping.
- r. Store all de-icing and dust-control agents in areas where these substances cannot enter water bodies.
- s. The use of mechanical brush control in the vicinity of water bodies is preferred over chemical methods (i.e. herbicides). The appropriate regulatory agencies should be contacted regarding the use of any chemicals in proximity to freshwater environments.

4.14.2 Transmission Lines

Like other linear developments, the activities involved in the construction of transmission line developments (watercourse crossings, right-of-way clearing, etc.) can have negative impacts on fish and fish habitat, such as habitat destruction or alteration and sedimentation. However, when properly managed, these harmful effects can be effectively mitigated. Guidance on transmission line development is provided below:

- a. Proposed transmission line routes and station locations should minimize the number of watercourse crossings.
- b. Poles and towers should be located so as to minimize potential environmental damage and should not be located within watercourses or flood plains.
- c. Right-of-way travel should be restricted to minimize watercourse crossings.

- d. Watercourse crossings, including temporary bridges or fordings, should be appropriately designed, installed and implemented to provide protection of fish and fish habitat.
- e. Activities associated with transmission line development (e.g. right-of-way cuttings, grubbing, etc.) should maintain an appropriate buffer zone of undisturbed vegetation from watercourses.
- f. All drainage channels and watercourse banks should be left in a stable condition at the end of construction.
- g. As soon as possible following construction activities, disturbed areas should be appropriately stabilized by revegetation or other means.

4.14.3 Fibre Optic Cable Development

The activities involved in the construction of fibre optic cable developments (watercourse crossings, right-of-way clearing, etc.) can have negative impacts on fish and fish habitat, such as habitat destruction or alteration and sedimentation. However, when properly managed, these harmful effects can be effectively mitigated. When planning and constructing fibre optic cable developments, the following guidance is provided:

- a. Proposed fibre optic cable routes should minimize the number of watercourse crossings.
- b. Underground watercourse crossings should be appropriately designed, installed and implemented to provide protection of fish and fish habitat.
- c. Activities associated with fibre optic cable development (e.g. right-of-way cuttings, grubbing, etc.) should maintain an appropriate buffer zone of undisturbed vegetation from watercourses.
- d. All drainage channels and watercourse banks should be left in a stable condition at the end of construction.

- e. As soon as possible following construction activities, disturbed areas should be appropriately stabilized by revegetation or other means.

4.15 MINERAL EXPLORATION

Without proper planning and implementation of mitigative measures, mineral exploration activities can result in a variety of chemical and physical impacts on fish and fish habitat. Chemical pollution of the freshwater environment can result from such releases as acid mine drainage, sewage discharge and accidental hydrocarbon spills. Physical impacts can be caused by mineral exploration activities if waste rock, particulate material, sand or gravel is dumped or washed into watercourses. In mineral exploration activities, the removal of vegetation and soil overburden is often necessary to gain access to the mineral deposit; topsoil and foliage can then wash into the river resulting in siltation or obstruction of watercourses.

Common practices associated with mineral exploration include clearing and timber salvage, stripping and stockpiling, quarries and borrow areas, blasting, access road construction, watercourse crossings, and abandonment and rehabilitation. Mitigation practices associated with these activities are addressed throughout this document. Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments. Guidance on mineral exploration is provided below:

- a. Careful planning should be undertaken to minimize the length and number of access roads/trails and watercourse crossing sites. This will help reduce potential erosion problems.
- b. Water lines and access routes to drill sites should be located in areas that create the least amount of disturbance to fish and fish habitat.

- c. If clearing and levelling are required, disturbed areas should be no larger than absolutely necessary.
- d. Appropriate buffer zones should be maintained between watercourses and project development activities (e.g. grubbing and clearing zones).
- e. If trenches are to be left open for a period of time, excavated material should be contoured and stabilized to prevent erosion and sediment entering watercourses. Trenches and ditches should not be drained directly into a watercourse.
- f. Drilling wastes should not be allowed to enter watercourses.
- g. If drilling is undertaken through an ice covered watercourse, all debris that is frozen into the ice/snow should be removed and discarded upon abandonment. Debris (Figure 4.43) should be discarded at a disposal site approved by the appropriate regulatory agencies. Material should not be deposited in a watercourse due to ice thaw.
- h. Measures to protect fish and fish habitat should be implemented during any blasting or water withdrawal activities.



Figure 4.43 Debris/waste from exploration activities should be removed upon project completion.

4.16 URBAN DEVELOPMENT

Watercourses in urban areas are altered for a variety of reasons ranging from flood control to maximizing land area available for development. Roads, sewers, watermains, power lines and telephone cables cross watercourses within urban areas and, in most cases, do so more or less at random. Ideally, all developments, both residential and industrial, should be designed to retain the natural state of watercourses and to minimize stream diversions and crossings.

Mitigative techniques for watercourse crossings, diversions, dams, erosion/ sedimentation control, restoration of disturbed areas, installation of water intake structures, and other urban development related activities are addressed in previous sections of this document. Physical habitat concerns associated with urban development include erosion, sedimentation, loss of riparian vegetation and obstruction of fish passage. The implications of urbanization on water quantity and quality should also be considered in addressing and implementing measures to mitigate potential impacts on fish and fish habitat.

Section 3.0 of this document should be consulted to determine the information required by DFO for review of proposed developments. General guidance for urban development include:

- Buffer zones of undisturbed vegetation should be maintained between watercourses and development areas.
- Erosion/ sedimentation control, runoff management and storm-water drainage systems should be incorporated into any development plan.
- Urban road routes should be designed so as to minimize the number of watercourse crossings required.

4.17 HYDROELECTRIC DEVELOPMENTS

There is an increasing demand in Newfoundland and Labrador on available streams and rivers that can be used for hydroelectric development. Activities associated with hydroelectric developments (dam construction, flooding/ inundation, dewatering, etc) can have a negative impact on fish and fish habitat. Depending on the capacity of the storage basin and the quality of flows that are being diverted, the construction and operation of a hydroelectric facility can have the following impacts:

- Disruption of the existing hydraulic regime.
- Obstruction of fish passage.
- Water quality upstream and downstream of the dam may be degraded (increase in the bioaccumulation of mercury by fish) due to stagnation of the reservoir/ headpond.
- Increase in water temperature upstream caused by interrupted flow and possibly an increase downstream due to a reduced volume of water present.
- Interruption of the food chain by the retention of nutrients in the reservoir/ headpond area.
- Loss of habitat due to the conversion of upstream free flowing water to a headpond or reservoir and inadequate flows downstream of the structure.

When planning, operating or constructing hydroelectric developments, the following guidance is provided.

- a. Maintenance /minimum flows should be provided downstream during construction of the dam and filling of the reservoir dependent ultimately on the sensitivity of the downstream fish habitat.
- b. Appropriate minimum flows should be determined based on the appropriate instream flow needs methodologies and in consultation with DFO and other appropriate regulatory agencies (Jacques Whitford Environment et. al. 1996c,1997).

- c. Detailed hydrological information (mean monthly flows, mean annual flows, daily flows, flow duration information, water levels, runoff characteristics, etc.) should be used to assess the potential impacts upon fish, fish habitat, stream morphology, and hydrology.
- d. Trees should be cut to approximately 10 centimetres above the ground and removed from the area to be flooded. Grubbing should not be carried out.
- e. All exposed erodible surfaces should be stabilized against erosion before the reservoir/ headpond is flooded.
- f. The predicted flushing rate of proposed headpond or reservoir should be determined to address the bioaccumulation of mercury by resident fish.
- g. Impacts of the entrainment/impingement of fish into the intake- and trailrace should be determined and mitigated by using an intake screen or other appropriate methods.
- h. The quantity and quality of fish habitat which may be impacted by flooding, dewatering and altered flow regimes should be determined. The fish species which utilize these habitats should also be identified. This information should be used to address DFO's No Net Loss guiding principle of DFO's *Policy for the Management of Fish Habitat*.
- i. Provision of fish passage via provision of appropriate flows, installation of a fishway, etc. should be addressed, as appropriate.
- j. Measures to mitigate siltation and provide erosion control should be implemented.

Fish and fish habitat protection measures associated with linear developments such as transmission facilities and access roads associated with hydroelectric developments should also be addressed.

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6.0 GLOSSARY

Alevins: The newly hatched salmon with yolk sac still attached.

Anadromous: Fish which migrate to freshwater to spawn but live all or part of adult life at sea.

Baffle: A barrier or obstruction that deflects, checks or dampens water flow. Culvert baffles are flow interference structures usually in the form of low weirs.

Ballast: Broken stone, gravel, slag, or similar material used to fill timber cribwork.

Bank: The rising ground bordering a stream channel.

Bed Load: Sediment moving on or near the stream bed and frequently in contact with it.

Berm: Mound of earth that can be used to direct or divert surface water.

Buffer Zone: Undisturbed border of vegetation (trees, shrubs, grass, etc.) along a stream or pond which isolates and protects the aquatic environment from nearby construction activities.

Checkdam: Impermeable dam constructed within a ditch to reduce water velocity, retain sediment, and prevent erosion.

Cofferdam: An impermeable barrier consisting of a double wall of sand bags with plastic in between. Used to isolate disturbed work areas from adjacent streams or ponds, or to divert flow.

Culvert: A fibreglass, metal, concrete, plastic or wooden conduit used to pass water under an access route.

	Culverts are used to provide permanent or temporary access across a watercourse.
Deleterious Substance:	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.
Dissolved Oxygen:	The concentration of oxygen dissolved in the water, expressed in mg/L or as percent saturation, where saturation is the maximum amount of oxygen that can theoretically be dissolved in water at a given altitude and temperature.
Entrainment:	Occurs when a fish is drawn into a water intake and cannot escape.
Erosion:	The process of soil and rock weathering caused by natural means (e.g. water, wind, ice, etc.) or by construction related disturbance.
Filter Fabric:	Synthetic fabric used to remove suspended sediment in runoff from disturbed work areas; also used in the construction of some bank stabilization structures to prevent erosion.
Fisheries Resource:	Fish stocks or populations that sustain commercial, recreational or subsistence fishing activities of benefit to Canadians.
Flocculant:	Chemical additive that holds minute suspended particles together.
Flood Plain:	Flat land bordering a stream that is subject to flooding during high water events.

Flow Regime: Seasonal variations in the hydraulic characteristics of stream flows.

Fording: A place where a river or other body of water is shallow enough to be crossed by wading.

Gabion: A rock filled metal cage or basket used for bank or slope stabilization.

Geotextile: Synthetic fabric used to stabilize banks & slopes; allows water to flow through but prevents the erosion of underlying soil.

Grubbing: The removal of vegetation, stumps, debris, etc. from a development site.

Hydrology: The study of water as it occurs on, over, and under the earth surface as streamflow, water, vapour, precipitation, soil moisture, and groundwater.

Impermeable: Any material that will not permit passage of a fluid.

Impingement: Occurs when an entrapped fish is held in contact with the intake screen and is unable to break free.

Invert: The lowest point in the internal cross section of an artificial or natural channel.

Mitigation: Actions taken during the planning, design, construction and operation of works and undertakings to reduce or eliminate potential adverse impacts of construction and operation activities on fish and fish habitat.

Pool: A deep, slow moving, quiet portion of a stream.

Rearing Area: Shallow riffles or pools in a stream which provide young fish with adequate shelter and food.

Riffle: A section of stream or river of shallow depth and rapid current with surface flow broken by gravel, rubble, or boulders. Usually separated by deeper pools.

Riparian: Dwelling on the bank of a stream or pond.

Riprap: Angular rock used for bank and slope stabilization.

Runoff: That part of precipitation appearing in surface streams.

Salmonid: Of the Salmonidae family of fishes; including the salmon, trout and char species.

Scarfify: To break up and loosen the surface of the ground.

Sedimentation: The settling and accumulation of material out of the water column and onto the stream bed. Occurs when the energy of flowing water is unable to support the load of suspended sediment

Settling Pond: Basin constructed to collect run-off from disturbed work areas and allow settling of sediment prior to release into the aquatic environment; often used in series.

Slash: The residue left on the ground after trees are felled or accumulated there as a result of storm, fire or silvicultural treatment.

Spawning Area: Section of stream offering the appropriate size gravel, water velocity, and water depth for spawning and egg development.

Straw Barrier: Straw bales used in ditches to reduce water velocity, retain sediment, and prevent erosion.

Swim Bladder: A hydrostatic organ present in most fishes that consists of a gas-filled sac lying dorsal to the alimentary canal. Also known as the air bladder of a fish.

Terrace: Sloping ground cut into a succession of benches for purposes of controlling surface runoff, minimizing soil erosion and encouraging revegetation.

Topography: A general term to include characteristics of the ground surface such as plains, hills, and mountains, degree of relief, steepness of slopes, and other physiographic features.

Undermining: The seepage or loss of water under a culvert, or other structure.

Water Balance: The balance between water entering a watershed and water leaving a watershed (i.e. precipitation minus all vapour and liquid transport losses out of a watershed).

Wetted Perimeter: The boundary of the channel cross section that is in contact with stream flow.

% Exceedence: Refers to the percentage of time a particular flow within a watercourse is equalled or exceeded with respect to flow duration data. For example, a 90% exceedence value is in reference to the flow being equalled or exceeded 90% of the time.

APPENDIX A

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APPENDIX B

The Environment Emergencies 24-Hour Report Line number (1-800-563-2444) should be utilized to report a chemical or hydrocarbon spill. Spills greater than 70 litres must be reported. However, it is recommended that spills less than 70 litres also be reported. Additionally, for any work in or near fresh water, in order to ensure that a quick and effective response to a spill event is possible, spill response equipment should be readily available on-site. Response equipment, such as adsorbents and open-ended barrels for collection of cleanup debris, should be stored in an accessible location on-site. Personnel working on the project should be knowledgeable about response procedures.

Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters

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1998

**Canadian Technical Report of
Fisheries and Aquatic Sciences 2107**

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Cat. No. Fs 98-6/2107E ISSN 0706-6457

Correct citation for this publication:

Wright, D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. *Can. Tech. Rep. Fish. Aquat. Sci.* 2107: iv + 34p.

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ABSTRACT

Wright, D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Can. Tech. Rep. Fish. Aquat. Sci. 2107: iv + 34p.

The federal *Fisheries Act* includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. The detonation of explosives in or adjacent to fish habitat has been demonstrated to cause disturbance, injury and/or death to fish and marine mammals, and/or the harmful alteration, disruption or destruction of their habitats, sometimes at a considerable distance from the point of detonation.

Within the context of the guidelines and procedures outlined in this report, an explosive is defined as a chemical compound which, when detonated, creates a compressional wave having an almost instantaneous rise time to a very high peak pressure followed by a decay to below ambient pressure by either rapid oxidation or the breaking of high-energy chemical bonds.

The purpose of this report is to provide information to proponents who are proposing works or undertakings that involve the use of confined or unconfined explosives in or near Canadian fisheries waters, and to which the *Fisheries Act*, Sections 32 and 35 in particular, may apply. Guidelines are provided on methods and practices for the conservation and protection of fish, marine mammals, and fish habitat from impacts arising from the destructive forces of explosives. The report describes the suggested application and review procedures and processes for proponents whose use of explosives may result in the destruction of fish, or the harmful alteration, disruption or destruction of fish habitat.

RÉSUMÉ ANALYTIQUE

Wright, D.G. et G.E. Hopky. *Lignes directrices concernant l'utilisation d'explosifs à l'intérieur ou à proximité des eaux de pêche canadiennes*, rapport technique canadien des sciences halieutiques et aquatiques 2107, 1998, iv + 34 p.

La *Loi sur les pêches* fédérale renferme des dispositions relatives à la protection du poisson, des mollusques, des crustacés, des mammifères marins et de leur habitat. Il a été prouvé que la détonation d'explosifs dans l'habitat du poisson ou à proximité perturbe, blesse ou tue des poissons et des mammifères marins ou encore entraîne la détérioration, la destruction ou la perturbation de leur habitat. Il arrive parfois que les dommages se fassent sentir à une distance considérable du point de détonation.

Aux fins des lignes directrices et des procédures énoncées dans le présent rapport, on entend par explosif un composé chimique qui, lorsqu'il explose, crée une vague de compression entraînant presque instantanément un pic de pression extrêmement élevé suivi d'une décroissance sous la pression ambiante soit par oxydation rapide ou par la rupture des liaisons chimiques à haute énergie.

Le présent rapport a pour but de fournir de l'information aux promoteurs qui proposent des ouvrages ou des entreprises nécessitant l'utilisation d'explosifs confinés ou non confinés à l'intérieur ou à proximité des eaux de pêche canadiennes et auxquels la *Loi sur les pêches*, plus précisément les articles 32 et 35, pourraient s'appliquer. Il renferme des lignes directrices concernant les méthodes et pratiques de conservation et de protection du poisson, des mammifères marins et de leur habitat contre les effets découlant de la force destructrice des explosifs. On y décrit les procédures de présentation des demandes et d'examen pour les promoteurs qui prévoient l'utilisation d'explosifs de nature à entraîner la destruction du poisson ou la détérioration, la perturbation ou la destruction de son habitat.

SCOPE AND RATIONALE

The federal *Fisheries Act* includes provisions for the protection of fish, shellfish, crustaceans, marine mammals and their habitats. The detonation of explosives in or adjacent to fish habitat has been demonstrated to cause disturbance, injury and/or death to fish and marine mammals, and/or the harmful alteration, disruption or destruction of their habitats, sometimes at a considerable distance from the point of detonation. Therefore, the Department of Fisheries and Oceans (DFO) has prepared this document to provide information to proponents on the conservation and protection of fish, marine mammals, and their habitat from impacts arising from the use of confined or unconfined explosives in or near Canadian fisheries waters. The guidelines, and application and review procedures and processes outlined in this document apply in the context of the legislative and policy framework summarized below.

APPLICABLE LEGISLATION AND POLICY

Fisheries Act

A number of sections of the *Fisheries Act* and its attendant regulations are applicable to the conservation and protection of fish and fish habitat from the destructive forces of explosives.

- Section 2 defines “Canadian fisheries waters” as meaning all waters in the fishing zones of Canada, all waters in the territorial sea of Canada and all internal waters of Canada.
- Section 2 defines “fish” as including shellfish, crustaceans, marine animals and the eggs, sperm, spawn, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
- Section 32 prohibits the destruction of fish by any means other than fishing, except as authorized by the Minister of Fisheries and Oceans or under regulations made by the Governor in Council under the *Fisheries Act*.
- Subsection 34(1) defines “fish habitat” as meaning spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes.
- Subsection 35(1) prohibits any person from carrying on any work or undertaking that results in the Harmful Alteration, Disruption or Destruction (HADD) of fish habitat.
- Subsection 35(2) provides for the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister of Fisheries and Oceans or under regulations made by the Governor in Council under the *Fisheries Act*.

- Subsection 36(3) prohibits the deposit of a deleterious substance into waters frequented by fish, unless otherwise permitted by regulation.
- Subsection 58(1) of the *Fishery (General) Regulations* provides for anyone proposing to carry on any work or undertaking likely to result in the HADD of fish habitat, to apply to have the means or conditions of that work or undertaking authorized by the Minister under Subsection 35(2) of the *Fisheries Act*, using the form set out in Schedule VI. Schedule VI includes a section for the applicant to provide details on the proposed use of explosives.
- Subsection 58(2) of the *Fishery (General) Regulations* provides the means for the Department of Fisheries and Oceans to issue Authorizations under Subsection 35(2) of the *Fisheries Act*, using the form set out in Schedule VII.
- Section 7 of the *Marine Mammal Regulations* prohibits disturbance of marine mammals except when fishing for them.

In addition, the Department of Fisheries and Oceans has developed a policy framework to assist in the interpretation and application of the applicable legislation. The most relevant documents are as follows:

- The **Policy for the Management of Fish Habitat** (1986) provides policy direction for interpreting the broad powers mandated in the *Fisheries Act* in a way that is consistent with the concept of sustainable development. To achieve the Policy's goal of fish habitat conservation when reviewing project proposals with the potential to affect fish habitat, DFO's habitat managers apply the No Net Loss (NNL) guiding principle. Under this principle, the Department strives to maintain the existing productive capacity of fish habitats, such that the fish habitat is able to sustain the production of fish suitable for fisheries purposes.

In summary, in order to meet the NNL guiding principle, the habitat manager's first preference is to avoid or reduce the project's potential for a HADD of fish habitat through the application of appropriate mitigation measures. Avoidance measures, such as project relocation or redesign, can be effectively applied at the project design stage. Failing that, impacts may be further reduced by application of specific mitigation measures, such as use of timing windows during the construction phase. If a HADD is still expected to occur, unavoidable - i.e. residual - losses in habitat productive capacity may be compensated on a case-by-case basis if the manager concludes that compensation is acceptable and feasible.

- The **Directive on the Issuance of Subsection 35(2) Authorizations** (1995) clarifies the circumstances when an Authorization under Subsection 35(2) may be issued, and on providing proponents with letters of advice suggesting means of avoiding HADD of fish habitat.

- The **Habitat Conservation and Protection Guidelines** (1998) is a document for use by DFO's staff in administering the habitat provisions of the *Fisheries Act*. It outlines a standard approach to habitat conservation and protection through the application of the NNL guiding principle.

Canadian Environmental Assessment Act

A decision to issue an Authorization under Section 32 or Subsection 35(2) of the *Fisheries Act* triggers an environmental assessment under the *Canadian Environmental Assessment Act* (CEAA).

IMPACTS

The use of explosives may result in a number of adverse impacts on fish and marine mammals, and their habitats.

Effects on Fish

The detonation of explosives in or near water produces post-detonation compressive shock waves characterized by a rapid rise to a high peak pressure followed by a rapid decay to below ambient hydrostatic pressure. The latter pressure deficit causes most impacts on fish.

The primary site of damage in finfish is the swimbladder, the gas-filled organ that permits most pelagic fish to maintain neutral buoyancy. The kidney, liver, spleen, and sinus venous also may rupture and haemorrhage. Fish eggs and larvae also may be killed or damaged (Wright 1982).

Studies (Wright 1982) show that an overpressure in excess of 100 kPa will result in these effects. The degree of damage is related to type of explosive, size and pattern of the charge(s), method of detonation, distance from the point of detonation, water depth, and species, size and life stage of fish.

Vibrations from the detonation of explosives may cause damage to incubating eggs (Wright 1982, Wright in prep.). Sublethal effects, such as changes in behaviour of fish, have been observed on several occasions as a result of noise produced by explosives. The effects may be intensified in the presence of ice and in areas of hard substrate (Wright 1982, Wright in prep.).

The detonation of explosives may be lethal to marine mammals and may cause auditory damage under certain conditions. The detonation of explosives in the proximity of marine mammals also has been demonstrated to induce changes in behaviour (Wright in prep.).

The number of shellfish and crustaceans killed by the detonation of explosives is believed to be negligible, however, few data are available. Sublethal effects of explosives on

shellfish and crustaceans including behavioural modifications are little known or understood (Wright 1982, Wright in prep.).

Effects on Fish Habitat

The use of explosives in and near fish habitat may also result in the physical and/or chemical alteration of that habitat. For example, sedimentation resulting from the use of explosives may cover spawning areas or may reduce or eliminate bottom-dwelling life forms that fish use for food. By-products from the detonation of explosives may include ammonia or similar compounds and may be toxic to fish and other aquatic biota (Wright in prep.).

GUIDELINES, AND APPLICATION AND REVIEW PROCESSES

The following sections have been prepared to guide proponents proposing works or undertakings that involve the use of confined or unconfined explosives in or near Canadian fisheries waters, and to which the *Fisheries Act*, Sections 32 and 35 in particular, may apply. Confined explosives are those that would be used within a substrate, including ice, while unconfined explosives are those that would be used in open water, or not within a substrate.

Note that the information and guidance provided in these sections pertains to the conservation and protection of fish and fish habitat in the context of the *Fisheries Act*, and to the CEAA requirements that may result. There is no intent to relieve the proponent of responsibilities under any other federal, provincial or municipal legislation. Proponents are encouraged to contact other appropriate regulatory agencies to ensure that the proposed work or undertaking is carried out according to their requirements.

GUIDELINES

This section provides guidelines on methods and practices which, if incorporated into a project proposal, are intended to prevent or avoid the destruction of fish, or any potentially harmful effects to fish habitat that could result from the use of explosives. Implementation of these measures, for this purpose, is at the discretion of the proponent. Use of these guidelines should not be taken to imply approval of the proposed project in accordance with the *Fisheries Act*. Note that should the proponent proceed with the project and the use of explosives results in the destruction of fish and/or the HADD of fish habitat as a result of a change in plans, or failure to implement the measures, contravention of Section 32 and/or Subsection 35(1) of the *Fisheries Act* could occur.

1. Proponents considering the use of explosives are encouraged to consult the appropriate DFO Regional/Area authorities (Appendix I) as early as possible in their planning process to identify possible alternatives to the use of explosives, the biological resources and their habitats at risk, and/or effective mitigation measures.

2. Where provincial or territorial resource management agencies, or aboriginal resource management boards undertake the administration of fisheries, the proponent is encouraged to consult with the relevant authorities.
3. The use of confined or, in particular, unconfined explosives in or near Canadian fisheries waters is discouraged, and proponents are encouraged to utilize other potentially less destructive methods wherever possible.
4. No use of ammonium nitrate-fuel oil mixtures occurs in or near water due to the production of toxic by-products (ammonia).

Note:

- The deposit of deleterious substances into waters frequented by fish is prohibited under Section 36(3) of the *Fisheries Act*, unless otherwise permitted by regulation. There is no regulation pursuant to the *Fisheries Act* that permits the deposit of by-products resulting from the use of ammonium nitrate-fuel oil mixtures.

5. After loading a charge in a hole, the hole is to be back-filled (stemmed) with angular gravel to the level of the substrate/water interface or the hole collapsed to confine the force of the explosion to the formation being fractured. The angular gravel is to have a particle size of approximately 1/12th the diameter of the borehole.
6. All "shock-tubes" and detonation wires are to be recovered and removed after each blast.
7. No explosive is to be knowingly detonated within 500 m of any marine mammal (or no visual contact from an observer using 7x35-power binocular).

Note:

- Upon review of a proposal, the DFO Regional/Area authority may impose a greater avoidance distance, depending on the size of the charge or other project specific or fishery resource conditions.

8. No explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change (i.e., overpressure) greater than 100 kPa (14.5 psi) in the swimbladder of a fish.

Notes:

- For confined explosives, setback distances from the land-water interface (e.g., the shoreline), or burial depths from fish habitat (e.g., from under the riverbed) that will ensure that explosive charges meet the 100 kPa overpressure

guideline are shown in Table 1. Equations to derive these relationships have been adapted from Nicholls et al. (1971) and Anon (1980). The equations are described in Appendix II, and should be used for weights of explosives not covered in Table 1. Sample calculations and examples are illustrated in Appendix III.

- If a confined explosive is to be detonated close to the substrate-water interface (such as in trenching or demolition), the set-back distance closely approximates the theoretical lethal range within which 50% of the fish may be killed or injured. Consequently, the 100 kPa guideline is not likely to be met in those situations where, because of the design constraint's of the project, it is also likely not possible or practical to 'adjust' the setback distance as a means to meet the 100 kPa guideline. For example, preparation of a trench for a pipeline crossing typically requires no more than a below grade burial depth of about 2m. Therefore, the weight of explosive charge per delay will have to be adjusted in an effort to meet the 100 kPa guideline. A sample calculation to illustrate a trenching example is given in Appendix III.
- For unconfined explosives, proponents are encouraged to contact the appropriate DFO Regional/Area authorities (Appendix I) for further guidance.

9. No explosive is to be detonated that produces, or is likely to produce, a peak particle velocity greater than $13 \text{ mm}\cdot\text{s}^{-1}$ in a spawning bed during the period of egg incubation.

Note:

- For confined explosives, setback distances or burial depths from spawning beds that will ensure that explosive charges meet the $13 \text{ mm}\cdot\text{s}^{-1}$ guideline criteria are shown in Table 2. Equations to derive these relationships have been adapted from Nicholls et al. (1971) and Anon (1980) and are described in Appendix II. Sample calculations and examples are illustrated in Appendix III.
- For unconfined explosives, proponents are encouraged to contact the appropriate DFO Regional/Area authorities (Appendix I) for further guidance.

APPLICATION AND REVIEW PROCESSES

Proponents planning to use an explosive that is likely to destroy fish and/or cause a HADD of fish habitat are subject to certain legal obligations under the *Fisheries Act*, as identified in the preceding 'Applicable Legislation and Policy' section. This section discusses these obligations with respect to the proposed use of explosives, and suggests to proponents how to fulfil them.

Proponents should contact the DFO Regional/Area authorities (Appendix I) as early as possible in their planning process. The purpose is to find out whether the proposed use of

explosives is likely to affect a Canadian fisheries water and whether its use is likely to destroy fish and/or cause a HADD of fish habitat. Depending on the outcome, DFO may also discuss potential issues, specific information requirements, or the next steps and possible outcomes in a further review of the proposal. For example, as summarized in the subsequent 'Review and Decision-making Process' section, possible next steps could include a request for further information, or a recommendation that the proponent seek an authorization pursuant to Section 32 and/or Subsection 35(2). Possible outcomes may include the provision of written advice, the issuance of (an) authorization(s) subject to completion of a CEAA review, or, refusal to issue (an) authorization(s).

Proponents should contact DFO before irrevocable commitments (such as contracts for equipment/services) are made, in order to avoid any unnecessary delays in the application and review process. Note that DFO may become aware of your proposed project through its participation in co-operative arrangements with other governments, agencies, boards, etc.

The following 'Application Procedures' section provides information to assist the proponent in deciding if it should seek Authorization to destroy fish by means other than fishing, and/or Authorization to harmfully alter, disrupt or destroy fish habitat, through the use of explosives and, if so, provides information on procedures for filing, etc.

Note that application for Authorization under Section 32 and/or Subsection 35(2) is voluntary. Proponents are not prohibited from going ahead with their use of explosives without Authorization. But, if as a result of the use of explosives, fish are destroyed and/or there is a HADD of fish habitat, contravention of Section 32 and/or Subsection 35(1) of the *Fisheries Act* could occur and the proponent is liable to prosecution.

Application Procedures

1. Proponents unable to meet the overpressure or peak particle velocity guideline values identified, respectively, in measures 8 or 9 of the preceding 'Guidelines' section, should complete and submit an application for Authorization under Section 32 of the *Fisheries Act*, to destroy fish by means other than fishing. The recommended application form is shown in Appendix IV. However, the proponent should contact the appropriate DFO Regional/Area authority (Appendix I) to verify that this is the appropriate application form to use and/or to identify information requirements.
2. Proponents who wish to file for Authorization under Subsection 35(2) of the *Fisheries Act* should complete and submit a separate application in accordance with the form prescribed pursuant to Subsection 58(1) of the *Fishery (General) Regulations* (Appendix V). Assistance on filing the application form, and related procedures, may be obtained by contacting the appropriate DFO Regional/Area authorities (Appendix I).

3. Proponents seeking Authorization under both Section 32 and Subsection 35(2) should complete and submit both Section 32 (Appendix IV) and Subsection 35(2) (Appendix V) applications. However, to minimize duplication, the proponent may choose to cross-reference those sections that are the same in each application form, and is expected to only submit one set of the documents requested in the forms, unless otherwise requested by the DFO Regional/Area authority. Contact the appropriate DFO Regional/Area authorities (Appendix I) for further information and assistance.
4. In seeking Authorization, the proponent will be expected to provide the information requested in the application forms. Doing so will expedite the review process.

In general, the proponent is expected to provide all plans, specifications, studies, procedures, samples or other information required to permit an assessment of the potential impact of the proposed use of explosives on fish and fish habitat, and the mitigation and/or compensation measures proposed to alleviate impacts and/or to compensate for any loss of productive capacity of habitat to produce fish. Typically, the fish and/or fish habitat information requirements include, but may not necessarily be limited to the items summarized below:

- a) A description of the project and the expected effects resulting from the use of explosives on the fisheries resources (including marine mammals) and/or fish habitat, including:
 - i) A description of fish and marine mammal species and their habitats likely to be affected by the detonation;
 - ii) A description of whether the fish, marine mammals and their habitats contribute, or have the potential to contribute, directly or indirectly, to a fishery - subsistence, commercial or recreational;
 - iii) The timing of any seasonal migration of fish and marine mammals;
 - iv) The theoretical lethal range (i.e., the range, or distance, over which the overpressure exceeds 100 kPa) of the explosives to be used (from equations provided in Appendix II);
 - v) An assessment of potential impacts arising from the proposed use of explosives and a description of proposed mitigation and/or compensation measures; and
 - vi) Other matters, such as the proposed contingency plan and monitoring and follow-up program.
- b) The proponent's mitigation plan should include discussion of the following measures that are particularly relevant to alleviating the potential impacts of explosives:
 - i) The work or undertaking should be undertaken at the time of least biological activity or biological sensitivity. Proponents should consult with DFO Regional/Area authorities to determine the appropriate timing;

- ii) If multiple charges are required, time-delay detonation initiators (blasting caps) should be used to reduce the overall detonation to a series of discrete explosions. Time delays for discrete explosions should be greater than 25 ms; and,
- iii) If possible, large charges should be subdivided into a series of smaller discrete detonations or explosions using time-delay detonation initiators (a procedure known as decking) to reduce the overall detonation to a series of smaller discrete detonations or explosions.

In addition to these measures, the proponent should also consider additional mitigation measures including, but not limited to the following:

- iv) Deployment of bubble curtains/air curtains to disrupt the shock wave;
- v) Deployment of noise generating devices, such as an air compressor discharge line, to scare fish away from the site; or,
- vi) Removal or exclusion of fish from the work area before the blast occurs.

5. Proponents should be aware that subsequent to filing the application, DFO may request additional information concerning fish and fish habitat, the mitigation and/or compensation plans, the contingency and monitoring and follow-up programs, and other matters as required to complete the *Fisheries Act* review. If the appropriate information is not already available, it is the proponent's responsibility to provide it and, also, to assure DFO that the proposed mitigation and/or compensation measures will be effective. Should it be necessary to conduct an environmental assessment of the project pursuant to the CEAA, then additional information will be required in order to meet the requirements of the CEAA.
6. The Department of Fisheries and Oceans will undertake to: respond to requests for review, or to referrals, of project proposals or activities; issue Authorizations or provide advice; and/or complete environmental assessments in a manner consistent with Departmental service standards. Generally, DFO will respond to requests for review or to referrals within 30 working days of notification. Timeframes required for the issuance of Authorizations or advice will be discussed with proponents. Proponents should be aware that the length of time required to complete a review can vary greatly, often depending on the type and complexity of project proposed, the fish and fish habitat issues involved, and whether or not an environmental assessment under the CEAA is required. Once again, proponents are encouraged to contact the appropriate DFO Regional/Area authorities (Appendix I) to discuss these issues.
7. If an unforeseen need to use explosives arises, Departmental service standards may be waived and a review completed as expeditiously as possible so as not to unduly delay a project. Further, Departmental service standards are waived in the event of an emergency where lives and/or property are threatened. In such cases, the amount of information required may be reduced due to the urgency of the

situation. Any verbal request for an emergency Authorization will be accepted only on the condition that it is followed by a written confirmation of the project details.

8. If applicable, proponents may be required by the Department of Fisheries and Oceans, Canadian Coast Guard, to issue a "Notice to Mariners" and/or a "Notice to Fishers". The appropriate DFO Area/Regional authorities (Appendix I) are prepared to assist the proponent with contacting the Canadian Coast Guard.
9. Resource management agencies of other governments, departments, or boards that have been established under some aboriginal land claim settlements, may have aquatic resource review requirements and service standards that are different than those described in this document. Proponents should contact those agencies to ensure compliance with any requirements they may have.

Review and Decision-making Process

This section summarizes the approach taken by the Department of Fisheries and Oceans in the review of referrals and of applications for Authorization. Included is a description of the key decisions possible from a review, and the criteria used in making decisions. There is also a brief summary of the linkage between Section 32 and/or Subsection 35(2) Authorizations and the responsibilities of the Department of Fisheries and Oceans to undertake environmental assessments pursuant to the *Canadian Environmental Assessment Act* (CEAA).

Fisheries Act

DFO will review the proponent's application in accordance with the *Fisheries Act* and its supporting policy framework, including this document. Upon receipt of information, notice, a referral, or application for Authorization concerning works or undertakings where the use of explosives is proposed, DFO will normally take the following steps in its review of the proposal:

1. Determine the adequacy of the information provided by the proponent.
2. Using the information provided, assess the extent of risk or potential damage to fish and marine mammals and/or fish habitat and the acceptability of this level of damage in context with the level of protection required.
3. Determine the probable success of proposed mitigation and/or compensation measures and, as appropriate the acceptability of any residual impacts.
4. Where relevant, consult with the appropriate provincial or territorial resource management agencies, and/or aboriginal resource management boards.
5. Note that prior to finalizing its review of the proposal DFO may, among other matters, advise the proponent of the need for more information, re-assess a revised project proposal, suggest that the proponent seek authorization, etc. The

review of a proposal is often an iterative process depending on a number of factors, such as the type of referral received by DFO, is completeness, its potential impacts on fish and/or fish habitat and the potential to mitigate and/or compensate for such impacts. Proponents should discuss this and related aspects of the review process with the relevant DFO/Regional area authority (Appendix I).

6. After examination of the proposal, DFO will make a decision regarding the proponent's application.

- **With respect to Section 32, DFO will either,**

⇒ upon determining that implementation of mitigation measures by the proponent is expected to prevent or avoid the destruction of fish, advise the proponent by letter that if such measures are incorporated into the project, Section 32 is not expected to be contravened. A letter of advice should not be taken to imply approval of the project pursuant to the habitat provisions of the *Fisheries Act*, or any other legislation. Note, if the destruction of fish occurs as a result of a change in the plans for the proposed project, or failure to implement the measures identified in the letter of advice, contravention of Section 32 of the *Fisheries Act* could occur.

OR

⇒ upon determining that even with the implementation of mitigation measures the destruction of fish is still expected to occur **and**, because this mortality is acceptable within the context of the fisheries resource, issue a Section 32 Authorization using a letter format.

OR

⇒ upon determining that even with the implementation of mitigation measures the destruction of fish is still expected to occur **but**, because this mortality is not acceptable within the context of the fisheries resource, reject the proposal, and notify the proponent that DFO will not issue a Section 32 Authorization and that a contravention of the *Fisheries Act* could occur should the proponent still choose to proceed as proposed.

- **With respect to Section 35, DFO will either,**

⇒ upon determining that implementation of mitigation measures by the proponent is expected to prevent or avoid a HADD of fish habitat, advise the proponent by letter that if such measures are incorporated into the project, Subsection 35(1) is not expected to be contravened. A letter of advice should not be taken to imply approval of the project pursuant to the habitat provisions of the *Fisheries Act*, or any other legislation. Note, if a

HADD of fish habitat occurs as a result of a change in the plans for the proposed project, or failure to implement the measures identified in the letter of advice, contravention of Subsection 35(1) of the *Fisheries Act* could occur.

OR

⇒ upon determining that even with the implementation of mitigation measures a HADD of fish habitat is still expected to occur **and**, because the proposed compensation for the unavoidable net loss of productive capacity of fish habitat is acceptable to DFO, issue a Subsection 35(2) authorization using the form provided in Schedule VII of Subsection 58(2) of the *Fishery (General) Regulations*.

OR

⇒ upon determining that even with the implementation of mitigation measures a HADD of fish habitat is still expected to occur **but**, because the proposed compensation for the unavoidable net loss of fish habitat productive capacity is not acceptable, reject the proposal, and notify the proponent that DFO will not issue a Subsection 35(2) Authorization and that a violation of the *Fisheries Act* could occur should the proponent still choose to proceed as proposed.

Notes:

- The Department of Fisheries and Oceans, in arriving at one of the above noted determinations, will also consider the following criteria:
 - Whether the use of explosives is the only technically feasible means by which to attain the desired objective; and
 - Whether the use of explosives is required to alleviate an emergency situation threatening human safety and/or property.
- Section 32 and/or Subsection 35(2) authorizations come with conditions attached, which among others may include:
 - The proponent may be required to develop, undertake and report on a monitoring program at its expense, typically, to monitor compliance and evaluate effectiveness of the mitigation and/or compensation measures.
 - If, during the course of the works or undertakings, the adverse effects of the explosives were significantly greater than anticipated, the proponent may be required to immediately cease all further use of explosives,

pending review of the situation with Department of Fisheries and Oceans personnel.

- Additional, site-specific terms and conditions as may be required in order to satisfy fishery resource and/or fish habitat protection requirements. For example, the conditions may be more stringent than the measures identified in the preceding 'Guidelines' section.

Canadian Environmental Assessment Act

Section 32 and Subsection 35(2) are included in the *Law List Regulation* of the *Canadian Environmental Assessment Act* (CEAA). Consequently, the Department of Fisheries and Oceans as the Responsible Authority must conduct an environmental assessment of the relevant proposed works or undertakings before an Authorization can be issued. If the result of the environmental assessment is that the work or undertaking will, after taking into account the appropriate measures, not likely result in significant impact that cannot be justified, then authorization(s) will normally be issued pursuant to Section 32 and/or Subsection 35(2) of the *Fisheries Act*. Procedures for coordinating the CEAA review with provincial and aboriginal government review processes vary. Proponents are strongly advised to contact the DFO Regional/Area authorities (Appendix I) to obtain additional information on environmental assessment procedures and requirements.

UPDATING

These guidelines will be reviewed and updated as necessary.

ACKNOWLEDGEMENTS

Many individuals and governmental and non-governmental organizations were consulted in the development of these guidelines. We gratefully acknowledge their interest and contributions. In particular, input from D. Haché, K. Fisher, K. Broughton and R. Drolet, from DFO, and L. Macanuf (Golder-VME) and R. Morin (Explotec Engineering Ltd) is appreciated.

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Table 1. Setback distance (m) from centre of detonation of a confined explosive to fish habitat to achieve 100 kPa guideline criteria for various substrates.

The data in this table is incorrect and should not be used.

Substrate Type	Weight of Explosive Charge (kg)							
	0.5	1	2	5	10	25	50	100
Rock	3.6	5.0	7.1	11.0	15.9	25.0	35.6	50.3
Frozen Soil	2.3	3.2	4.5	7.2	14.3	16	22.6	32
Ice	1.5	2.1	3.0	4.7	6.6	10.5	14.8	21
Saturated Soil	1.5	2.1	3.0	4.8	6.7	10.0	15.1	21.3
Unsaturated Soil	0.7	1.0	1.4	2.2	3.1	4.9	6.9	9.8

Erratum:

Wright, D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Can Tech. Rep. Fish. Aquat. Sci. 2107: iv + 34p.

Page 15: Table 1 should be replaced by the following Table:

Table 1. Setback distance (m) from centre of detonation of a confined explosive to fish habitat to achieve 100 kPa guideline criteria for various substrates.

Substrate Type	Weight of Explosive Charge (kg)							
	0.5	1	2	5	10	25	50	100
Rock	3.6	5.0	7.1	11.0	15.9	25.0	35.6	50.3
Frozen Soil	3.3	4.7	6.5	10.4	14.7	23.2	32.9	46.5
Ice	3.0	4.2	5.9	9.3	3.2	20.9	29.5	41.8
Saturated Soil	3.0	4.2	5.9	9.3	13.2	20.9	29.5	41.8
Unsaturated Soil	2.0	2.9	4.1	6.5	9.2	14.5	20.5	29.0

Table 2. Setback distance (m) from centre of detonation of a confined explosive to spawning habitat to achieve $13 \text{ mm} \cdot \text{sec}^{-1}$ guideline criteria for all types of substrate.

	Weight of Explosive Charge (kg)						
	0.5	1	5	10	25	50	100
Setback distance (m)	10.7	15.1	33.7	47.8	75.5	106.7	150.9

Appendix I
DFO Regional/Area Authorities

Newfoundland Region

Habitat Evaluation Engineer,
 Habitat Management Division
 Fisheries and Habitat Management Branch
 PO Box 5667
 St. John's, NF A1C 5X1
 Voice: (709) 772-6157
 Fax: (709) 772-4525

Maritime Region

New Brunswick and Prince Edward Island

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Nova Scotia

Brian Jollymore, P. Eng.
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Laurentian Region

Manager, Fish Habitat
 Fish Habitat and Environmental Science
 Maurice-Lamontagne Institute
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Central and Arctic Region

Ontario

Area Manager, Ontario Area
 Fisheries Management Branch
 PO Box 5050, 867 Lakeshore Road
 Burlington, ON L7R 4A6
 Voice: (905) 336-4567
 Fax: (905) 336-6437

Manitoba, Saskatchewan and Alberta

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 Winnipeg, MB R3T 2N6
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 Fax: (204) 984-2402

Appendix I (concluded)
DFO Regional/Area Authorities

Central and Arctic Region (continued)

Nunavut

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 Fax: (867) 979-8039

Western Arctic

Area Manager, NWT West Area
 Fisheries Management Branch
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Pacific Region

North Coast

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Fraser River

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Appendix II
General Equations to Determine Setback Distance for Confined
Explosives to Meet Guideline Criteria of 100 kPa

Equation (A)

Equation (A) describes the transfer of shock pressure from the substrate to the water.

$$P_W = \frac{2(Z_W / Z_R)P_R}{1 + (Z_W / Z_R)}$$

where:

P_W	=	pressure (kPa) in water
P_R	=	pressure (kPa) in substrate
Z_W	=	acoustic impedance of water
Z_R	=	acoustic impedance of substrate

Equation (B)

Equation (B) describes the relationship between acoustic impedance and the density and velocity of the medium through which the compressional wave travels.

$$Z_W / Z_R = \frac{D_W C_W}{D_R C_R}$$

where:

D_W	=	density of water = 1 g•cm ⁻³
D_R	=	density of the substrate in g•cm ⁻³
C_W	=	compressional wave velocity in water
	=	146,300 cm•s ⁻¹
C_R	=	compressional wave velocity in substrate in cm•s ⁻¹

Appendix II (concluded)
General Equations to Determine Setback Distance for Confined
Explosives to Meet Guideline Criteria of 100 kPa

Equation (B) (continued):

The following values are used for D_R and C_R for various substrates:

Substrate	D_R (g \cdot cm $^{-3}$)	C_R (cm \cdot s $^{-1}$)
Rock	2.64	457,200
Frozen Soil	1.92	304,800
Ice	0.98	304,800
Saturated soil	2.08	146,300
Unsaturated soil	1.92	45,700

Equation (C)

Equation (C) describes the relationship between the peak particle velocity (V_R) and the pressure, density and compressional wave velocity in the substrate.

$$V_R = \frac{2P_R}{D_R C_R}$$

Equation (D)

Equation (D) represents the scaled distance relationship and is used to equate the peak particle velocity to charge weight and distance.

$$V_R = 100 (R/W^{.5})^{-1.6}$$

where:

V_R = peak particle velocity in cm \cdot s $^{-1}$
 R = distance to the detonation point in m
 W = charge weight per delay in kg

Appendix III
Sample Calculations and Examples for Confined Explosives

SAMPLE CALCULATIONS

Sample Calculation 1: Calculation of Setback Distance Required for a 100 kg Charge Set in Rock to Meet the 100 kPa Guideline.

1. From Equation (B):

$$\begin{aligned}
 Z_w/Z_R &= \frac{D_w C_w}{D_R C_R} \\
 &= \frac{(1\text{g}\bullet\text{cm}^{-3})(146,300\text{cm}\bullet\text{s}^{-1})}{(2.64\text{g}\bullet\text{cm}^{-3})(457,200\text{cm}\bullet\text{s}^{-1})} \\
 &= 0.1212
 \end{aligned}$$

2. From Equation (A):

$$P_w = \frac{2(Z_w/Z_R)P_R}{1+(Z_w/Z_R)}$$

$$P_w = \frac{2(0.1212)P_R}{1+(0.1212)}$$

$$P_w = 0.22 P_R$$

3. To limit P_w to 100 kPa ($\text{kg}\bullet\text{m}\bullet\text{s}^{-2}\bullet\text{m}^{-2}$):

$$P_R = \frac{P_w}{0.22}$$

$$P_R = \frac{100 \text{ kPa}}{0.22}$$

$$P_R = 455 \text{ kPa}$$

$$P_R = 4.55 \times 10^2 \text{ kPa}$$

Appendix III (continued)
Sample Calculations and Examples for Confined Explosives

4. Convert kPa to dynes ($\text{g}\cdot\text{cm}\cdot\text{s}^{-2}$):

$$\text{dynes} = \text{kPa} \times 10^4$$

$$P_R = 4.55 \times 10^2 \times 10^4$$

$$P_R = 4.55 \times 10^6 \text{ dynes} (\text{g}\cdot\text{cm}\cdot\text{s}^{-2})$$

5. From Equation (C):

$$V_R = \frac{2P_R}{D_R C_R}$$

$$V_R = \frac{(2)(4.55 \times 10^6 \text{ g}\cdot\text{cm}\cdot\text{s}^{-2})}{(2.64 \text{ g}\cdot\text{cm}^{-3})(457,200 \text{ cm}\cdot\text{s}^{-1})}$$

$$V_R = 7.54 \text{ cm}\cdot\text{s}^{-1}$$

6. From Equation (D):

$$V_R = 100(R/W)^{-1.6}$$

$$R = (W)^{0.5} (V_R/100)^{-0.625}$$

$$R = (100\text{kg})^{0.5} (7.54\text{cm}\cdot\text{s}^{-1}/100\text{kg}\cdot\text{cm}\cdot\text{s}^{-1}\cdot\text{m})^{-0.625}$$

$$R = 50.3 \text{ m}$$

Therefore, a 100 kg charge of explosives detonated in rock requires a setback of 50.3 m from fish habitat in order to reduce the overpressure produced by the detonation to less than 100 kPa.

Now, the calculation of the set-back distance required for a 100 kg charge set in rock to meet the peak particle velocity guideline of $13 \text{ mm}\cdot\text{sec}^{-1}$ is as follows:

Appendix III (continued)
Sample Calculations and Examples for Confined Explosives

From Equation (D):

$$R = (W^{.5})(V_R/100)^{-0.625}$$

When

$$V_R = 13 \text{ mm}\cdot\text{sec}^{-1} = 1.3 \text{ cm}\cdot\text{sec}^{-1}$$

$$\text{and } W = 100 \text{ kg}$$

$$R = (100^{.5})(1.3/100)^{-0.625}$$

$$R = 150.9 \text{ m}$$

Therefore, a 100 kg charge of explosives detonated in rock requires a setback of 150.9 m from a spawning area in order to reduce the peak particle velocity produced by the detonation to less than 13 mm \cdot sec $^{-1}$.

Sample Calculation 2: Simplified Calculation of Setback Distance from Fish Habitat.

The calculations to determine the required setback distance to meet the 100 kPa guideline may be simplified. Since the weight of the charge and the distance from the charge to fish habitat are the only variables in the equations, a factor can be developed for substitution in Equation (D).

From Equation (D):

$$V_R = 100(R/W^{.5})^{-1.6}$$

$$R = (W^{.5})(V_R/100)^{-0.625}$$

Therefore:

$$R = W^{.5}(K)$$

By working through the equations of Appendix II and solving for V_R for each substrate

Appendix III (continued)
Sample Calculations and Examples for Confined Explosives

type, the following results are obtained:

SUBSTRATE TYPE	K
Rock	5.03
Frozen Soil	3.2
Ice	2.1
Saturated Soil	2.13
Unsaturated Soil	0.98

Therefore, to determine the setback distance required to meet the peak pressure guideline of 100 kPa, multiply the square root of the charge weight by the appropriate "K" factor.

Sample Calculation 3: Simplified Calculation of Setback Distance from Fish Spawning Habitat.

Similarly, to determine the set-back distance required to meet the peak particle velocity (V_R) guideline of $13 \text{ mm}\cdot\text{sec}^{-1}$, a constant can be developed for substitution in Equation (D):

From Equation (D):

$$V_R = 100(R/W^{.5})^{-1.6}$$

$$R = (W^{.5})(V_R/100)^{-0.625}$$

where:

$$V_R = 13 \text{ mm}\cdot\text{sec}^{-1} = 1.3 \text{ cm}\cdot\text{sec}^{-1}$$

$$R = (W^{.5})(1.3/100)^{-0.625}$$

$$R = (W^{.5})(15.09)$$

Therefore, to determine the setback distance required to meet the peak particle velocity (V_R) guideline of $13 \text{ mm}\cdot\text{sec}^{-1}$, multiply the square root of the charge weight by a factor of 15.09.

Appendix III (continued)
Sample Calculations and Examples for Confined Explosives

EXAMPLES

Example 1: On-shore Setback Distance from Fish Habitat.

A proponent wishes to use explosives to break rock in a quarry near a stream. What is the minimum setback distance from the stream required in order to limit the overpressure in the stream to less than 100 kPa?

Calculate the required set back distance for a 35 kg charges set in rock.

$$\begin{aligned}
 W &= 35 \text{ kg} \\
 K_{(\text{rock})} &= 6.75 \\
 R &= (W^{.5})(K) \\
 R &= (35^{.5})(5.03) \\
 R &= 29.8 \text{ m}
 \end{aligned}$$

Note: It is assumed that the rock formation being quarried extends under the stream. Therefore the K factor for rock is used.

Therefore, the proponent would be required to maintain a set back distance of at least 29.8 m in order to meet the DFO guideline criteria of 100 kPa.

Example 2: Buried Charges for Geophysical Exploration.

A proponent wishes to conduct a geophysical survey beneath a shallow lake. Because of the shallow depth of the lake, it is not possible to use an air gun or other similar non-explosive energy source. To what depth must explosive charges (5 kg) be buried in order to limit the overpressure to less than 100 kPa?

$$\begin{aligned}
 W &= 5 \text{ kg} \\
 K_{(\text{sat. soil})} &= 2.13 \\
 R &= (W^{.5})(K) \\
 R &= (5^{.5})(2.13) \\
 R &= 4.8 \text{ m}
 \end{aligned}$$

Note: It is assumed that the charges are buried in un-consolidated sediments. Therefore the K factor for saturated soil is used.

Therefore the proponent would be required to bury the charges to a depth of at least 4.8 m below the substrate-water interface in order to limit the overpressure at the interface to less than 100 kPa.

Appendix III (continued)
Sample Calculations and Examples for Confined Explosives

Example 3: In-stream Trench Excavation.

A proponent wishes to use explosives to assist in the excavation of a trench for a pipeline across a trout stream. The right-of-way is located in a cobble bottom riffle area that is used as a feeding area. There is a potential spawning bed located 75 m upstream of the right-of-way. The explosives' parameters are as follows:

Weight of individual charges:	15 kg
# of holes detonated/delay:	5
Weight of charge/delay:	75 kg

Does the proposal meet the DFO guideline criteria for overpressure and peak particle velocity?

a) For the Overpressure Criteria:

$$\begin{aligned}
 W &= 75 \text{ kg} \\
 K_{(\text{rock})} &= 5.03 \\
 R &= (W^{.5})(K) \\
 R &= (75^{.5})(5.03) \\
 R &= 43.6 \text{ m}
 \end{aligned}$$

Note: Since explosives must be used to excavate the trench, it is assumed that the substrate consists of rock or strongly consolidated sediments. Therefore the K factor for rock is used.

Therefore the detonation of 75 kg of explosives could kill or injure fish within a radius of 43.6 m of the right-of-way.

b) For the Peak Particle Velocity Criteria:

To determine the setback distance required to meet the peak particle velocity (V_R) guideline of $13 \text{ mm}\cdot\text{sec}^{-1}$ in a spawning area, multiply the square root of the charge weight by a factor of 15.09.

$$\begin{aligned}
 R &= (W^{.5})(15.09) \\
 R &= (75^{.5})(15.09) \\
 R &= 130.7 \text{ m}
 \end{aligned}$$

Therefore, the detonation of 75 kg of explosives would exceed the DFO Guideline for peak particle velocity of $13 \text{ mm}\cdot\text{sec}^{-1}$ in a spawning bed.

Appendix III (concluded)
Sample Calculations and Examples for Confined Explosives

Therefore, the application for an authorization to use explosives would be denied and major changes in the explosives program would be required in order for the project to be acceptable to DFO.

For example:

If the weight of explosive/delay were reduced to 5 kg by increasing the number of holes in the pattern and detonating each hole separately with 25 msec delays between each hole, the zone of overpressure exceeding 100 kPa would be:

$$\begin{aligned}
 W &= 5 \text{ kg} \\
 K_{(\text{rock})} &= 5.03 \\
 R &= (W^{.5})(K) \\
 R &= (5^{.5})(5.03) \\
 R &= 11.2 \text{ m}
 \end{aligned}$$

Similarly, the distance at which the peak particle velocity in the substrate would not exceed $13 \text{ mm}\cdot\text{sec}^{-1}$ would be:

$$\begin{aligned}
 R &= (W^{.5})(15.09) \\
 R &= (5^{.5})(15.09) \\
 R &= 33.7 \text{ m}
 \end{aligned}$$

Therefore, if the weight of explosives per delay were reduced to 5 kg, the spawning area would be protected, as it is further than 33.7m from the detonation area. However, the detonation would still produce over-pressures exceeding 100 kPa to a distance of 11.2 m. Additional mitigation such as undertaking the project at a time of least fish activity or by removing/excluding fish from the area by either physical exclusion or scare tactics may be required.

Appendix IV
Application Form for Authorization to Destroy Fish by Means
Other Than Fishing

Page 1

**APPLICATION FOR AUTHORIZATION TO DESTROY FISH BY MEANS
OTHER THAN FISHING**

I, the undersigned, hereby request authorization to carry out the works or undertakings described on this application form. I understand that the approval of this application, if granted, is from the Department of Fisheries and Oceans standpoint only and does not release me from my obligation to obtain permission from other concerned regulatory agencies.

If an authorization is granted as a result of this application, I hereby agree to carry out all activities relating to the project within the designated time frames and conditions specified in the authorization.

Applicant's Name (Please Print) _____

Applicant's Business Address _____

Applicant's Telephone Number

Applicant's Facsimile Number

Applicant's E-Mail Number

Date of Application

I solemnly declare that the information provided and facts set out in this application are true,

I solemnly declare that the information provided and facts set out in this application are true, complete and correct, and I make this solemn declaration conscientiously believing it to be true and knowing that it is of the same force and effect as if made under oath. This declaration applies to all material submitted as part of this application.

Applicant's Signature

Appendix IV (continued)
Application Form for Authorization to Destroy Fish by Means
Other Than Fishing

Page 2

**APPLICATION FOR AUTHORIZATION TO DESTROY FISH BY MEANS
OTHER THAN FISHING (continued)**

Location Details

Name of watercourse or waterbody (including co-ordinates)

Nearest Community _____

County _____

Province/Territory

Provide details of proposed activity including reasons as to why explosives must be used (attach additional information as required)

Appendix IV (continued)
Application Form for Authorization to Destroy Fish by Means
Other Than Fishing

Page 3

**APPLICATION FOR AUTHORIZATION TO DESTROY FISH BY MEANS
OTHER THAN FISHING (continued)**

Schedule of Operations

Proposed starting date (D/M/Y)

Proposed completion date (D/M/Y)

The following documents will assist in assessing your application and help expedite its approval. Please check which documents you have attached.

Map indicating location of project

Engineering specifications

Dimensional drawings

Assessment of fish and marine mammal resources

Assessment of potential effects of project on fish and marine mammals []

Measures proposed to mitigate potential damage to fish and marine mammals []

Other []

Appendix IV (concluded)
Application Form for Authorization to Destroy Fish by Means
Other Than Fishing

Page 4

**APPLICATION FOR AUTHORIZATION TO DESTROY FISH BY MEANS
OTHER THAN FISHING (concluded)**

Explosives Contractor (If different from applicant)

Name _____

Address

Telephone number

Facsimile number

Details of Explosives

Type (including trade name)

Total weight of explosive to be used (kg)

Weight of individual shots/

Weight per delay

Shot pattern

Detonation depth

Delay period (msec)

Method of detonation

APPENDIX V

Application Form to Harmfully Alter, Disrupt or Destroy Fish Habitat

SCHEDULE VI / ANNEXE VI
(Subsection 58(1)/paragraphe 58(1))

Fisheries and Oceans



Pêches et Océans

Page 1

Application No./N° de la demande

APPLICATION FOR AUTHORIZATION FOR WORKS OR UNDERTAKINGS AFFECTING FISH HABITAT
DEMANDE D'AUTORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

I, the undersigned, hereby request authorization to carry out the works or undertakings described on this application form. I understand that the approval of this application, if granted, is from the Minister of Fisheries and Oceans standpoint only and does not release me from my obligation to obtain permission from other concerned regulatory agencies.

If an authorization is granted as a result of this application, I hereby agree to carry out all activities relating to the project within the designated time frames and conditions specified in the authorization.

Je soussigné, demande par les présentes l'autorisation d'exploiter les ouvrages ou entreprises décrits dans la formule. Je comprends que l'approbation de cette demande, le cas échéant, porte sur ce qui relève du ministre des Pêches et des Océans et ne me dispense pas d'obtenir la permission d'autres organismes réglementaires concernés.

Si la demande est approuvée, je consens par les présentes à exécuter tous les travaux relatifs à ce projet selon les modalités et dans le laps de temps prescrits dans l'autorisation.

Applicant's Name (Please Print) _____ Nom du requérant (lettres moulées) _____

Applicant's Business Address _____ Adresse d'affaires du requérant _____

Applicant's Telephone No./ N° de téléphone du requérant _____ Date _____

I solemnly declare that the information provided and facts set out in this application are true, complete and correct, and I make this solemn declaration conscientiously believing it to be true and knowing that it is of the same force and effect as if made under oath. This declaration applies to all material submitted as part of this application.

Je déclare solennellement que les renseignements fournis et les faits énoncés dans cette demande sont véridiques, complets et exacts, et je fais cette déclaration solennelle, la croyant conscientieusement vraie et sachant qu'elle a la même force et le même effet que si elle était faite sous serment. Cette déclaration s'applique à tout document qui est présenté dans le cadre de cette demande.

Applicant's Signature (and corporate seal)

Signature du requérant (et sceau de la société)

Name of watercourse or waterbody (give coordinates)
Cours d'eau ou plan d'eau (donner les coordonnées) _____

This watercourse is a tributary of (where applicable)
Cours d'eau tributaire de (le cas échéant) _____

Nearest community
Localité la plus proche

County
Comté

Province
Province

APPENDIX V

Application Form to Harmfully Alter, Disrupt or Destroy Fish Habitat (continued)

SCHEDULE VI-Continued/ANNEXE VI (suite)

Fisheries and Oceans



Pêches et Océans

Page 2

Application No./N° de la demande

APPLICATION FOR AUTHORIZATION FOR WORKS OR UNDERTAKINGS AFFECTING FISH HABITAT
DEMANDE D'AUTORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

Type of Activity/Genre d'activité

<input type="checkbox"/> Bridge Pont	<input type="checkbox"/> Stream Realignment Alignement de cours d'eau	<input type="checkbox"/> Gravel Removal Enlèvement du gravier	<input type="checkbox"/> Stream Traverse Traversée de cours d'eau
<input type="checkbox"/> Culvert Ponceau	<input type="checkbox"/> Channelization Canalisation	<input type="checkbox"/> Obstruction Removal - Bypass Enlèvement ou contournement d'obstacle	<input type="checkbox"/> Seismic Survey Levé sismique
<input type="checkbox"/> Dam Barrage	<input type="checkbox"/> Wharf - Break water Quai - Brise-lames	<input type="checkbox"/> Stream Utilization - Recreation Utilisation récréative du cours d'eau	<input type="checkbox"/> Agriculture
<input type="checkbox"/> Stream Diversion Dérivation de cours d'eau	<input type="checkbox"/> Dewatering Assèchement	<input type="checkbox"/> Erosion Control Lutte contre l'érosion	<input type="checkbox"/> Other (specify) Autres (préciser)
<input type="checkbox"/> Mining Activité minière	<input type="checkbox"/> Aquaculture	<input type="checkbox"/> Flood Protection Protection contre les inondations	

List of Agencies (Federal, Provincial or Municipal) contacted or notified, or who have initiated contact with the applicant.

Liste des organismes (fédéraux, provinciaux ou municipaux) contactés ou qui ont pris contact avec le requérant.

PROVIDE DETAILS OF PROPOSED ACTIVITY INCLUDING REASONS FOR THE PROJECT AND TYPES OF EQUIPMENT TO BE USED
DONNER DES PRÉCISIONS SUR LES TRAVAUX PROJETÉS Y COMPRIS LA JUSTIFICATION DU PROJET ET
LE TYPE D'ÉQUIPEMENT À UTILISER

APPENDIX V

Application Form to Harmfully Alter, Disrupt or Destroy Fish Habitat (continued)

SCHEDULE VI-Continued/ANNEXE VI (suite)

Fisheries and Oceans



Pêches et Océans

Page 3

Application No./N° de la demande

APPLICATION FOR AUTHORIZATION FOR WORKS OR UNDERTAKINGS AFFECTING FISH HABITAT
DEMANDE D'AUTORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON

SCHEDULE/CALENDRIER

D/J M/M Y/A

Proposed Starting Date
Date prévue du début des travaux _____Proposed Completion Date
Date prévue de l'achèvement des travaux _____Approximate Timing of Work in shoreline, foreshore, tidal zone, or underwater areas.
Période approximative des travaux sur le rivage et les estrans ainsi que dans les zones à marées et les zones sous-marines.

D/J M/M Y/A D/J M/M Y/A

From/De _____ To/A _____

The following documents will assist in assessing your application and help expedite its approval. Please check which documents you have attached.**Les documents suivants faciliteront l'évaluation de votre demande et permettront d'accélérer son approbation. Veuillez cocher les documents vous avez joints à votre demande.**Map indicating location of project Carte indiquant l'emplacement du projetEngineering Specifications Spécifications techniquesScale Drawings Dessins à l'échelleDimensional Drawings Plans cotésAssessment of Existing Fish Habitat Characteristics Évaluation des caractéristiques existantes de l'habitat du poissonAssessment of Potential Effects of Project on Fish Habitat Évaluation des répercussions possibles sur l'habitat du poissonMeasures Proposed to Offset Potential Damage to Fish Habitat Mesures proposées pour compenser les ventuels dommages à l'habitat du poissonOther Autres**ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS
CONSIDERATIONS****CONSIDERATIONS CONCERNANT LE PROCESSUS
D'ÉVALUATION ET D'EXAMEN EN MATIÈRE
D'ENVIRONNEMENT**NOTE: All applications pursuant to section 35 of the
Fisheries Act will be assessed in accordance with
applicable federal environmental assessment requirements.REMARQUE : Toute demande en vertu l'article 35 de la Loi
sur les pêches sera soumise aux exigences fédérales
applicables à l'évaluation environnementale.

APPENDIX V

Application Form to Harmfully Alter, Disrupt or Destroy Fish Habitat (concluded)

SCHEDULE VI-Concluded/ANNEXE VI (fin)

Fisheries and Oceans



Pêches et Océans

Page 4

Application No./N° de la demande

APPLICATION FOR AUTHORIZATION FOR WORKS OR UNDERTAKINGS AFFECTING FISH HABITAT
DEMANDE D'AUTORISATION POUR DES OUVRAGES OU ENTREPRISES MODIFIANT L'HABITAT DU POISSON**COMPLETE ONLY IF USE OF EXPLOSIVES IS INTENDED**
A REMPLIR SEULEMENT EN CAS D'UTILISATION D'EXPLOSIFS

EXPLOSIVES CONTRACTOR (IF DIFFERENT FROM APPLICANT)/RESPONSABLE DES EXPLOSIFS (SI AUTRE QUE LE REQUIRANT)

Name/Nom : _____

Address/Adresse : _____

Telephone No./N° de téléphone : _____

Anticipated Starting Date Date prévue du début des travaux	D/J	M/M	Y/A	Completion Date Date d'achèvement	D/J	M/M	Y/Y
_____	_____	_____	_____	_____	_____	_____	_____

DETAILS OF EXPLOSIVES/PRÉCISIONS SUR LES EXPLOSIFSType (including trade name)
Genre (y compris la marque) _____Weight and configuration (where applicable)
Poids et forme (le cas échéant) _____
_____Weight of individual shots and shot pattern where multiple charges are used
Poids des coups individuels et déploiement des coups, en cas de charges multiples
_____Detonation depth (in the rock; note also the depth of water, if applicable)
Profondeur de détonation (dans le roc; indiquer aussi, la profondeur de l'eau, s'il y a lieu)
_____Method of detonation
Méthode de détonation _____



APPENDIX C

Department of Environment and Conservation Newfoundland and Labrador Species at Risk Data Sheets



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

Data Sheet #	Title
1	American Eel
2	Banded Killifish
3	Barrows Goldeneye
4	Piping Plover
5	Short-Eared Owl

American Eel

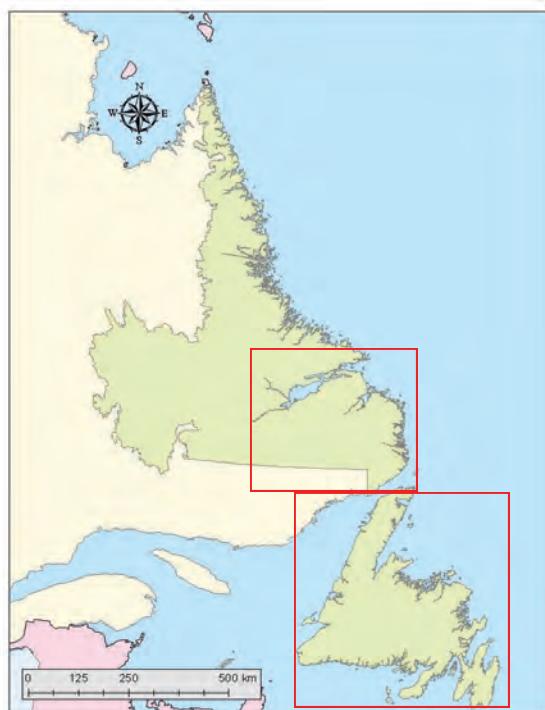
(*Anguilla rostrata*)

- The American eel has a long, snake-like body with a wedge shaped head.
- Females are larger than males and can grow to lengths of 1 meter.
- Eels go through a number of phases during their lifecycle - egg to leptocephali to glass eel to elvers to yellow eels to silver eels.
- The American eel can live for more than 20 years.



© Government of Ontario

Provincial Distribution



Habitat/ Range

American eels spawn in the Sargasso Sea, in the southern North Atlantic Ocean, but grow and mature in our freshwater rivers, lakes, and estuaries. They have been found in many coastal rivers in Newfoundland and as far north as the English River in Labrador.

Population Trends

A downward trend in the number of American eel counted during surveys has been recorded on the Avalon Peninsula and the west coast of Newfoundland since the late 1980s.

Limiting Factors and Threats

American eel populations are limited by dams that prevent access to upstream habitats and hydroelectric developments that kill migrants moving downstream. They can also be limited by pollutants in the water. Fishing is limited in this Province, and large areas of eel habitat are unfished.

Special Significance

There is a small commercial fishery of American eel in Newfoundland and Labrador. They are an important food source for the Mi'kmaq people of the Maritime Provinces.

You can help protect the American eel:

- Support habitat conservation for all our rare species.
- Be careful not to pollute our ponds, rivers, and lakes.
- Learn something new about a species at risk in Newfoundland and Labrador and tell a friend!

Department of Environment & Conservation

Wildlife Division

Endangered Species & Biodiversity

(709) 637-2026

www.gov.nl.ca/env

Banded Killifish

(*Fundulus diaphanus*)

- Banded killifish are a small fish, about 75 mm in length that live for 3 to 4 years.
- They have an elongated and slender body that is slightly flattened at the back of the head.
- Banded killifish have a dark brown to olive-green back and silvery or yellowish sides.
- They have white bands on their belly and numerous black, vertical bands on their back.



© J. Abatemarco Njdep

Provincial Distribution



Habitat/ Range

Banded killifish are found throughout southeastern Canada. In this Province they are only known from several locations on the west coast, northeast coast, and Burin Peninsula of Newfoundland. These locations represent the eastern most extent of this species' range and a unique Canadian population. Banded killifish are most often seen in the shallow areas of clear ponds with a muddy/sandy substrate, high detrital content, and submerged aquatic vegetation.

Population Trends

They are abundant within the confined regions of the watersheds in which they are found, but these regions are widely scattered.

Limiting Factors and Threats

Banded killifish are limited by small numbers of available habitat and barriers, such as steep gradients, impassable rapids, and waterfalls, which restrict access to some of this habitat. Any habitat loss or pollution associated with forestry or land use/development would put these rare fish at further risk.

Special Significance

The population of banded killifish in Newfoundland and Labrador is isolated from mainland populations and research is ongoing to determine if it is a distinct subspecies.

You can help protect the banded killifish:

- Support habitat conservation for all our rare species.
- Be careful not to pollute ponds, rivers, and lakes.
- Learn something new about a species at risk in Newfoundland and Labrador and tell a friend!

Department of Environment & Conservation

Wildlife Division

Endangered Species & Biodiversity

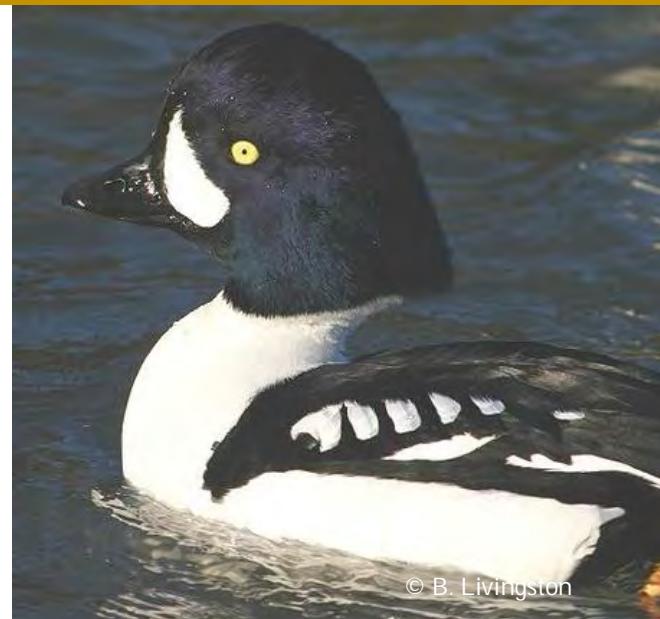
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Barrow's Goldeneye

(*Bucephala islandica*)

- The Barrow's Goldeneye is a medium-sized sea duck with a large rounded head and yellow eyes.
- Males have a black back and wings, a white belly and breasts, a purplish-black head, and a white crescent-shaped patch at the base of their bill.
- Females have a chocolate brown head, a greyish brown back, and a whitish belly and flanks.
- They form monogamous pairs and have strong fidelity to breeding and wintering areas.



Provincial Distribution



Habitat/ Range

While this rare duck is most common in Québec, Newfoundland and Labrador is also used by the Barrow's Goldeneye as a molting and wintering area. Groups of molting birds have been found as far north as Little Ramah Bay, Labrador, but have more commonly been reported from the north coast of Newfoundland.

Population Trends

The world distribution of Barrow's Goldeneye consists of three separate populations. There are approximately 4500 Barrow's Goldeneye in the eastern North America population.

Limiting Factors and Threats

Because the Barrow's Goldeneye population congregates in a relatively small geographic areas in important shipping corridors, it is a risk of being limited by oil spills and bioaccumulation of environmental contaminants. Barrow's Goldeneye are also incidentally killed each year by hunters.

Special Significance

These rare ducks dive for their food and are able to stay underwater for up to 70 seconds.

You can help protect Barrow's Goldeneye:

- Report any sightings to the Wildlife Division.
- Be careful not to pollute our oceans.
- Learn something new about a species at risk in Newfoundland and Labrador and tell a friend!

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Piping Plover

(*Charadrius melanotos melanotos*)

- A small, thrush-sized shorebird.
- Piping Plover are the colour of dry sand, with a distinctive black breast band, a black band above the forehead, and a partially black tail.
- They have a white rump, bright orange legs, and a short bill that is orange with a black tip.
- Piping Plover winter along the southern Atlantic coast of the United States and in the Caribbean.



© Emily Herdman

Provincial Distribution



Habitat/ Range

This rare shorebird nests on sandy beaches in all four Atlantic provinces and Québec. In this province it is only found on beaches on the southwest and west coasts of Newfoundland.

Population Trends

The 2006 census counted 48 adult Piping Plovers nesting in Newfoundland, an increase from 39 birds counted in 2001. Piping Plovers used to be found on the northeast coast but have not been seen there since 1987. In 2009, a pair of Piping Plovers nested in Gros Morne National Park for the first time since 1975.

Limiting Factors and Threats

Piping Plovers are affected by disturbances to beaches. Nests and eggs are destroyed by off-road vehicles, dogs, and sometimes deliberately by humans. Predators, such as mink, can also prey on nests and predation rates seem to have increased in recent years.

Special Significance

Piping Plover is one of the few shorebirds which nest on sandy beaches and in dune systems. They are endemic to North America.

You can help protect the Piping Plover:

- Stop habitat and nest destruction by keeping bikes, all-terrain vehicles, and trucks off beaches.
- Our dogs are curious, when on a beach keep your dog on a short leash so that they stay away from birds and nests.

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Wildlife Division

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Short-eared Owl

(*Asio flammeus*)

- The Short-eared Owl is a medium-sized, buffy white owl with short ear tufts and yellow eyes.
- In flight, they show a distinctive black patch near the 'wrist' on the underside of each wing.
- Although they can sometimes be seen during the day, they are most active at dusk and dawn.
- They prey on small mammals and while foraging they can fly slowly and hover above the ground.



© Bex Ross

Provincial Distribution



Habitat/ Range

Short-eared Owls in Newfoundland and Labrador have been reported in tundra, coastal barrens, sand dune, field, and bog habitats. These habitats are particularly abundant on the west coast and Great Northern Peninsula of Newfoundland, and on the coastal barrens and above the treeline in Labrador, although virtually all coastal areas and nearshore islands are suitable habitat.

Population Trends

Breeding Bird Surveys suggest that this species has undergone a long-term population decline across Canada, except for in the Atlantic provinces where the population seems stable.

Limiting Factors and Threats

Increased development and recreational use of coastal areas may have caused some habitat loss; however, it is more likely in this Province that Short-eared Owls are limited by prey abundance, predation of eggs and juveniles, competition for resources, and human disturbance of nests.

Special Significance

Short-eared Owls are only one of six owls native to Newfoundland and Labrador. Its diurnal habit and ability to hover make it unique among our owls.

You can help protect the Short-eared Owl:

- Report any sightings to the Wildlife Division.
- Participate in bird surveys and counts.
- Learn something new about a species at risk in Newfoundland and Labrador and tell a friend!

Department of Environment & Conservation

Wildlife Division

Endangered Species & Biodiversity

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APPENDIX D

Environmental Protection Procedures



D.1 - CLEARING OF VEGETATION

Environmental Concerns

Vegetation clearing (e.g., trees and shrubs) will be required during site preparation for work areas, storage and laydown areas, new access roads, etc. Environmental concerns include alteration or loss of habitat, sedimentation of waterbodies, and disturbance or destruction of historic resources.

Environmental Protection Procedures

Measures will be implemented to reduce the potential effects of vegetation removal. Clearing activities will be limited to those areas that are required for construction and will comply with the requirements of all applicable permits, including the Commercial Cutting Permit and the Operating Permit. Wherever practical, previously disturbed areas will be used for staging and stockpiling, and existing access roads used where possible.

- Where possible, vegetation clearing, and grubbing and stripping activities (Appendix D.2) will be avoided during the bird breeding season, which occurs from April 1 to September 1 in the region (Environment Canada 2014a). If some clearing, grubbing or stripping is necessary during the bird breeding season, CFI will assess if the work can be conducted without contravention of the *Migratory Birds Convention Act* and a contingency plan (e.g., nest surveys prior to clearing) will be developed in consultation with the CWS to maintain compliance with the Act.
- If a nest is identified on the site, a species-specific buffer will be established around the nest, and potentially disruptive activities within the buffer will be halted to protect nests until chicks have fledged (Environment Canada 2014b).
- If a nest is identified on the site, consult with CWS for further advice.
- Implement a 1 km buffer from breeding seabird colonies as recommended by Environment Canada for high-disturbance activities (Environment Canada 2013, 2014c).
- A cutting permit shall be obtained prior to the start of any site clearing. Clearing and tree removal shall be restricted to the minimum areas needed for the site and stockpiles. Under no circumstances will any merchantable timber be bulldozed.
- Clearing shall consist of cutting to within 15 centimetres (cm) of the ground and disposing of all standing trees; as well as the removal of all shrubs, debris and other perishable materials from the area. All residual slash shall be stockpiled in windrows for subsequent disposal.
- Limits of clearing will be shown on all drawings issued for construction. Only those areas designated on drawings shall be cleared. Trees shall be blazed at intervals in advance of clearing to demarcate the limits of the work. Blazed trees shall not be felled. Clearing activities shall not remove any trees outside the authorized clearing areas.
- All trees in the cutting area that are greater than 9 cm diameter-at-breast-height (dbh) must be felled and removed from the cutting area. All trees must be utilized to a top diameter of 8 cm.
- All merchantable or forest product timber within the specified clearing limits shall be located so as not to obstruct the access or work of others. All merchantable or forest product timber shall be salvaged. It shall be cut into standard harvesting lengths (i.e., 2.5 to 3.5 m lengths), trimmed, and stored adjacent to the road so that it is easily located during winter. The timber will be available for local residents to recover and use as firewood or saw logs.
- Slash and any other construction material or debris shall not be permitted to enter any watercourse or water body and shall be piled above spring flood levels.



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

- Chain saws or other hand-held equipment shall be used in clearing vegetation except where alternative methods or equipment are approved by the HSE Manager through consultation with the HSE technician. Mechanical clearing by heavy equipment shall not occur except where it can be demonstrated that there is no merchantable timber, and where the resulting terrain disturbance and erosion will not result in the loss of topsoil or the sedimentation of watercourses and water bodies.
- All chainsaw operators shall be equipped with an adequate fire extinguisher during the fire season, as well as shovels and axes.
- Mobile mechanical equipment will not be used for timber removal within 15 m of a stream or water body. Manual methods or a mechanical long lead choker system may be used in these instances. Activities will be monitored and if necessary this buffer may be increased where necessary.
- A buffer zone of undisturbed vegetation shall be maintained between construction areas and all water bodies, watercourses (Appendix D.7), and ecologically sensitive areas (e.g., wetlands). Buffer zones of features will be key elements of the environmental review of drawings prior to construction.
- Where possible, timber shall be felled inward toward the work area to avoid damaging any standing trees within the immediate work area.
- Burning of vegetation and debris will not be permitted.
- Workers shall not destroy or disturb any features that are indicative of a historical or archaeological site. Any such findings shall be reported to the HSE Manager and an appropriate buffer zone established (Appendix D.7) in consultation with NL Business, Tourism, Culture and Rural Development.

D.2 – GRUBBING, STRIPPING AND DISPOSAL OF RELATED DEBRIS

Environmental Concerns

The principal concerns associated with grubbing, stripping and disposal of related debris are the potential effects of erosion on marine and freshwater ecosystems, and water quality.

Environmental Protection Procedures

All grubbing, stripping and disposal of related debris near watercourses shall adhere to relevant regulatory requirements, including the permits and conditions of approval from NL DOEC and DFO.

Other specific measures to be undertaken to minimize potential effects on aquatic habitat and resources are as follows:

- Grubbing of the organic vegetation mat and / or the upper soil horizons shall be minimized. These shall be left in place where possible. Limits of stripping and / or grubbing must be shown on all drawings issued for construction.
- The organic vegetation mat and / or upper soil horizon material, which has been grubbed, shall be spread in a manner that attempts to cover exposed areas. Any surplus material shall be stored or stockpiled for site rehabilitation and revegetation purposes elsewhere in the Project area. Any material unsuitable for construction purposes will be placed in an approved stockpile.
- Organics / topsoil shall not be contaminated with underlying overburden, subsoil or other unsuitable material during grubbing and stripping. It shall be kept separate to be used for reclamation purposes.



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- Topsoil shall be stockpiled separately from the overburden and separated by a buffer zone (Appendix D.7) from any water bodies, watercourse or ecologically sensitive areas where possible. The location of the stockpiles shall be shown on drawings issued for construction and accessible for future rehabilitation purposes. Wherever practical, make use of previously disturbed areas for staging and stockpiling.
- A minimum of 5 m should separate stockpiles of grubbed material from standing timber.
- Grubbed material and / or topsoil should be stored in low piles to decrease the effect of compaction on soil structure. Stockpiles should be seeded or otherwise protected to prevent erosion and loss of nutrients. This is especially important if stockpiles are to remain in place for periods of a year or more.
- Discourage ground- and burrow-nesting species from nesting on denuded soil (e.g., by covering unattended soil piles).
- Silt fences, check dams, settling ponds, ditch blocks, interception ditches and filter fabrics shall be installed to minimize and control runoff of sediment laden water during grubbing, and the re-spreading and stockpiling of grubbed materials. Where grubbed materials are re-spread or stockpiled, as many stumps and roots as possible shall be left on the ground surface to maintain soil cohesion, to dissipate the energy of runoff, and promote natural revegetation. Erosion control measures shall be implemented in areas prone to soil loss; these measures can include brush cover, stone riprap, filter fabrics, wire mesh, settling ponds, drainage channels and gravel or wood chip mulches. Refer to Appendices B and E for specific guidance and Environmental Guidelines.
- The length of time that grubbed areas are left exposed to the natural elements shall be minimized to limit the potential for erosion. These areas will be monitored for erosion and such findings shall be reported to the HSE Manager.
- During grubbing, care shall be taken to ensure that grubbed material will not be pushed into areas that are to be left undisturbed.
- Grubbing shall be avoided on steep slopes near watercourses. A buffer zone shall be maintained between grubbed areas and watercourses, water bodies and ecologically sensitive areas (Appendix D.7). Grubbing limits adjacent to watercourses will be flagged in the field prior to undertaking grubbing / stripping activities.

D.3 – STORAGE, HANDLING AND TRANSFER OF FUEL AND OTHER HAZARDOUS MATERIALS

A variety of fuels and potentially hazardous materials will be used during Project construction activities. Gasoline, diesel fuel, grease, motor oil and hydraulic fluids are all needed for equipment. Other potentially hazardous materials, which may be routinely used, include:

- propane;
- explosives;
- acetylene;
- paints;
- epoxies;
- concrete additives;



- antifreeze;
- cleaners and solvents;

Environmental Concerns

The primary concern regarding the use of fuel and hazardous materials is their uncontrolled release to the environment through spillage, and the subsequent adverse effects on human health and safety, terrestrial, aquatic and marine habitat and species, soil and groundwater quality.

Environmental Protection Procedures

The following protection procedures will be implemented in accordance with the Waste Management Plan:

Transport of Fuel and Other Hazardous Materials

The *Transportation of Dangerous Goods Act* applies when dangerous goods are being transported to and from site. The transport of fuel and other hazardous materials to and from site will be undertaken in compliance with the Act. All goods entering the site will be inspected to ensure that the appropriate placards or labels and manifest are in place and the security of the product is assured. All persons handling dangerous goods must show proof of certification of training in the transportation of dangerous goods as required under the Act. Site security and the HSE Manager will be trained in the requirements of the Act.

Storage of Fuel and Other Hazardous Materials

Bulk storage of fuel products and other hazardous materials on land will be stored and handled in compliance with the Storage and Handling of Gasoline and Associated Products Regulations (2003), the Heating Oil Storage Tank System Regulations (2003), or other applicable regulations.

The following conditions shall apply to the storage of fuels and other hazardous materials:

- Before installing fuel storage tanks, the necessary approvals under the Storage and Handling of Gasoline and Associated Products Regulations shall be obtained from the NL Department of Government Services.
- Only trained, qualified persons will handle fuels and other hazardous materials. The Workplace Hazardous Materials Information System (WHMIS) will be implemented to ensure proper handling and storage is achieved.
- Oils, grease, gasoline, diesel or other fuels or any material deemed to be hazardous shall be stored at least 100 m from any surface water.
- Fuels shall be stored inside dykes or self-dyked units and will be clearly marked to ensure they are not damaged due to moving vehicles. The markers will be visible under all weather conditions.
- Any aboveground fuel tank shall be positioned over an impervious mat and shall be surrounded by an impervious dyke of sufficient height (minimum height 0.6 m) to contain:
 - Where a dyked area contains only one storage tank, the dyked area shall retain not less than 110% of the capacity of the tank.
 - Where a dyked area contains more than one storage tank, the dyked area shall retain not less than 110% of the capacity of the largest tank or 100% of the capacity of the largest tank plus 10% of the aggregate capacity of all the other tanks, whichever is greater. Otherwise approved self-dyked storage tanks shall be used where required.



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- Dyked areas are to be dewatered on an as needed basis. The water shall be decontaminated prior to release into the environment.
- Any dykes of earthwork construction shall have a flat top not less than 0.6 m wide, and be constructed and maintained to be liquid tight to a permeability of 25 L/m²/day. The distance between a storage tank shell and the centre line of a dyke shall be at least one half the tank height. Dykes shall be fenced.
- Fuel storage areas and non-portable transfer lines shall be clearly marked or barricaded to ensure that they are not damaged by moving vehicles. The markers will be visible under all weather conditions. Barriers will be constructed in compliance with the provincial Storage and Handling of Gasoline and Associated Product Regulations (2003).
- Waste oils, lubricants, and other used oil shall be reused, recycled or disposed of at an approved, licensed waste management facility or eliminated using controlled burning methods (i.e., incineration or burner) in accordance with the Policy Directive PPD05-01: Management of Impacted sites, Guidance Document for the Management of Impacted sites, and Guidance Document GD-PPD-045: Protocol for the Management of Soils Excavated on Impacted sites and the Air Pollution Control Regulations (2004). Controlled burning of used oil products shall not proceed without approval from the NL DOEC.
- Storage areas will be equipped with suitable firefighting equipment.
- All storage tank systems shall be inspected on a regular basis as per Sections 20 and 21 of the Storage and Handling of Gasoline and Associated Products Regulations (2003). This involves, but is not limited to, gauging or dipping and the keeping of reconciliation records for the duration of the program.
- Contracted fuel suppliers must comply with the *EPP for the Construction Phase* and before transporting or positioning fuel at the site, have on file at the CFI office a copy of the Emergency Response Plan (ERP).
- Smoking shall be prohibited within 10 m of a fuel storage area.
- Hot Work Permits shall be required before undertaking welding or torch cutting at a fuel storage area.
- Temporary fuelling or servicing of mobile equipment in areas other than the main fuel storage site shall not be allowed within 30 m of a watercourse. Gasoline or lubricant depots must be placed 100 m from the nearest water body.
- Within 30 days of known decommissioning of a storage tank system, empty the system of all products, remove the tank and associated piping from the ground, remove any contaminated soil, clean the area and reclaim the site.
- Any soil contaminated by small leaks of fuel, oil or grease from equipment shall be disposed of in accordance with the provincial *Environmental Protection Act* and Used Oil Control Regulation. The Used Oil Control Regulation will be used as a guideline to the NL DOEC requirements for such disposal.
- A fuel and other hazardous materials spill Contingency Plan, ERP, and appropriate emergency spill equipment shall be in place on site (see Section 7.0 of this *EPP for the Construction Phase*, in addition to contingency plans required by fuel suppliers).
- Bulk fuel storage facilities shall be dipped on a weekly basis to accurately gauge fuel consumption. These consumption rates shall allow for visually undetectable sources of contamination to be identified and corrected.
- Outdoor storage of gasoline or diesel in portable containers is acceptable only in designated areas for that purpose.



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Fuel Transfer

The following procedures shall apply to the transfer of fuel or hazardous material:

- In all cases, a qualified person shall attend transfer to storage tanks, for the duration of the operation. This person shall be trained in proper fuel handling procedures to minimize the risk of an unattended spill. The attendant shall be trained in the requirements of the Contingency Plan (Section 7.0), and WHMIS.
- Hoses or pipes used for fuel transfer shall be equipped with properly functioning and approved check valves, spaced to prevent backflow of fuel in the case of failures.
- Exposed pipelines shall be protected from vehicular collision damage by the installation of guardrails.
- Fuel transfers between ships shall be conducted in accordance with the *Canada Shipping Act, Oil Pollution Prevention Regulations*.
- Bulk fuel transfers between ships shall only take place during daylight hours.

Equipment Fuelling

The following procedures shall apply to the fuelling of heavy construction equipment:

- Fuelling and lubrication of equipment shall occur in such a manner as to minimize the possibility of contamination to soil or water.
- When refuelling equipment, operators shall:
 - Use leak free containers and reinforced rip and puncture proof hoses and nozzles.
 - Be in attendance for the duration of the procedure.
 - Seal all storage container outlets except the outlet currently in use.
- Regular inspections shall be performed on the hydraulic and fuel systems of machinery. Leaks shall be repaired immediately.
- Fuelling or servicing of mobile equipment on land shall occur in designated areas (i.e., low permeability) and not be allowed within 30 m of watercourses, water bodies or ecologically sensitive areas. Gasoline or lubricant depots must be placed 100 m from the water body.
- Fuelling attendants shall be trained in the requirements under the Spill Contingency Plan and ERP.

Hazardous Materials

The following procedures shall apply to the use of hazardous materials:

- Hazardous materials shall be used only by personnel who are trained and qualified in the handling of these materials and only in accordance with manufacturers' instructions and government regulations. WHMIS and the provisions of the *Transportation of Dangerous Goods Act* (Transport Canada) shall be implemented throughout the job site. All employees involved with hazardous materials shall be appropriately trained.
- All hazardous materials shall be removed and disposed of in an acceptable manner in accordance with government regulations and requirements.
- Material Safety Data Sheets (MSDS) must be available on-site prior to receipt of any hazardous materials.
- A hazardous waste storage area shall be constructed and properly marked.



Spills of Fuel and Hazardous Materials

The following procedures shall apply to spills of fuel and hazardous materials:

- All necessary precautions shall be implemented to prevent the spillage of fuels and other hazardous materials used during the construction phase.
- There shall be appropriate emergency spill response equipment on-site for all phases of the Project.
- A complete list of the emergency spill response equipment shall be available on-site and kept up to date.
- All emergency response equipment should be kept in good working condition suitable for required use. To ensure working condition of equipment, periodic practice deployments will be conducted under the supervision of the HSE Manager.
- Regular inspections of all spill response supplies and equipment will be conducted and documented to ensure adequate supply and condition.
- The use of chemical dispersants to treat oil slicks shall take place only under the authorization of Environment Canada, Environmental Protection Branch (Newfoundland and Labrador Region).
- All spills of fuel and hazardous materials shall be reported immediately to the HSE Manager, HSE technician and the contractor. Any spill to the marine or freshwater environments and spills of 70 L or more on land shall be reported immediately to the Canadian Coast Guard at 1-800-563-9089 as outlined in CFI's ERP.
- Every effort shall be made to immediately control the source of the leak or spill and clean-up the contaminated area as long as it is safe to do so.
- All material and equipment used during spill clean-up must be stored properly until it can either be disposed of or cleaned to avoid further contamination. Disposal of clean-up materials must be in accordance with this *EPP for the Construction Phase*, the Waste Management Plan and all government regulations and requirements.

D.4 – SEWAGE DISPOSAL

Environmental Concerns

The incidental release of untreated sewage is a concern to human health, drinking water quality, and freshwater and marine ecosystems.

Environmental Protection Procedures

Sewage generated during site preparation and construction will be collected and routinely transported off-site for treatment and disposal. Portable washrooms and toilets will be used onsite until permanent facilities are completed. Where possible, permanent sewage systems will be installed and maintained to prevent the release of hazardous substances, pathogens and excess nutrients to the environment. All sewage and other wastewaters will be adequately treated prior to release to the environment, in accordance with the Waste Management Plan.

D.5 – SOLID WASTE DISPOSAL

Environmental Concerns

Solid waste (e.g., domestic waste, paper, cardboard, and wood), if not properly controlled and disposed of, will be unsightly, may cause human safety and health concerns, and could adversely affect wildlife. Refer to the Waste Management Plan.



Environmental Protection Procedures

- A Waste Management Plan will be in place to address waste generation, handling and disposal during construction. Any procedures or strategies for management of solid waste will be in accordance with the provincial Waste Management Strategy (Government of NL 2002).
- During the construction phase, a temporary Waste Management Station will be operated under the direct supervision of the Site Services Contractor and managed by the HSE Manager. Access to the temporary Waste Management Station will be controlled at all times via a gated, chain link fence. Solid waste will be removed from site and disposed at an existing landfill by a certified waste management company.
- All contractors will be required to submit detailed waste management plans which adhere to the Waste Management Plan.
- The minimum qualifications of the temporary Waste Management Station Operator include:
 - WHMIS certification;
 - TDG certification; and,
 - Working knowledge of applicable provincial and federal waste management legislation (e.g., Newfoundland and Labrador *Environmental Protection Act*, Used Oil Control Regulations, Air Pollution Control Regulations, Storage and Handling of Gasoline and Associated Products Regulations).
- Waste accumulated on-site prior to disposal shall be confined so that it does not pose an environmental or health hazard or cause conflict with wildlife. Storage of waste shall be in proven bear proof containers; this can be done in consultation with the Wildlife Division of the NL DOEC.
- Workers will be instructed to maintain good housekeeping practices and not leave any food or garbage at the Project site to avoid attracting wildlife, including omnivorous predators which may disturb or cause direct mortality or injury to other wildlife (including birds).
- All non-recyclable, non-hazardous solid domestic wastes will be transported for off-site disposal at an approved waste disposal site.
- To reduce the amount of waste being generated and land filled, all site personnel will abide by the Reduce, Reuse, Recycle Program outlined in the Waste Management Plan.
- Waste that is not approved for landfill shall be transported off-site to an approved disposal location.
- No waste material will be deposited in a body of water.

D.6 – QUARRYING AND AGGREGATE REMOVAL

Environmental Concerns

The principal concerns for quarry development and associated aggregate removal include the potential for sedimentation of marine and freshwater systems, alteration or loss of terrestrial habitat and historic resources, Acid Rock Drainage (ARD) potential and the possible requirement for quarry development / reclamation plans.

Environmental Protection Procedures

The following measures shall be implemented to minimize these effects:

- Permits to quarry shall be obtained from the NL DNR before quarries are established. Quarry activity will be undertaken in compliance with these quarry permits and shall comply with all other relevant regulations.



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- The development of quarry sites and rock excavations will require frequent ARD monitoring to determine the absence or presence of sulphide bearing rock. For environmental protection against ARD, the HSE technician will visually inspect bedrock before, during, and after excavation work on a periodic basis.
- Quarry areas shall be developed in a controlled manner to minimize potential environmental effects. The following protection procedures shall be implemented to minimize disturbance and facilitate rehabilitation:
 - A buffer zone of undisturbed vegetation shall be maintained between quarries and watercourses, water bodies and ecologically sensitive areas (Appendix D.7).
 - The quarry area, stockpile area and limits of clearing shall be staked and / or flagged to prevent over extension of the development, thereby limiting the extent of the operation (corner posts at least 1 m high will be installed to mark the quarry area).
 - The area to be excavated shall be clear cut of all vegetation prior to grubbing, excavation or removal of any material (Appendices E.1 and E.2). Only the area necessary for one year's production will be cleared.
 - All stumps, organic matter and topsoil shall be stripped from the area to be excavated and stockpiled at least 5 m from uncleared areas; stripping stockpiles shall be kept at least 10 m from the area of excavation; separate overburden piles shall be developed where this material is present; topsoil and the underlying overburden shall not be mixed.
 - Stockpile areas are to be approved by the HSE Manager, in consultation with the HSE technician, prior to stripping, and previously disturbed areas used where possible.
 - Working faces must not exceed 10 m for a rock quarry or 5 m for unconsolidated materials. The faces should also be worked so that their height doesn't exceed that which can be safely reached with the equipment being used. Available material left over from quarrying and stockpiled overburden shall be used to minimize slopes and face heights.
 - Each quarry will be evaluated on a site-specific basis to determine if, based on topography and presence / absence of Potentially Acid Generating (PAG) material, whether the cliff faces will be converted to rubbished slope.
 - Following sloping, the topsoil and any organic materials shall be spread over the disturbed area to promote natural revegetation by adjacent seed sources.
- To prevent sedimentation of water bodies, watercourses and ecologically sensitive areas, settling ponds shall be established, if required, and cleaned on a regular basis, as required, to ensure that the retention capacity is maintained at all times. Refer to Appendices B and E for specific guidance and Environmental Guidelines.
- The Total Suspended Solids (TSS) content of construction altered water that is released into a natural water body shall not exceed 30 milligrams per litre (ppm) more than the TSS level of the receiving water body.
- Dust from aggregate processing, storage and handling shall be controlled with water or water-based dust suppressants, as required, during times when temperatures are above freezing.
- If crushing activities in the quarry require a water source, approval from the NL DOEC, WRMD, shall be obtained prior to any water use.

Rehabilitation

- Minimize the need for borrow pits, by using granular material from the waste rock to the extent practical.
- Any organic material or overburden removed during development of the borrow pits and quarries shall be stockpiled near the pit or quarry area for future use during reclamation of the borrow pit or quarry. Overburden or non-PAG rock that is not suitable for reclamation purposes shall be stockpiled in stable configurations,



contoured to match the surrounding landscape, for permanent disposal or temporarily stockpiled and returned to the borrow pit or quarry opening once extraction from the pit or quarry is complete.

- As site conditions dictate, vegetation or other cover materials may be established on slopes to control erosion and dust. Quarries and pits reclaimed during operations may be used as test plots to evaluate suitable revegetation techniques to be used for the reclamation of other work areas in the future.
- The NL DNR will be contacted not less than three days prior to abandonment of a site to arrange for an inspection.
- All equipment and material will be removed from the site.
- All pit and quarry slopes will be re-contoured to a slope angle less than or equal to 30°, or to a slope conforming to that existing prior to quarrying.
- Waste overburden may be used for sloping but topsoil or organic material may not be used for sloping. Following sloping, topsoil or organic material may be spread over the entire quarry area.
- Further conditions regarding sloping and revegetation requirements will be determined through the Rehabilitation and Closure Plan if required, or as a condition of the quarry permit itself. Each quarry will be evaluated on a site specific basis to determine if, based on topography and presence / absence of PAG material, cliff faces should be converted to rubbished slopes.

D.7 – BUFFER ZONES

Environmental Concerns

The potential for erosion / sedimentation and resulting effects on water quality, fish and fish habitat is a key environmental concern associated with construction activities. In addition, sensitive and listed environmental receptors require protection from activities associated with construction.

Buffer zones of natural vegetation or undisturbed areas that separate these environmental receptors from construction activities are needed to mitigate environmental effects. These undisturbed areas may also provide wildlife habitat or travel corridors near work areas and Project features.

Due to the many buffer zones referenced in various government documents and others that may be stated in regulatory permits yet to be obtained, the appropriate buffer zone to use in a specific area may be a source of confusion. Therefore, the HSE Manager, and his / her designate, shall be the only site-based personnel to determine which buffer is applicable, and contractors shall be required to consult with these individuals prior to establishing buffers. For general guidance, however, the following procedures shall define the minimum requirements during construction.

Environmental Protection Procedures

- A minimum buffer zone of natural vegetation of 30 m from the high water mark of water bodies and watercourses shall be maintained around work areas where available space poses a constraint. For ecologically sensitive areas (e.g., migratory bird nests) a minimum buffer zone of natural vegetation of 50 m will be maintained around work areas where available space poses a constraint. If the available space allows, then wider buffer zones of 100 m shall be maintained between construction areas and watercourses, water bodies and ecologically sensitive areas.
- A buffer of at least 25 m will be maintained between all natural water bodies and waste rock, overburden, and topsoil piles to minimize the risk of sedimentation.



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- DFO recommends buffer zones to separate resource roads running adjacent to water bodies be calculated by the following formula:
 - buffer width (m) = $20\text{ m} + 1.5 \times \text{slope (\%)}$; however, a minimum buffer zone of 30 m and where possible a 100 m buffer zone shall be maintained at all times, except where specified otherwise, e.g., ecologically sensitive areas.
- Sediment runoff control fences shall be constructed at the toe of all slopes outside the buffer zones, as required by the HSE Manager or his / her designate.

This is required to control runoff from areas of exposed soils and prevent transport of sediments towards water bodies. Silt fences and buffer strips shall be inspected on a regular basis. Any accumulations of sediment observed shall be removed and disposed of in an area where it will not re-enter any water body. Also, repairs and replacement of damaged silt fences shall be addressed immediately.

- CFI will comply with DFO guidance which stipulates that, for large blasts, in the order of 100 kg per hole, a setback of 150 m is required from water bodies (Wright and Hopky 1998).
- Implement 1 km buffer from breeding seabird colonies recommended by Environment Canada for high-disturbance activities (Environment Canada 2013, 2014c).
- If a nest is identified on the site, establish a species-specific buffer around the nest, halt potentially disruptive activities within the buffer area and protect nests until chicks have fledged (Environment Canada 2014b).
- A minimum buffer zone of 20 m shall be maintained around any archaeological site within which no construction activities will take place. Where available space poses constraints, this width may be reduced and supplemented by other protective measures. Site specific mitigation measures for known historic resources in the Project area will be addressed within the ERP.



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Recommended Buffer Strips for Various Activities

Activity	Environmental Receptor	Recommended Width (m) of Buffer Strip	Reference
Clearing, Grubbing and Stripping	Water body	30 m	NL DOEC. 1999. Policy for Land and Water Related Developments in Protected Public Water Supply Areas. Land and Water Developments. Prepared by Haseen Khan. Issue Date: April 7, 1995. Re-Issue Date: March 10, 1999. NL DOEC and NL DNR (Newfoundland and Labrador Department of Natural Resources). Undated. Environmental Guidelines for Construction and Mineral Exploration Companies Available at: http://www.nr.gov.nl.ca/mines&en/mqrights/environment.pdf Accessed: September 2015.
Stockpiles (waste rock, overburden, and topsoil piles)	Water body	25 m	CFI 2015.
Roads	Water body	20 m +1.5 x slope (%)	Gosse, M.M., A.S. Power, D.E. Hyslop, and S.L. Pierce. 1998. Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans, St. John's, NF. x + 105 pp., 2 appendices.
Fuelling / Vehicle Servicing	Water body	100 m	NL DOEC and NL DNR (Newfoundland and Labrador Department of Natural Resources). Undated. Environmental Guidelines for Construction and Mineral Exploration Companies Available at: http://www.nr.gov.nl.ca/mines&en/mqrights/environment.pdf . Accessed: September 2015.
Fuel Storage	Water body	100 m	Gosse, M.M., A.S. Power, D.E. Hyslop, and S.L. Pierce. 1998. Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans, St. John's, NF. x + 105 pp., 2 appendices.
Quarries / Borrow Pits	Water body	100 m	Gosse, M.M., A.S. Power, D.E. Hyslop, and S.L. Pierce. 1998. Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador. Fisheries and Oceans, St. John's, NF. x + 105 pp., 2 appendices.
Blasting (large blasts in the order of 100 kg per hole)	Water body	150 m	Wright and Hopky 1998.



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High disturbance activities	Breeding seabird colonies	1 km	Environment Canada 2014c.
Potentially disruptive activities	Nest	Species-specific	Environment Canada 2014b.
Construction	Historic Resource	20 m (buffer implementation will minimize potential to disturb historic resource before the area is assessed as per the regulations)	<p>Work should cease immediately upon discovery of historic resources in accordance with:</p> <p>Government of NL. 1990. Historic Resources Act. RSNL1990 CHAPTER H-4. Amended: RSN1990 cR-8 s44; 1993 cD-19.1 s21; 2001 c31; 2001 cN-3.1 s2; 2004 cL-3.1 s39; 2005 cR-15.1 s38; 2007 c17; 2008 c59 s18. Available at: http://www.assembly.nl.ca/legislation/sr/statutes/h04.htm#13_. Accessed: August 2015.</p> <p>In the case of an incidental discovery of Historic Resources, a Stage 1 Historic Resources Overview Assessment (HROA) to assess the potential sensitivity of the study area is required in accordance with:</p> <p>NL Business, Tourism, Culture and Rural Development. 2015. HRIA Summary Stage 1. Available at: http://www.btcrd.gov.nl.ca/pao/hria_summary/hria_summary_stage1.html. Accessed: August 2015.</p>



D.8 – EROSION PREVENTION

Environmental Concerns

The potential for erosion and resulting effects on water quality and fish and fish habitat is a key environmental concern associated with construction activities.

Environmental Protection Procedures

Erosion prevention shall be a main objective in all work areas where soil may be transported by water, wind, or ice. The application of erosion control measures is found throughout Appendix D but reiterated here to provide a more thorough evaluation of site specific activities required by Project personnel.

General

The primary way to control erosion is to avoid activities that contribute to it. All areas of exposed soil are to be stabilized by back blading or grading to meet engineered slope requirements. Where erosion along an exposed slope is of concern, and a sufficient natural vegetation buffer (Appendix D.7) does not exist between the high water mark of the nearby water body and the exposed soil, a silt fence shall be constructed to control sediment runoff. Engineering requirements will vary depending on the locations of the silt fence and will take such factors into consideration as drainage / surface area of exposed soils and time of year the silt fence is employed.

Specific erosion and sedimentation control measures may be designed for the site to minimize the effects of construction activities on the environment. They may include; site drainage and ditching systems in accordance with the Site Grading and Drainage Plan and the Water Management Plan, including culverts and risers, installation of piped outlet sedimentation control ponds, temporary run-off interceptor ditches, and check sediment dam traps which will provide both energy dissipation and sedimentation control. However, regardless of these protection measures, if an environmental inspection reveals that sediment is entering a watercourse, additional mitigation measures shall be implemented.

Contractors will use erosion and sedimentation control measures to ensure water control on-site. Any water discharged into a water body, watercourse or ecologically sensitive area due to construction activities, shall comply with applicable discharge guidelines as presented in the Newfoundland and Labrador Environmental Control Water and Sewer Regulations under the *Environmental Protection Act* for applicable analysis parameters which include, but may not be limited to, pH and TSS. The analyses and frequency of monitoring may be altered to satisfy regulatory requirements.

Exposed surfaces that are at risk of erosion will be protected by using appropriate slopes and by diverting surface runoff away from disturbed areas. After precipitation events, slopes will be inspected and corrective measures will be implemented to prevent soil erosion. Slopes for finished-grade surfaces will be built in accordance with best engineering practices and will be surface-finished / stabilized to provide long-term stability. Final grading will be undertaken immediately after completion of an activity rather than at the end of construction. Revegetation will also be considered for areas adjacent to existing roads where erodible soil has been exposed.

RipRap is used to stabilize slopes prior to the natural stabilization post-construction. General design criteria will be implemented by contractors:

- Should not be used where the bank exceeds 3 m high and the grade is greater than 2:1.
- The rock used should be clean and large enough to withstand being displaced by peak flood events.
- Rock material should consist of a mixed gradation and be blocky and angular.



Streams

All stream banks that contain loose or erodible materials shall be stabilized. No material shall be deposited within the watercourse. Sloping shall be accomplished by back blading and the material removed is to be deposited above the high water mark of any watercourse. A field survey shall be conducted at all stream crossings prior to construction to determine sensitivity. A buffer of at least 25 m will be maintained between all natural water bodies and waste rock, overburden, and topsoil piles to minimize the risk sedimentation (Appendix D.7).

D.9 – EXCAVATIONS, EMBANKMENT AND GRADING

Excavation, embankment and grading of common rock and other materials may be required at various locations within the Project site.

Environmental Concerns

The principal environmental concerns associated with excavation, embankment and grading are potential effects on water quality, fish and fish habitat, terrestrial habitat and historic resources due to ground disturbance.

Environmental Protection Procedures

All work shall be conducted in a manner that controls potential sedimentation of watercourses and water bodies in or adjacent to the work areas as outlined in the following procedures.

Excavation, embankment and grading shall be done only when grubbing and stripping is completed. Where engineering requirements do not require grubbing and stripping (e.g., within the buffer zone of a stream crossing), filling shall occur without any disturbance of the vegetation mat and / or the upper soil horizons. Avoid leaving excavations open for long periods and compaction / covering loose materials. Compact soils as soon as excavations, filling or levelling activities are complete.

Excavation, embankment and grading in the vicinity of stream crossings shall be done in a manner that minimizes erosion and sedimentation of watercourses and water bodies.

A buffer zone of undisturbed vegetation shall be maintained between construction areas and all watercourses, water bodies and ecologically sensitive areas (Appendix D.7).

D.10 – STREAM CROSSINGS

Environmental Concerns

The environmental concerns associated with stream crossings, culvert installations, bridge construction, and maintenance include direct disturbance to, or mortality of fish, disturbance to birds, loss of fish habitat caused by sedimentation and removal of substrate, and stream bank vegetation.

Environmental Protection Procedures

Erosion stabilization methods and effective sedimentation control practices shall be implemented when required, and these shall conform to requirements, guidelines, and principles contained in Appendix B (Guidance), NL DOEC Environmental Guidelines (Appendix E), and the Measures to Avoid Causing Harm to Fish and Fish Habitat (DFO 2013). CFI will also comply with specific requirements of regulatory permits and approvals, including NL DOEC approvals for Alteration of a Body of Water pursuant the provincial *Water Resources Act*, as well as guidance materials provided by NL DOEC with respect to the design, construction, and maintenance of the crossing structures to avoid or minimize the potential adverse effects on water quality and fish habitat. Culvert installation shall comply with permits issued by NL DOEC and DFO.

The following measures shall be implemented to minimize adverse effects of stream crossings:



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- Stream crossing construction activities, in areas of fish habitat, will be undertaken under the direct guidance of the HSE Manager and / or HSE technician.
- Work shall be performed in such a way as to ensure that materials such as sediment, fuel and oil do not enter watercourses and waterbodies.
- The banks and flood plains of watercourses must be adequately protected from erosion by seeding, sodding or placing of riprap.
- A suitable buffer (Appendix D.7) of undisturbed natural vegetation shall be left between the access road and the bank of any adjacent watercourse, unless otherwise specified. The buffer width shall be determined through the formula:
 - Buffer width (m) = 20 m + 1.5 x slope (%).
- In those locations where culverts are required, permit applications shall be made to NL DOEC and DFO. The culverts used shall be sized to handle the 1-in-25 year return period flood and will be constructed in accordance with the Environmental Guidelines for Culverts from the NL DOEC (WRMD 1992b). The following measures shall also be implemented:
 - Install culvert(s) in accordance with good engineering and environmental practice.
 - Unless otherwise indicated, all work shall take place in dry conditions, either by the use of cofferdams or by diverting the stream with pumps and hoses. All work involving major alterations to stream channels must be carried out at a time of low flow, in a manner that prevents downstream sedimentation.
 - Cylindrical culverts shall be counter sunk only where necessary to protect fish habitat such that the culvert bottom is one-third the diameter below the streambed in the case of culverts less than 750 mm outside diameter; for culverts greater than 750 mm outside diameter, the culvert bottom shall be installed a minimum of 300 mm below the streambed.
 - In multiple (gang) culvert installations, install one culvert at an elevation lower than the others.
 - Ensure that the natural low flow regime of the watercourse is not altered; culverts must not disrupt flow of water or cause ponding at the upstream side of the installation.
 - A culvert shall not be installed before site specific information such as localized stream gradient, fish habitat type and species present have been evaluated.
 - Inlet and outlet areas will be adequately protected from erosion by placing riprap, filter stone, or concrete headwalls.
 - Use culverts of sufficient length to extend a short distance beyond the toe of the fill material.
 - Use backfill material which is of texture that shall support the culvert and limit seepage and subsequent washing out.
 - Align culverts such that the original direction of stream flow is not substantially altered and the gradient at the culvert follows the stream channel gradient to the extent possible. Infilling or reduction of the natural cross sectional area of the watercourse is not permitted.
 - Remove fill and construction debris from the culvert area to a location above the peak flow level to prevent its entry into the stream.



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- Confine construction activity to the immediate area of the culvert.
- Fill material shall not be removed from streambeds or banks except when removal of material is necessary to ensure a flat foundation for installing a culvert.
- The use of heavy equipment in streams or bodies of water is not permitted (see NL DOEC - Environmental Guidelines for Watercourse Crossings; Environmental Guidelines for Bridges; Environmental Guidelines for Culverts; Environmental Guidelines for Fording (Appendix E), Fisheries and Oceans Canada - Guidelines for Protection of Freshwater Fish Habitat in Newfoundland and Labrador [Gosse et al. 1998], and other documents in Appendix B (Guidance)).
- As required, cofferdams of non-erodible material shall be installed above and below work areas to separate them from the watercourse when excavating for culverts and footings. All sandbags used in construction must be accounted for and removed after work is completed. Where pumping is used to bypass flow, pumps must have sufficient capacity to prevent washout of the cofferdams (refer to Appendices B and for specific guidance and Environmental Guidelines).
- Cofferdams shall be removed upon completion of construction and the streambed returned as closely as possible to its original condition.
- Water pumped from work areas or other runoff must have sediment and turbidity removed by settling ponds, filtration, or other suitable means before discharging to a water body.
- The release of sediment laden water into a water body, watercourse or ecologically sensitive areas, due to construction activities, shall comply with applicable discharge guidelines as presented in the NL Environmental Control Water and Sewer Regulations under the *Environmental Protection Act* for applicable analysis parameters which include, but may not be limited to, pH and TSS. The analyses and frequency of monitoring may be altered to satisfy regulatory requirements.
- When fording any watercourse, the Environmental Guidelines for Fording from the NL DOEC, WRMD and the guidelines outlined in the Appendix B (Guidance) shall be followed in conjunction with the following:
 - Areas of spawning habitat shall be avoided.
 - Where feasible crossings shall be restricted to a single location and made at right angles to the watercourse.
 - Equipment activity within the watercourse shall be minimized by limiting the number of crossings.
 - All equipment shall be clean and mechanically sound to avoid the introduction of oil, gasoline, and hydraulic fluids to water bodies.
 - No servicing or washing of heavy equipment shall occur adjacent to a watercourse, water body, or ecologically sensitive area unless it is at a location approved by the HSE technician.
 - Temporary fuelling services or washing of equipment in areas other than the main fuel storage site shall not be allowed within 30 m of a watercourse, water body, or ecologically sensitive area except, within a refuelling site approved by the HSE technician, where conditions allow for containment of accidentally spilled fuels. All waste oil, filters, containers or other such debris shall be removed from the work area and disposed of in an approved waste disposal site.
 - Where the ford area is not natural bedrock or is easily disturbed by fording, the entire ford area shall be stabilized using vegetation mats, corduroy roads or coarse material (125 mm diameter or greater) when such material is available from a reasonably close location within the right-of-way; when the substrate of the ford area is not subject to easy disturbance by fording or coarse material is not easily available within



the right-of-way, fording under existing substrate conditions may occur under the guidance of the HSE Manager and the HSE technician.

- Fording activities shall not decrease the depth of the watercourses to less than 20 cm. Where the existing depth is less than 20 cm, that depth shall be maintained.
- Water bodies shall not be forded during high flow periods.
- All bank sections which contain loose or erodible materials shall be stabilized or avoided if possible; if banks must be sloped for stabilization, no material shall be deposited within the watercourse; sloping shall be accomplished by back blading and the material removed shall be deposited above the high water mark of the watercourse.
- Environmental protection measures outlined above which are applicable to bridge construction and maintenance will be adhered to.
- During bridge construction all applicable guidelines are outlined in the Appendix B (Guidance).
- To safely convey peak flows, bridges will be designed for a 100 year return period stream flow.
- Bridge abutments will be set back above the high water mark, in accordance with the engineering design. However, each installation will take into consideration site specific conditions and additional set back may be required.
- The upstream and downstream sides of abutments will be protected with riprap, concrete or heavy timber to prevent erosion and scouring.
- Roadside embankments near the watercourse will be adequately protected from erosion by sodding, seeding or placing of riprap.
- Adequate erosion protection will be provided where roadside ditches discharge into the watercourse near the bridge.
- Abutments and piers will be constructed in the dry and during times of low flow.
- During construction of concrete components, formwork will be constructed to prevent any fresh concrete from entering bodies of water. Dumping of concrete or washing of tools and equipment in any body of water is prohibited.
- Wood preservatives such as pentachlorophenol (PCP) or ammoniacal copper arsenate (ACA) or creosote or treated wood products will not be used for bridgework.
- Periodic maintenance such as painting, resurfacing, clearing of debris, or minor repairs, will be carried out without causing any physical disruption of the watercourse. Care will be taken to prevent spillage of pollutants into the water.
- All waste materials will be disposed of in accordance with the Waste Management Plan.
- All areas affected will be returned to a state that resembles local natural conditions.

D.11 – DUST CONTROL

Environmental Concerns

The environmental concerns associated with dust include effects on human health and aquatic ecosystems, wildlife and vegetation.



Environmental Protection Procedures

The following measures shall be taken to mitigate potential effects of dust:

- Dust from construction activities and on unpaved roads shall be controlled where possible by using frequent applications of water or water-based dust suppressants. Waste oil shall not be used for dust control but other agents such as wood chips, matting and revegetation will be considered on a site-specific or as needed basis (i.e., high winds).
- Dust control agents (wood chips, matting, etc.) shall be stored at suitable distances from all watercourse, water body, or ecologically sensitive areas using proper buffer zones (see Section D.7).
- Perform regular and adequate maintenance of the unpaved roads.
- Reduce drop heights during material transfers.
- Size trucks appropriately to reduce the number of vehicle trips.
- Properly design haul and access roads, to minimize distance travelled.
- Consider the use of fogging systems and wind barriers to reduce wind erosion.
- Implement a speed limit on the access and haul roads.
- Implement a no-idling policy to reduce combustion emissions.
- Promote the use of block heaters during winter months as part of the no-idling policy.
- Implement an awareness program to promote fuel consumption reduction.

D.12 – TRENCHING

Environmental Concerns

Where excavation for the construction of water lines or any other infrastructure is undertaken (e.g., TMF pipelines), potential runoff of sediment laden water could result in effects on terrestrial habitat, marine or freshwater fish and fish habitat, water quality and historic resources.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of trenching:

- Topsoil and excavated overburden and bedrock shall be stored in separate stockpiles for later use during rehabilitation.
- Any unsuitable material shall be disposed of in a disposal area approved by the HSE Manager in consultation with the HSE technician.
- Dewatering of trenches shall make use of measures to minimize and control the release of sediment laden water through the use of filtration, erosion control devices, settling ponds, straw bales, geotextiles or other devices.

D.13 – DEWATERING – WORK AREAS

Environmental Concerns

The main concerns associated with dewatering are sedimentation, direct fish mortality, and / or habitat alteration or loss for freshwater and marine fish species.



Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of dewatering:

- Filtration or other suitable measures, such as settling ponds, silt fences and dykes, shall be implemented for sediment removal and turbidity reduction in water pumped from work areas before discharging (Appendix D.8).
- Where possible, clean water shall be discharged to vegetated areas to further reduce any potential adverse effects on watercourses. Additionally, mechanisms for energy dissipation shall be implemented to prevent scouring and erosion of the discharge location (e.g., impervious geotextile mats, perforated end of pipe, discharge to small settling sump).
- The size of sedimentation ponds shall be designed to accommodate the anticipated volume of collected water and meet discharge criteria for water quality.
- Discharged water shall be encouraged to follow natural surface drainage patterns in accordance with the Water Management Plan and Site Drainage and Grading Plan.
- Serious harm to commercial, recreational and aboriginal (CRA) fisheries shall not be permitted unless formal approval has been obtained from DFO.
- Water pumped from excavations or work areas, or any runoff or effluent directed out of the Project site shall have sediment removed by settling ponds, filtration or other suitable treatment before discharging to the environment.

In addition, any effluent directed out of the Project site shall be tested for TSS and hydrocarbons (if there are any indications of hydrocarbon contamination, such as a sheen or odour) before being discharged to the environment. Effluent discharge shall comply with the effluent discharge criteria set by NL DOEC through the issuance of a Certificate of Authorization prior to start of construction and effluent quality limits established in Schedule A of the Environmental Control Water and Sewage Regulations, 2003.

- Contingency measures shall be implemented to deal with storm events and high runoff to minimize adverse environmental effects resulting from these events. Erosion prevention and sediment containment materials such as silt fence material, riprap, straw bales, filter fabric and designated equipment shall be available to address contingency / emergency situations.
- In the unlikely event that runoff exceeds acceptable ranges for TSS as determined through monitoring, contingency measures may include pumping of sediment laden water to vegetated areas (away from down gradient water systems) or through filter bags for additional filtration and / or the implementation of additional settling ponds or erosion and sedimentation control structures. Remedial action will be taken as quickly as practical, and as necessary. In the event of a failure, Project construction will be shut down until appropriate controls are restored.

All contractors on-site shall follow the above environmental protection procedures to ensure water control at site in accordance with the Water Management Plan developed for the Project. Any water discharged into a water body, watercourse or ecologically sensitive area, due to construction activities, shall comply with applicable discharge guidelines as presented in the NL Environmental Control Water and Sewer Regulations under the *Environmental Protection Act* for applicable analysis parameters. These parameters include, but may not be limited to, pH and TSS, as well as the monitoring/treatment program (Environmental Effects Monitoring Plan) that will



comprehensively address all regulatory requirements to ensure that permitted limits are not exceeded. The analyses and frequency of monitoring may be altered to satisfy regulatory requirements.

D.14 – PUMPS AND GENERATORS

Environmental Concerns

A variety of water pumps, hoses and generators will be in frequent use in many areas of the construction site. Environmental concerns are associated with any incidental spills or chronic leaks contaminating soil or water bodies. There may also be concerns with air emissions from generators on the site.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of pumps and generators:

- Oils, grease, gasoline, diesel, or other fuels shall be stored at least 100 m from any surface water.
- Drip pans shall be placed underneath pumps and generators. Absorbent material will be kept at all sites where pumps and generators are in use.
- Hoses and connections on equipment located near water bodies shall be inspected routinely for leaks and drips.
- All leaks shall be reported immediately to the HSE Manager, who will then inform the HSE technician. Upon detection of a leak, the equipment (e.g., pump, generator) should be shut down immediately and corrective action taken to repair the leak and clean-up any contaminated soil and / or water in accordance with Contingency Plans and the ERP.

D.15 – NOISE CONTROL

Environmental Concerns

A variety of noises associated with construction and operation activity can adversely affect wildlife distribution and abundance. Noises associated with blasting are temporary in nature and noises associated with drilling are considered medium-term, but localized.

Environmental Protection Procedures

Measures shall be implemented wherever possible to minimize potential adverse effects arising from a variety of noise sources, including:

- Adherence to all applicable permits and approvals through a noise monitoring program. In the event that applicable noise levels would be exceeded, implement additional engineering mitigation and control measures (e.g., perform the activities during favorable wind conditions, install an acoustic berm, barriers, or equipment enclosures) to reduce noise to an acceptable level.
- Consider evaluating the use of newer technologies associated with back-up alarms to reduce to amount of noise from equipment operation.
- All equipment shall have exhaust systems regularly inspected and mufflers will be operating properly.
- Reduce travel speeds around potentially sensitive habitats and reschedule high disturbance activities during ecologically sensitive time periods where applicable.
- Reduce vehicle traffic during night-time.
- Low-level flying of aircraft should be avoided in areas where wildlife, particularly caribou, are present.
- No blasting is to be carried out in the marine environment.



- Implement a complaints management mechanism to record, address and resolve complaints related to Project activities and phases.

D.16 – BLASTING

Environmental Concerns

The general environmental concerns associated with on-land blasting include:

- destruction of vegetation outside excavation limits;
- noise disturbances to wildlife;
- disturbance of archaeological resources; and,
- dust generation.

Blasting in or near water bodies can affect organisms with swim bladders (fish) but may also affect a variety of aquatic animals including shellfish, marine mammals, otters, seabirds and waterfowl. The introduction of sediment into the water column is also a concern for marine / freshwater water quality and related effects on aquatic life.

Environmental Protection Procedures

The handling, transportation, storage and use of explosives and all other hazardous materials shall be conducted in compliance with all applicable laws, regulations, orders of the NL DOEC and the NL Department of Government Services, the *Explosives Act*, the TDG Act, CFI OH&S standards, and in compliance with the construction permits. Blasting will be undertaken by licensed contractors.

The following measures shall be implemented to minimize the potential adverse effects of blasting:

- Explosives shall be used in a manner that will minimize damage or defacement of landscape features, trees, ecologically sensitive areas such as wetlands, and other surrounding objects by controlling these effects through the best methods possible (including precisely calculated explosive loads and adequate stemming) the scatter of blasted material beyond the limits of activity. Outside of cleared areas, inadvertently damaged trees shall be cut, removed, and salvaged if merchantable (Appendix D.1).

Fly rock that inadvertently enters a water body, watercourse or any ecologically sensitive area, and that can be recovered without further damage to the environment shall be removed. Instances where larger fly rock (i.e., boulders) enters these areas or deep water bodies, recovery of this shall be discussed with the HSE Manager, who will decide whether or not it is practical to proceed.

- Blasting activities will be co-ordinated and scheduled to minimize the number of blasts required per week.
- Perform blasting during day time only at a regular scheduled time.
- Blasting patterns and procedures shall be used which minimize shock or instantaneous peak noise levels.
- Time delay blasting cycles or blasting mats shall be used, if necessary, to control the scatter of blasted material.
- Blasting shall not occur in the vicinity of fuel storage facilities.
- Blasters' Safety Certificates and the Temporary Magazine License shall be obtained prior to drilling and blasting.
- Use of explosives shall be restricted to authorized personnel who have been trained in their use.



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- There shall be separate magazines on site for explosives and for dynamite blasting caps. All temporary magazines for explosive storage shall have appropriate approvals.
- The immediate area of the blast site shall be surveyed to identify the presence of any wildlife within one hour prior to a blast and operations will be curtailed if wildlife is observed within 500 m. Environmental personnel and the HSE technician shall conduct pre-blast monitoring where knowledge and competency is required to see and identify species of concern. Additionally, any individual animal sightings by other personnel shall be reported to the HSE Manager and the HSE technician.
- All blasting associated debris, such as explosive boxes and used blasting wire, will be collected for proper disposal as soon as possible following blasting activity.
- If blasting is necessary within the vicinity of an archaeological site, precautions shall be taken to ensure that blasted material and shock waves do not disturb any part of the site. If necessary, protective covering shall be applied to the site under the supervision of an approved archaeologist and in consultation with NL Business, Tourism, Culture and Rural Development. Blasting shall not be undertaken in these areas without first notifying the HSE Manager and the HSE technician.

Blasting in Close Proximity to Water Bodies

If blasting is necessary within a water body, it shall be undertaken in compliance with the required Water Resources permits from the NL DOEC and DFO guidelines (Appendix E). Reference may also be made to the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (Wright and Hopky, 1998). A copy of this reference shall be kept at the CFI HSE office at the Project site and made available to all contractors.

- Drilling and blasting activities shall be undertaken in a manner that ensures the magnitude of explosions is limited to that which is absolutely necessary. A blasting plan shall be reviewed with the local DFO Fisheries Officer in advance of work in close proximity to water bodies.
- CFI will comply with DFO guidance which stipulates that, for large blasts, in the order of 100 kg per hole, a setback of 150 m is required (Wright and Hopky 1998).
- For multiple charges, time delay detonators should be used to reduce the overall detonation to a series of single explosions separated by minimum delay.
- Large charges should be subdivided into a series of smaller charges with minimum delay detonation.
- The on-land set back distance from the blast site to the water body or the setback distance around the blast site in the water body are based on the maximum weight of charge to be detonated at one instant in time and the type of fish or fish habitat in the area of the blast. Refer to Appendices B and E for specific guidance and Environmental Guidelines.
- Blast holes must be stemmed with sand or gravel to grade or to streambed / water interface to confine the blast.
- Ammonium nitrite based explosives shall not be used in or near water due to the production of toxic by-products.
- If fish or marine mammals are detected in the area described, blasting may proceed only when the fish or marine mammals have left the area. Blasting activities shall not be carried out in the marine environment.



D.17 – DRILLING – GEOTECHNICAL

Drilling may be required on land during geotechnical investigations to determine foundation conditions - assess stability, and underlying geology for Project infrastructure.

Environmental Concerns

The environmental concerns associated with drilling on land are surface disturbances, disposal of drilling fluids and cuttings, generation of dust, noise, and the potential adverse effects on terrestrial habitats, historic resources, air quality and aquatic ecosystems.

Environmental Protection Procedures

Potential drilling sites in sensitive areas shall be inspected by the HSE Manager and the HSE technician.

The following measures shall be implemented to minimize the potential adverse effects of drilling:

- Drilling sites shall be cleared of vegetation following the procedures detailed in Appendix D.1.
- Disposal of all drilling materials and associated solid wastes shall be undertaken in accordance with the procedures in Appendix D.5.
- Fuel shall be stored, handled and transported according to Appendix D.3.
- Water or water-based dust suppressant applications shall be used to control dust, where necessary and the source of water shall be approved for use. The use of water for dust control or coring / wash boring shall be undertaken in a manner which ensures that runoff does not enter watercourses.
- Drilling equipment shall have muffled exhaust to minimize generated noise.
- Drilling of water wells shall be conducted in compliance with the *Water Resources Act* and the Well Drilling Regulations.

D.18 – CONCRETE CONSTRUCTION ACTIVITIES

Environmental Concerns

The main concern relating to concrete construction activities is the effects of washwater released to the environment. Liquid wastes may contain hazardous materials such as cement, concrete additives, and form oil.

Cement is alkaline and washwater from spoiled concrete or from the cleaning of the batch plant mixers and mixer trucks, conveyors and pipe delivery systems can be expected to have a high pH which may exceed the acceptable limit, as determined by the Environmental Control Water and Sewage Regulations. Similarly, spoiled concrete or washwater would contain concrete additives and agents, some of which are toxic to aquatic species. Aggregates, particularly the finer sand fractions, may be washed from spoiled concrete or discharged in washwater. Uncontrolled release of such washwater, chemicals and sediments could adversely affect aquatic life and aquatic habitat.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of concrete production:

- Washwater from the cleaning of mixers, mixer trucks and concrete delivery systems shall be directed to a closed system rinsing / settling basin.
- In the event that water from the closed settling system is to be released, it shall be tested prior to release, for parameters related to any concrete additives to be used in the production of concrete (e.g., total



hydrocarbons, pH, and TSS). The water to be released shall also meet the limits specified by NL DOEC as referenced in the Environmental Control Water and Sewage Regulations, and shall adhere to those portions of the *Fisheries Act* that relate to fish habitat protection and pollution prevention. Release shall be via runoff control procedures in accordance with the Water Management Plan.

- If water to be released does not meet discharge criteria, it will be further treated until these discharge criteria have been met.
- The settling basin shall be cleaned, on an as required basis, to ensure that the retention capacity is maintained at all times.
- The Environmental Code of Practice for Concrete Batch Plant and Rock Washing Operations will be adhered to during concrete production activities.

D.19 – LINEAR DEVELOPMENTS

Environmental Concerns

Linear developments encompass a diverse range of standard construction related activities such as ditching, right-of-way clearing and grubbing, roads, pipelines and transmission line construction. Environmental concerns associated with linear developments include potential sedimentation / erosion, and the alteration or loss of vegetation and fish / wildlife habitat.

Environmental Protection Procedures

In addition to environmental protection procedures stated below, reference may be made to Gosse et al. 1998, pp 84-88, as appropriate.

The following measures shall be implemented to minimize the potential adverse effects of linear developments:

Road Construction

- Aggregate (fill) materials for construction purposes shall not be removed from any stream.
- Sedimentation control measures such as sediment traps and check dams shall be installed where required (Appendix D.8). Solids that accumulate in a settling pond or behind a sediment trap shall be removed on a regular basis to ensure such devices remain effective.
- Work shall not be undertaken on easily erodible materials, during or immediately following heavy rainfalls without appropriate protection measures in place.
- Buffer zones shall be flagged prior to any disturbance activities.
- Mechanical methods of brush control shall be used at all times.
- Natural vegetation shall be left in place where practical. Buffer zones (Appendix D.7) shall be maintained around all fill areas adjacent to wetlands. Rights-of-way, particularly in areas of dense vegetation, shall be as narrow as practicable; loss of ground vegetation shall be kept to a minimum.
- Drainage from areas of exposed fill shall be controlled by grade or ditching and directed away from watercourses in accordance with the Site Grading and Drainage Plan developed during the detailed engineering phase, as well as the Water Management Plan. Surface water shall be directed away from work areas by ditching. Runoff from these areas shall have sediment removed by filtration or other suitable methods.
- The requirements of ditch blocks / check dams or sediment traps to intercept runoff shall be determined in the field in consultation with the HSE Manager, HSE technician, and Contractor personnel.



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- Check dams shall be used, as required, to reduce runoff from work areas with exposed soil.
- In areas where natural vegetation must be removed, the resulting woody slash material shall be stored for possible use as erosion control material on exposed slopes.
- Temporary erosion control shall be applied on exposed slopes in sensitive areas immediately following exposure of a slope.
- The cutting and filling phase of road construction, and the development of other work areas, shall be conducted in a manner which ensures minimum disturbance, and which controls potential sedimentation of watercourses, water bodies and other ecologically sensitive areas such as wetlands in or adjacent to the roads, as outlined in the following procedures:
 - Cutting and filling shall be done only upon completion of grubbing as outlined in Appendix D.2. Where engineering requirements do not require grubbing (e.g., within the buffer zone of a stream crossing, Appendix D.7), filling shall occur without any disturbance of the vegetation mat and / or the upper soil horizons.
 - Filling in the vicinity of stream crossings shall be done in a manner which ensures that erosion and sedimentation of watercourses, water bodies and other ecologically sensitive areas such as wetlands is minimized and done in strict compliance with the required watercourse alteration permits from NL DOEC and DFO Freshwater and Marine Fish Offset plans.
 - The infilling of watercourses and water bodies shall not be permitted except, where it is necessary, at an approved stream crossing or where the road alignment cannot avoid some infilling. CFI, in consultation with the HSE technician shall ensure that the work is completed in strict compliance with the required watercourse alteration permits from NL DOEC and DFO, if required.
 - Buffer zones (Appendix D.7) shall be maintained between the roads and the bank of any watercourse they parallel.
 - Road fill shall be dry and ice free. On areas of sensitive terrain, the fill shall be end-dumped from the established roadbed.
- Culverts shall be properly installed to maintain natural cross drainage and to prevent ponding.
- The number of stream crossings will be minimized. Where the road must cross a stream, the environmental protection procedures detailed in Appendix D.10 shall be followed.
- Where possible, construction activities shall avoid areas of wildlife concentrations to prevent undue disturbance of wildlife during sensitive periods. If encounters with wildlife are unavoidable, then contingency measures detailed in Section 7.0 and in the ERP will be followed.
- Rights-of-way shall avoid known archaeological sites and required buffers shall be respected. If any archaeological sites are encountered, then all work in the immediate area within 20 m shall cease pending approval from the HSE Manager in consultation with NL Business, Tourism, Culture and Rural Development.

Pipeline Development

Pipelines, such as those for the tailings discharge shall be constructed above ground and follow the access or service roads where feasible.

All exterior surface pipelines with the potential to freeze shall be self-draining to containment or employ other protection measures to prevent spillage to the environment. The environmental protection procedures for road construction as outlined above shall be used for pipeline construction, where applicable.



Transmission Line Development

Transmission lines will be constructed on site. The environmental protection procedures for road construction as outlined above shall be used for transmission line construction, as applicable.

- Wood, pressure-treated with pentachlorophenol (PCP) or ammoniacal copper arsenate (ACA) shall not be used. Alternatives to wood will be preferred, or where necessary, wood treated with either ACQ (amine) or Copper Azole.
- Vegetation control along the transmission line shall use mechanical methods of brush control rather than chemical (herbicides).

Drainage

- Drainage discharge locations shall be determined in consultation with the HSE Manager and the HSE technician.
- Roads shall be adequately ditched to allow good drainage.
- Roadside ditches shall discharge onto vegetated or forested areas, and never directly into a watercourse.
- Wherever possible, ditches shall be kept at the same gradient as the road.
- The location of all culverts shall be marked with a post so that they can be located during snow removal operations or if they become covered from debris accumulation.
- Refer to Appendices B and E for specific guidance and Environmental Guidelines.

D.20 – VEHICULAR TRAFFIC

Environmental Concerns

Direct physical disturbances from vehicular movements can adversely affect both terrestrial and aquatic environments as well as historic resources (e.g., collisions with wildlife). During any construction related operation, the level of activity involving equipment movement, types of equipment and supply requires various infrastructure such as roads, to conduct the work efficiently and in an environmentally acceptable manner. Typically, vehicles ranging in size from all-terrain vehicles (ATVs) to heavy equipment, all of which can result in ground disturbance, may be used during access road construction. CFI shall ensure roads are developed properly to minimize environmental damage resulting from equipment movement. Where possible, existing site access will be used to limit the requirement for new road construction.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of vehicular traffic:

- ATVs shall not be allowed on the site except as required by field personnel in the performance of the work.
- Where possible, the use of ATVs shall be restricted to designated trails, thus minimizing ground disturbance. ATV use shall comply with All Terrain Vehicle Use Regulations and NL DOEC Environmental Guidelines for Stream Crossings by All Terrain Vehicles (1994).
- Vehicle movements shall be restricted to developed areas and roadways.
- Appropriate speed limits and road signage shall be established and enforced to minimize environmental disturbance and incidents.
- During winter when the ground is covered with snow, snowmobiles and heavy equipment, whether equipped with low-impact tread or not, shall not be used for equipment movement and supply outside of established roadways, pathways or trailways.



- Equipment and vehicles will yield the right-of-way to wildlife. Any attempt to interfere with the natural movement of wildlife shall be considered harassment and dealt with accordingly.
- All Project vehicles, including ATVs, will be properly inspected and maintained in good working order including all exhaust systems, mufflers and any other pollution control devices.
- Implement a no-idling policy to reduce combustion emissions.
- Promote the use of block heaters during winter months as part of the no-idling policy.
- Implement an awareness program to promote fuel consumption reduction.

D.21 – SURVEYING

Environmental Concerns

Surveying activities may include: vegetation removal; traversing; and establishing targets, permanent benchmarks and transponder stations. Surveying activities may disturb vegetation, wildlife, and historic resources.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of surveying:

Vegetation Removal

- Width of survey lines will be limited to that which is absolutely necessary for line-of-sight and safe, unobstructed passage.
- Whenever possible, cutting lines to the edge of open areas will be avoided.
- Trees and shrubs will be cut flush with the ground wherever possible (Appendix D.1), with stumps not to exceed 15 cm in height.
- Cutting of survey lines will be kept to a minimum.
- All trees not exactly on transit lines shall be left standing and trees partly on-line should be notched (notch not to exceed 1/3 tree's diameter) instead of removed, to allow sighting.
- Discretion should be used when large trees are encountered. For example, trees 30 cm dbh or larger should, whenever possible, not be cut. On grid lines, trees of 30 cm diameter or larger shall be left intact and shall be traversed to continue the line.
- No attempt to harass or disturb wildlife will be made by any person.
- Vehicles will yield the right-of-way to wildlife.
- There will be no cutting in areas designated as sensitive without notification and written approval of the HSE Manager and consultation with the HSE technician.
- Archaeological sites and features will not be disturbed during survey work. Any historic resource discoveries will be reported to the HSE Manager.

Traversing

- ATVs will not be allowed off the right-of-way except as approved by the HSE Manager, in consultation with the HSE technician.
- No attempt to harass or disturb wildlife will be made by any person.



- No motorized vehicles will enter the areas designated as sensitive without notification and approval of the HSE Manager, in consultation with the HSE technician.
- The extent of activities in sensitive areas will be minimized.
- Walking in sensitive areas will be restricted to established walking paths, where available.

Establishing Targets, Permanent Benchmarks and Transponder Locations

- A driven T-bar, well embedded to readily identify each benchmark location will be used.
- No attempt to harass or disturb wildlife will be made by any person.
- Access to sensitive areas is to be approved in writing by the HSE Manager.
- Standard iron bars and sledgehammers are to be used to establish benchmarks.
- Heavy equipment will not be used to access sensitive areas.

D.22 – EQUIPMENT OPERATIONS

A variety of equipment will be used on-site during construction, which is potential sources of noise, air emissions, and potential leaks or spills.

Environmental Concerns

Noises associated with construction activity may adversely affect wildlife. Air emissions may have air quality implications. Accidental leaks or spills of fuel or other hazardous materials may affect soils, water, fish, vegetation and wildlife.

Environmental Protection Procedures

The following measures shall be implemented to minimize the potential adverse effects of equipment operations:

- All approvals, authorizations and permits for Project activities will be followed.
- Noise control procedures will be put in place during construction (Appendix D.16).
- Avoid any off-site equipment and vehicle movement.
- Vehicles accessing the site will be required to check-in at the security gate.
- Access and haul roads will be sufficiently wide to allow safe passage of two vehicles side by side.
- There will be adequate line-of-sight around corners and at road junctions.
- Speed limits will be posted and enforced.
- All equipment will have exhaust systems regularly inspected and mufflers will be operating properly.
- All equipment (e.g., diesel generators) will meet the requirements of the provincial Air Pollution Control Regulations under the *Environmental Protection Act*.
- All equipment used during construction will follow the environmental protection procedures outlined in this EPP. In the case of an accidental event resulting from the use of equipment (e.g., a fuel spill), the appropriate contingency plans (Section 7.0) and the ERP will be implemented.



- Regular maintenance inspections for leaks (i.e., pre-shift inspections) will be made on all equipment. If problems are identified the equipment will be taken out of service and repaired to prevent release of hydrocarbons into the environment (e.g., drip tray, spill pan, absorbent material). Necessary critical spares will be maintained in the event that a change out of parts or equipment is required.

D.23 – FISH RELOCATION

The Great St. Lawrence Harbour provides suitable habitat for a number of fish species. There are a number of freshwater bodies, streams and ponds in the Project area.

Environmental Concerns

Serious harm caused to CRA fish during re-location efforts.

Environmental Protection Procedures

CFI is currently preparing Freshwater and Marine Fish Offset plans and monitoring programs in consultation with DFO. Fish relocation procedures will be outlined as part of the Fish Offset plans.

D.24 – HISTORIC RESOURCES

Sites of historic or archaeological significance have been identified in the general area of St. Lawrence. There is a registered archaeological site in Blue Beach Cove; the wreck of the tug Rio Sama from 1946. No Project construction activities will occur in this area and the Project will have no adverse effect on historic / archaeological resources in the area.

Environmental Concerns

Incidental discovery of historic resources on-site during construction activities is an environmental concern.

Environmental Protection Procedures

All field personnel shall be informed of the historic resources potential of the area, of their responsibility to report any unusual findings, and to leave such findings undisturbed.

In the event of the discovery of an archaeological site or artefact, the following procedures will apply:

- Under the provincial *Historic Resources Act* (1990), all archaeological sites and artefacts are considered the property of the Crown, and must not be disturbed. CFI and their contractors will take all reasonable precautions to prevent employees or other persons from removing or damaging any such articles or sites and may be held liable for prosecution under Section 35.1 and 35.2 of the provincial *Historic Resources Act* (1990) for any contravention.
- Personnel working in the vicinity will be advised of the find, including the HSE Manager and the HSE technician. The site area will be flagged for protection and avoidance. All work will cease within 20 m of the discovery until CFI advises NL Business, Tourism, Culture and Rural Development of the discovery. NL Business, Tourism, Culture and Rural Development, in consultation with CFI will provide direction regarding the discovery and may authorize a resumption of the work. If required, a Stage 1 Historic Resources Overview Assessment (HROA) will be conducted of the site and immediate area (NL Business, Tourism, Culture and Rural Development 2015). Archaeological materials encountered will be reported initially to the HSE Manager, and immediately thereafter by the HSE Manager to the provincial Archaeologist at NL Business, Tourism, Culture and Rural Development with the following information:
 - nature of activity;



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

- nature of the material discovered; and,
- precise location of the find.

NL Business, Tourism, Culture and Rural Development will assess the significance of the discovery and determine if mitigation is required. NL Business, Tourism, Culture and Rural Development will develop mitigation measures and advise CFI of their decisions.

Regular monitoring will be conducted by the HSE technician to ensure that site protection measures are adequate and that the terms and intent of the EPP commitments are being met.



APPENDIX E

**Newfoundland and Labrador Department of Environment and
Conservation Water Resources Management Division -
Environmental Guidelines**



ST. LAWRENCE FLUORSPAR PROJECT - ENVIRONMENTAL PROTECTION PLAN

Chapter #	Title
3	Environmental Guidelines for Watercourse Crossings
3A	Environmental Guidelines for Stream Crossings by ATVs
4	Environmental Guidelines for Bridges
5	Environmental Guidelines for Culverts
6	Environmental Guidelines for Fording
7	Environmental Guidelines for Diversions, New Channels, Major Alterations
9	Environmental Guidelines for Pipe Crossings
13	Environmental Guidelines for General Construction Practices

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF ENVIRONMENT AND LABOUR



CHAPTER 3
Environmental Guidelines for
WATERCOURSE CROSSINGS

WATER RESOURCES MANAGEMENT DIVISION
Water Investigations Section

Chapter 3
Environmental Guidelines For
WATERCOURSE CROSSINGS

Water Resources Management Division
Water Investigations Section

February 20, 1992

3.0 WATERCOURSE CROSSINGS

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3.1 General

This section consists of general information and preferred methods for planning and installing watercourse crossings. For the purpose of these guidelines watercourse crossings are placed in three categories:

- Bridges, Culverts and Fording

More specific technical information and recommended practices for installing these types of watercourse crossings are contained in:

Chapter 4 - Bridges
Chapter 5 - Culverts
Chapter 6 - Fording

Any watercourse crossing has the potential to alter the existing natural flow regime for the entire range of low to high flow conditions. The alteration of natural stream flow, if carried out improperly, can result in many types of serious problems. Improperly installed watercourse crossings can result in extensive loss and damage to public and private property, danger to human life, as well as damage to the environment in general through flooding, erosion, and washouts.

While installations such as culverts always alter natural flow it is preferred that watercourse crossings be appropriately designed to alter the natural flow regime as little as possible. The final decision as to permitting any stream alterations through the installation of a crossing, rests with the Minister of the Department of Environment and Lands.

3.2 Selection of Route and Crossing Site

In planning linear facilities such as roads, pipelines, railways or transmission lines which require crossings of watercourses, consideration is required in the route selection and corridor location to mitigate the impact of the development on water resources.

Route selection should be made to:

- Minimize the number of watercourse crossings.
- Avoid wetlands or floodplain areas.

3.0 WATERCOURSE CROSSINGS

- Maintain substantial buffer strips on all bodies of water.

In selecting a site for a proposed major watercourse crossing, it is important to examine the physical characteristics of the watercourse and its drainage basin and to identify the site which will provide the best features and conditions for a crossing.

The site selected should enable construction of an economical and easily maintained crossing, be suitable for routing and approach requirements, consider the nature of the waterway and its environment, and minimize the use of such training works as may be necessary to deal with adverse natural features.

Where there is a choice between alternative crossing sites on a watercourse the crossing should be located:

- where the stream is straight, unobstructed and well defined;
- on an existing right-of-way if one exists;
- where stable geological and soil conditions are present;
- where a minimum of scour, deposition or displacement of sediments are expected to occur at or near a crossing;
- where possible effects on other existing bridges and hydraulic structures can be avoided;
- where it is possible to minimize the risk of damage from environmental hazards such as floods, landslides, or avalanches;
- where aesthetic conditions are favourable;
- away and preferably downstream from areas such as fish spawning sites or water use intakes.

3.3 Types of Crossings

3.3.1 Distinction Between Culverts & Bridges

For the most part, the term culvert has become synonymous with galvanized corrugated steel pipe products although concrete pipe culverts still find limited use mostly for smaller size drainage installations. Installations which maintain the original natural stream bed are not considered to be culverts in these guidelines. (See definitions in Appendix "culvert", "bridge"). Poured in place concrete structures which form two sides and a top over a watercourse but maintain a natural channel bed have been referred to elsewhere as "box culverts". The term is a misnomer as these structures more closely resemble bridges in their construction, installation procedures, and hydraulic effects on

flow in the channel. Similarly, structural plate arches, although they utilize corrugated steel, are considered for the purpose of these guidelines to be classed as bridge installations as they require concrete foundations and allow a natural channel bed. For further information on concrete box structures or structural steel plate arch structures refer to *Chapter 4, "Bridges"*.

3.3.2 Preference of Bridges over Culvert Crossings

Bridges and bridge-type structures are environmentally preferred to culverts as a means of stream crossing. The following reasons are cited:

- Culvert installations usually result in the loss of a section of natural stream bed, whereas bridges leave the channel bed relatively unaltered.
- Confining stream flow to culverts can result in an extensive alteration of the flow regime which can result in problems such as erosion, or scouring at outlet or deposition of material at the inlet of the installation.
- Bridges usually provide better capacity to accommodate high flows than would a culvert crossing. Inadequate capacity can result in serious problems such as washouts and flooding.
- Bridges provide better inlet and outlet conditions than culverts thereby allowing safer passage of debris without causing constrictions and blockages.
- Culverts often create total or partial barriers to fish migration which is rarely a problem in bridge installations.

3.3.3 Timber "Culverts"

The use of logs or timber to construct an enclosed structure under road fill also known as timber culverts, is not considered an acceptable method of stream crossing. Such structures do not provide long term service and their final demise usually results in the collapse of the road material into the stream with such problems as siltation and deposition downstream, washout of the road, or the blocking of the stream with associated flooding.

3.0 WATERCOURSE CROSSINGS

3.3.4 Choose a Type of Crossing Appropriate for the Site Conditions

Prior to the construction of watercourse crossings careful study and examination of the environmental implications of each proposed crossing should be undertaken.

The decision to install a bridge or culverts for a proposed crossing should be made only after examining the hydraulic implications of the proposed structure with respect to the hydrology, physical conditions and features of the proposed site. Generally these factors include but are not limited to:

- Quantity or volume of peak flows
- Depth of flow
- Flow velocity
- Low flow characteristics

This will provide an indication of the appropriateness and ability of the structure to perform satisfactorily under those particular conditions identified. These are the determining factors to be considered in deciding between a bridge or culvert installation and the decision should not be based primarily on economic considerations.

3.3.5 Temporary Crossings

These guidelines have not made a substantial distinction between permanent and temporary watercourse crossings as all installations are expected to provide satisfactory performance during the intended period of use. In this regard the design capacity of a crossing may vary from an installation which is to be used only for several weeks during low flow summer conditions and subsequently removed, to installations which must safely accommodate high spring runoff or provide many years of satisfactory service for a major highway.

Where watercourse crossings are installed to provide service for a period of less than one year and the installations are not required to pass peak spring runoff, the following guidelines should be followed:

- The installation should provide adequate capacity to safely accommodate design flows without causing erosion, flooding, or other environmental problems.
- The installation should be carried out with the least amount of

disturbance to the channel bed, banks, and adjacent vegetation and property.

- Upon completion of its intended function, the crossing and all associated works and material should be removed from the vicinity of the channel.
- Site restoration involving revegetation and stabilization of all disturbed areas should be carried out to return the channel to its previous condition. Further details on this are contained in *Chapter 14, "Restoration and Stabilization"*.

3.3.6 Choosing Between a Fording, or a Structural Crossing

There are a number of environmental factors to consider in deciding whether to ford a watercourse or provide an installation such as a bridge or culvert.

If a location with stable channel bed and banks has been identified, the flow is not too deep, and very infrequent use is anticipated, fording may be an acceptable alternative to installing a bridge or culvert.

In some instances the installation of a bridge or culvert and its subsequent removal would result in greater channel disruption and more potential for environmental problems than the installation of a fording site.

One of the initial factors to consider is the frequency and period of use of the proposed crossing. In instances where the fording would only involve crossing a watercourse to gain access into an area and subsequent return from the area, (two fording operations per piece of equipment), the installation of bridges or culverts may not be warranted provided the fording would not create environmental problems or conflict with downstream water users.

Details regarding the installation of fording sites and guidelines for their use are contained in *Chapter 6, "Fording"*.

3.4 Design Flow and Water Level

To design and construct an adequate watercourse crossing and provide appropriate environmental mitigation, it is essential that the flow regime at the crossing location be determined. The important flow characteristics are the timing and magnitude of the annual peak and low flow period, the range of flows which may be encountered,

3.0 WATERCOURSE CROSSINGS

and flow velocities. Also of concern in some regions are the dates of freeze-up and break-up and the potential for ice blockage of culverts.

3.4.1 Return Period

The streamflow characteristic of major importance is the peak or flood flow usually related to a certain probability of being equalled or exceeded in terms of a "return period". Determining a design peak flow with a certain return period allows one to assess the probability that a crossing structure could be damaged or destroyed within a selected time period. For example, a 50-year return period peak flow will be equalled or exceeded, on the average, once in a 50-year period. The probability or risk of a 50-year return period peak flow occurring in the 25-year "life" of a structure is about 40%; the probability of a 100-year return period event occurring is about 22%.

3.4.2 Design Data

The main source of data for the analyses used to estimate peak flow is the hydrometric station network operated by Water Survey of Canada under the cost shared Canada - Newfoundland Hydrometric Surveys Agreement. The peak flow magnitude can be estimated by regionalization methods, or empirical formulae which relate peak flow to precipitation input. The method used will depend on the climate, watershed characteristics (especially drainage area) and the data available.

3.4.3 Site Inspection

Much information required for the design of a stream crossing can only be obtained from a site inspection. Physical measurements of the stream include width, depth and flow velocity. Such measurements must include up- and downstream sections and these must be compared in terms of elevation in order to determine the channel slope. In addition a field inspection should establish:

- type and grading of bed material,
- existence of shoals and their composition,
- the material forming the banks,
- vegetation on the banks,
- steepness of banks and evidence of bank erosion,

- debris marks on shrubs, trees or banks which may indicate the water level of recent floods,
- elevation of ice scars.

Much of this information is vital to confirm the appropriateness of the hydraulic as well as the structural design.

3.5 General Installation Procedures

Design and the actual installation of a watercourse crossing are separate components often handled by different persons or agencies (engineers/owners vs. contractors). Invariably, it is necessary to consider the installation methods in the design of the crossing, thus a team effort is needed to ensure that a project is carried out in an environmentally acceptable manner. A crossing design must be such that it can have a realistic chance of being installed with a minimum of environmental disruption.

The contractor usually has the sole responsibility for the day to day construction effort. In this regard it usually falls upon the contractor to ensure that pollution, siltation, drainage problems and general disturbance be minimized. Each crossing installation is unique and a well planned installation procedure as well as rules, specifications and regulations governing the site work are essential. More details about construction practices are given in *Chapter 13, "General Construction Practices"*.

3.5.1 Low Flow Conditions

It is preferred that all watercourse crossings be installed during times of low flow conditions during the summer months. Where flows must be diverted or confined to allow work to proceed in a portion of the channel, high flow conditions can create problems of erosion and flooding. Watercourse crossings installed during the summer months also will allow adequate time for stabilization and revegetation of disturbed areas before higher flows of the fall months occur.

3.0 WATERCOURSE CROSSINGS

3.5.2 Reduce Time Spent With In-Stream Work

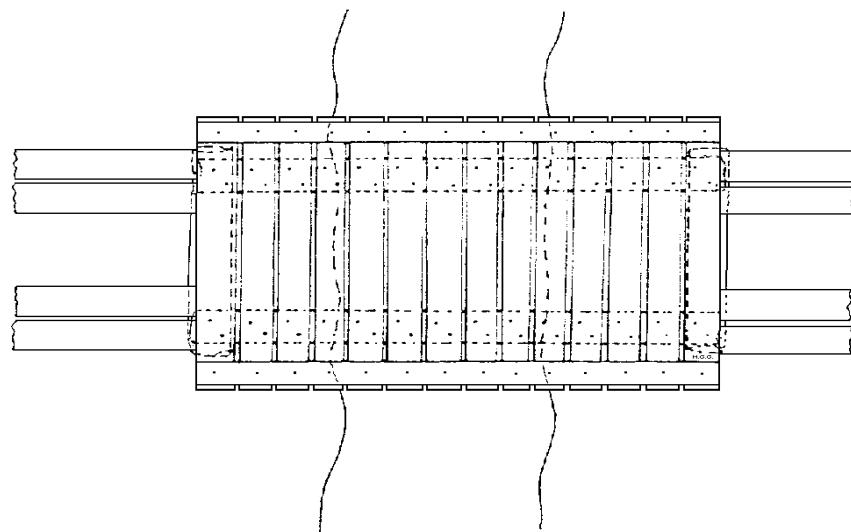
The installation of any watercourse crossing should be carried out as quickly as possible to prevent prolonged channel disruption or exposure of vulnerable areas to erosion. The extent of channel disruption and other environmental problems such as siltation often relates directly to the amount of time spent with instream works.

3.5.3 Watercourse Crossings and Fish Habitat

The installation of watercourse crossings has the potential to impede or block fish migration and destroy fish populations or fish habitat. In particular, culvert installations if improperly installed can create structural and flow velocity barriers to the passage of fish. The installation of bridges, culverts, and fording sites if improperly carried out can result in siltation and pollution which can kill fish, or incubating eggs and ruin spawning locations.

The installation of watercourse crossings in areas of fish habitat should be scheduled to avoid instream work during periods of high environmental sensitivity such as fish migration, spawning, fish egg incubation and fry emergence. The installation should not impede fish migration or effect fish or incubating eggs.

The Federal Fisheries Act contains clauses which govern the alteration of fish habitat. Therefore, approval from Fisheries and Oceans, Canada, may be required in addition to approval from the provincial Department of Environment and Lands.



CHAPTER 3A
Environmental Guidelines for
STREAM CROSSING BY
ALL-TERRAIN VEHICLES

Chapter 3A
Environmental Guidelines For
STREAM CROSSING BY ALL-TERRAIN VEHICLES

Water Resources Management Division
Water Investigations Section

March 31, 1994

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1. Introduction

The purpose of these guidelines are to outline a simple yet consistent methodology for crossing small streams or any other body of water with all-terrain vehicles (ATVs) on licensed trails or any other "approved area" as defined in the *All-Terrain Vehicle Use Regulations, 1994*. Those regulations specify in Schedule B, Terms and Conditions of Licensed Trails, that all stream crossings must be authorized by a Certificate of Environmental Approval issued by the Minister pursuant to Section 11 of the *Environment Act* prior to trail construction. These guidelines will assist any prospective licence holder with making a proper application for the stream crossings that might be required for the licensed trail

The main objective in requiring approval for stream crossings is to ensure that the least possible disturbance occurs when crossing streams. In fact, the best approach is to avoid crossing streams whenever possible by selecting routes that do not cross streams at all. Only when avoidance is not possible or practical, should we consider making a stream crossing. There are several alternatives such as fording or building bridges and these are discussed in the following pages. Generally for frequent crossing of the same watercourse, a bridge structure is recommended. These guidelines provide a design for a very simple wooden bridge that can be built with just a few logs, boards and nails. Nothing elaborate is required as long as the structure spans the stream and thereby avoids instream travel and prevents disturbance of the stream banks. These guidelines also discuss some good construction practices and restoration measures.

3A ATV STREAM CROSSINGS

2. Selection of Route and Crossing Sites

In planning ATV trails careful consideration is required in selecting a route to mitigate the impact on all water resources.

Routes should be selected to:

- minimize the number of watercourse crossings,
- avoid steep slopes and other sensitive areas,
- avoid wetlands and floodplain areas,
- reduce travel and access through Protected Water Supply Areas, and
- maintain substantial buffer strips of 15 metres on all bodies of water.

Where there is a choice between alternative crossing sites on the same watercourse the crossing should be located:

- where the stream is straight, unobstructed, and well defined,
- on an exiting right of way if one exists,
- where stable geological and soil conditions are present,
- where a minimum of scour, deposition, or displacement of sediments are expected to occur at or near a crossing,
- where possible effects on existing bridges and hydraulic structures can be avoided,
- where it is possible to minimize the risk of damage from environmental hazards such as floods, mudslides, or fires,
- where aesthetic conditions are favourable, and,
- away and preferably downstream from such areas as fish spawning sites or water intakes.

Much of the information required for selecting a site and for deciding the best method of crossing is obtained from a site inspection. Physical measurements of the stream should include its width at top and bottom, the depth of channel from top of embankment to bottom of stream as well as the depth of water and its flow velocity. Other necessary information includes:

- type and grading of bed material,
- existence of shoals and their composition,

- the type of material forming the stream banks,
- type and density of vegetation on the banks,
- steepness of banks and evidence of erosion,
- debris marks on shrubs, trees, or banks which may indicate the level of recent floods, and,
- elevation of ice scars which may indicate ice jam elevations.

3. Fording

There are a number of environmental factors to consider in deciding whether to ford a watercourse or to provide a structure such as a bridge or culvert.

If a location with stable channel bed and banks has been identified, the flow is not too deep, and very infrequent use is anticipated, fording may be an acceptable alternative to the installation of a bridge or culvert. In some cases the installation of a bridge or culvert and its subsequent removal would result in greater channel disruption than preparing a fording site.

The fording site must be located at a shallow section of the channel where there are low approach grades, and where the channel consists of stable non-erodible rock or cobbles or better yet, exposed bedrock. Any areas with vegetated, silty, or sandy bottoms are not considered acceptable fording sites.

Timbers or rocks may be placed in the stream to facilitate crossing or to minimize damage to the channel section provided the stream is not unnecessarily constricted or backed up.

Stream banks at fording sites that contain loose or erodible material must be adequately stabilized before crossing to minimize any siltation of the stream. This can be done by placing brush mats, rocks or timbers on the stream bank. This material must be removed after use of the fording site is completed.

Fording may only be carried out during periods of low flow.

All vehicles and equipment must be clean and in good repair, free of mud and oil, or other harmful substances that could impair water quality.

3A ATV STREAM CROSSINGS

4. Bridges

Bridges are the preferred type of stream crossing because only bridges can avoid the alteration of flow regimes and protect the integrity of the stream channel. Bridges are recommended on all watercourses supporting fish because there is no need to disturb the streambed. Bridges must have sufficient flow capacity to ensure that flow velocities are kept slow enough or at their natural speed so that fish can swim upstream past the bridge. Culverts can be a fish barrier in this regard.

The proponent should avail himself of sufficient expertise to design and construct a crossing structure that will be sufficiently strong to safely carry a fully loaded ATV.

Creosote treated wood must not be used within 15 metres of a body of fresh water. For this reason, bridges over fresh water should not use any lumber that originates from old or new railway ties, telephone poles or wharves that were built of creosote treated wood.

The completed bridge should safely accommodate reasonably predictable levels of water flow.

a. Bridge Location

The alignment of a bridge relative to a waterway should be at right angles. This will reduce the length of bridge required to cross.

Bridges should not be located near abrupt bends in the channel.

Bridges should be located at a narrow section of the watercourse but where stream banks are stable and are not likely to erode under the bridge supports.

b. Bridge Capacity

The bridge must provide adequate capacity to safely discharge flood flows without causing backwater effects upstream or increased flow velocity downstream. Also bridges that are too small for the amount of water flow anticipated will likely be washed away.

Where insufficient information is available to estimate the maximum discharge at the site over a design period of reasonable length, the physical characteristics of the site may be utilized to determine the peak flow. The maximum historical water level as observed or recorded at the site may be used and a bridge should be built higher than this level. For minor bridges, such as those for ATVs, if the bottom of the bridge span is at the elevation of the top of the stream embankment it may be inferred that the bridge has the same capacity as the existing channel.

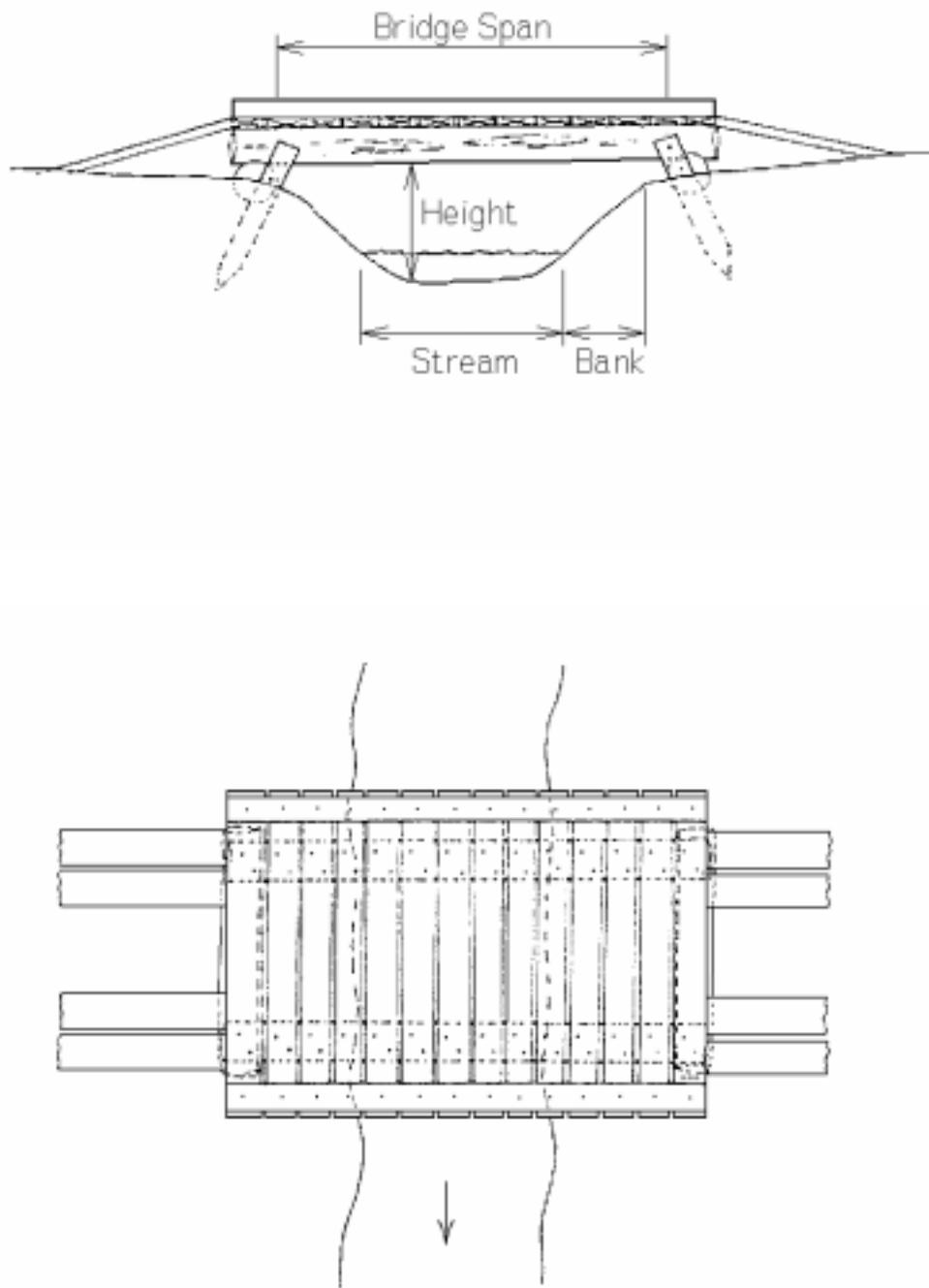
Bridge abutments must be set back at least 0.5 metres from the normal edge of the watercourse to prevent constriction during high flow conditions.

c. **Bridge Type**

Once a suitable site for the bridge is selected and having established the height and width requirements, one must then choose a type of bridge. Bridges for all terrain vehicles will typically be of timber construction with width adequate for one ATV. An example of acceptable bridge design is shown in the figure on the next page.

The basic design uses two or more sufficiently heavy logs laid on a flat rock or a log sill. Boards are nailed across the logs. A curb or toe-board should be provided to help guide the wheels and keep the ATV from running off the open edges. A solidly fastened handrail should also be added if the bridge is more than 1.12 metres (4 feet) high above the channel. If necessary, approach ramps can be made out of a few short boards or the gap can be filled with rocks. Pointed stakes should be driven into the ground to nail the bridge to in order to prevent the bridge from sliding off the sills and to prevent the bridge from washing away in the event of a flood.

3A ATV STREAM CROSSINGS



Profile and Plan of a Simple ATV Bridge

5. Construction Practices

At all times, every necessary precaution should be taken to prevent the disturbance of channel banks, bank vegetation, and land within the high water zone of the stream.

Any work that must be performed below the high water mark must be carried out during a period of low flow. It is not a good idea to do any work around a stream when the stream is in flood.

Winter is a good time for construction or at least for bringing materials to the site and for doing site preparation because one can work from an ice surface. No separate permits are required to cross ice covered bodies of water using an ATV or snowmobile.

All construction operations must be carried out in a manner that prevents damage to land, vegetation, and watercourses, and which prevents pollution of bodies of water.

The use of heavy equipment in streams or bodies of water is not permitted. The operation of heavy equipment must be confined to dry stable areas.

Wood preservatives such as penta, CCA or other such chemicals must not be applied to timber near a body of water. All treated wood or timber must be thoroughly dry before being brought to the site and installed. No treated wood shall be used on any portion of a trail that passes through a Protected Water Supply Area.

If the bridge is constructed using natural logs, then the bark should be removed from the logs. Peeled logs are better at resisting rot.

Abutments and piers must be constructed in the dry and during times of low flow.

The channel, including any land up to the high water mark, must be kept free of all excavated or unused construction materials at all times.

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. It is best however to make sure that the work is performed without disturbing vegetative ground cover and thereby avoid causing any silting to occur in the first place.

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6. Inspection, Maintenance, and Other Concerns

Bridges require frequent inspection to determine if they are performing satisfactorily without causing any environmental disruption, and to identify any problems which may threaten the structural integrity of the bridge.

General maintenance work should be carried out as required from time to time.

Periodic maintenance such as painting, resurfacing, clearing of debris, or minor repairs, must be carried out without causing any physical disruption of the watercourse. Care must be taken to prevent spillage of pollutants into the water.

7. Site Restoration

All areas affected by a project must be restored to a state that resembles local natural conditions. Further remedial measures to mitigate environmental impacts on water resources can and will be specified, if necessary in the opinion of this Department.

When the fording site or a bridge is no longer required, the owner must dismantle and remove all constructed works and restore the site to its original condition. All material placed in the stream must be completely removed from the channel.

8. Applying for Environmental Approval for Stream Crossings

All stream crossings must be approved in writing by the Minister before the crossing takes place or before beginning the construction of a bridge. Proponents should be aware that in addition to this requirement under Section 11 of the *Environment Act* other jurisdictions may require that the project be approved under their own legislation. A common example is the possible need to obtain a permit under *The Fisheries Act* if fish habitat is involved.

While these guidelines apply to any watercourse crossing no matter how small, written approval for each crossing need only be obtained for those stream crossings that appear on 1:50,000 scale topographic maps. An application form is attached in Appendix "A". One application must be completed for each type of stream crossing on each trail.

Applicants for licensed trails can apply for environmental approval for the necessary bridges either after the location of the trail is approved in principle by Crown Lands or at the same time. A recommendation that a trail will be eligible to be licensed must be made by Crown Lands before any certificate of approval is issued. Stream crossings on private land or any land that is not Crown Land must be approved under Section 11 but there is no need to have a licence for that trail. In such cases, proof of title or land ownership will be required before any written approval is issued.

In actually filling out the application form, it is important that the details be provided accurately and completely. Incomplete applications cannot be properly evaluated and they will be returned. Obviously, this will cause delays in getting approvals issued. Where dimensions are asked for, these dimensions must be obtained by taking actual measurements at the site of the proposed stream crossing. The bridge design should be customized for each site. In designing the bridge one should follow the important principles of these guidelines but actual details will be based on the actual site conditions, availability of materials to use for construction, ability and skill of the proponent and the constructability. Some people like to build elaborate structures, others prefer to keep things simple. Regardless of what these details actually are, they should be described fully in the application.

Each application will be evaluated to determine if the crossing is likely to avoid causing any impact on water resources. Applicants should be aware that structures are not evaluated for personal safety requirements or structural strength in terms of load carrying capacity. This is the owners sole responsibility. However, structures that appear likely to fail and can thereby cause obstruction of water flow or other environmental damage, can be refused environmental approval unless structural analysis is carried out.

The certificate of environmental approval will be subject to terms and conditions specifying such details as the location, size, materials, methods of construction, site preparation and restoration, and methods to control silt. These terms and conditions must be adhered to strictly. When the crossing is completed a completion report

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which is a form attached to the certificate must be signed and returned promptly. A certificate of approval is generally valid for two years. This applies to the construction phase only. A bridge crossing can be used indefinitely as long as it is kept in good repair. A certificate of approval for fording will be valid only for the period specified in the certificate.

Applicants for approvals should note that it takes about 3 to 6 weeks to process an application for approval beginning from the time that it is received by the Water Resources Division. All applications are reviewed on a first come first serve basis. However, failure to provide complete information will result in delays since the proposal cannot be assessed properly and the approval may take considerably longer than 6 weeks.

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF ENVIRONMENT AND LABOUR



CHAPTER 4
Environmental Guidelines for
BRIDGES

WATER RESOURCES MANAGEMENT DIVISION
Water Investigations Section

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January 12, 1989

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4.1 General

Bridges are often required to provide access across large rivers, and streams, to cross wetland or flood plain areas, or to cross narrow lakes, ponds or ocean inlets. There is obviously a direct economic and social benefit for a bridge in that it shortens the time of travel between two points or it replaces an inconvenient mode of travel such as by ferry. Most bridges are constructed to carry traffic, however, bridges may also be constructed for railways, pedestrians, conveyors, pipes or other special uses. Not all bridges are new; sometimes there is a need to replace an old bridge or to improve a bridge to carry more traffic or heavier loads.

It is environmentally desirable, even on small streams, to construct bridges instead of other alternatives such as culverts because only bridges can avoid the alteration of flow regimes. (See Figure 4.1). Such problems as flooding, erosion, and siltation are avoided through the use of properly designed and constructed bridges. Bridges are recommended for all watercourses supporting anadromous fishes because there is no need to disturb the streambed and sufficient capacity will ensure that flow velocities are kept to a level where fish passage is maintained. Bridges are also recommended where the natural channel is too steep to accommodate maximum culvert slopes or where steep banks would necessitate a great deal of infilling if culverts were used.

Consideration of such factors as channel gradient, flow velocity, channel cross-section, channel roughness, discharge patterns, peak water levels, quantity of flow, ice formation, etc., are required for comprehensive hydraulic

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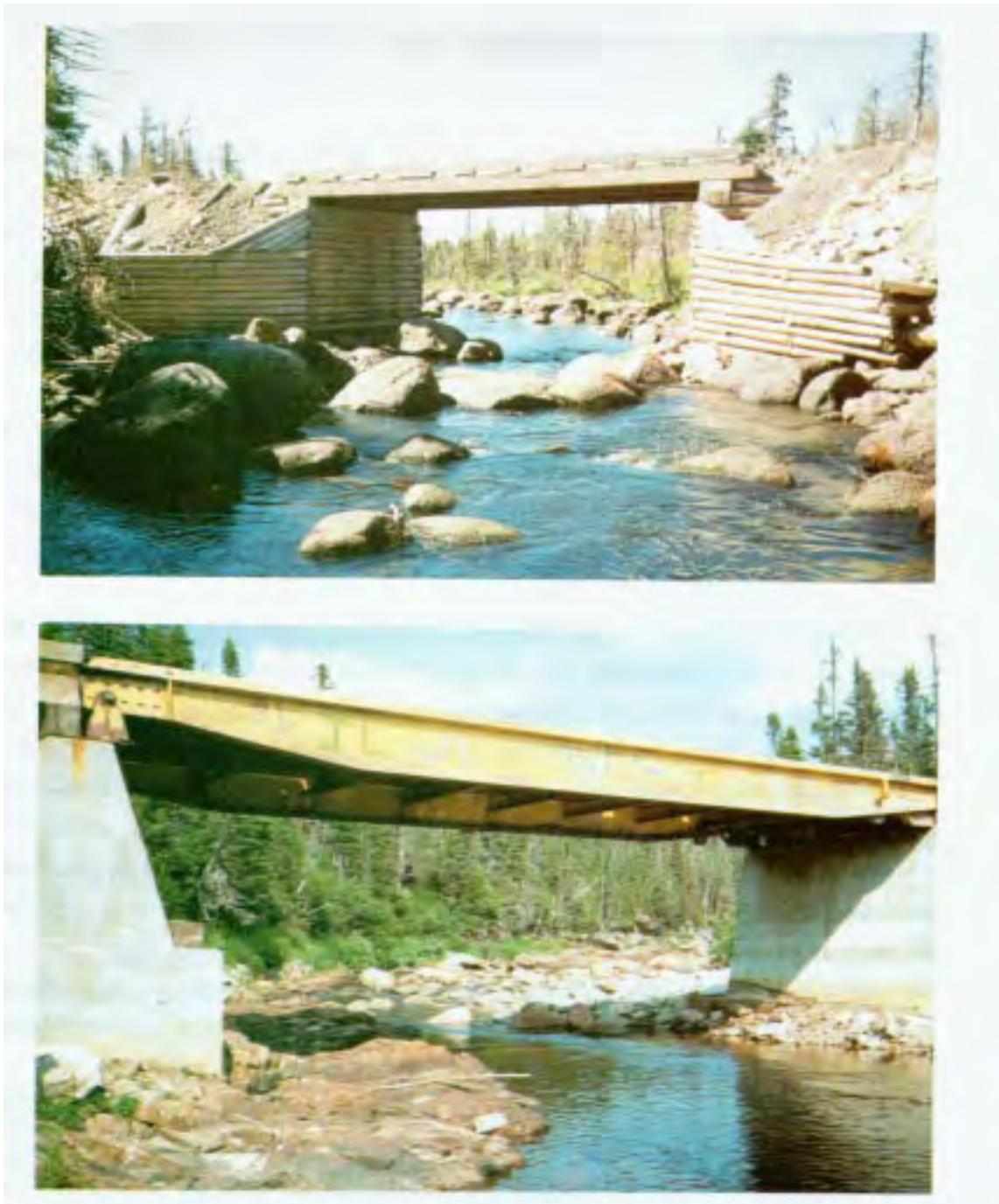


Figure 4.1

Bridges can avoid alterations to the flow regime.

and hydrological design. Physical geographic and geotechnical considerations such as channel morphology, geological history, bed and boundary materials, sedimentation, and erosion are other points to be considered.

The completed bridge should safely accommodate reasonably predictable levels of flow and ice buildup as well as the forces of moving water and ice upon the structure without causing any adverse environmental impact at the crossing or in upstream or downstream areas. Table 4.1 lists the major points for consideration of a proposed bridge design.

Improper or inadequate design and construction of bridges have caused problems of considerable magnitude. The erosive action of flowing water, high rates of discharge, and the movement of ice can be adversely affected by bridges and cause environmental damage, flooding, great expense in loss of property and even loss of human life. Usually the first thing to fail in a poor bridge design is the bridge itself. Figure 4.2 shows bridge failures resulting from unanticipated bed scour.

It is therefore imperative that all bridge installations be properly designed and constructed to perform safely and adequately under varying natural conditions. This always involves the use or application of proven methods of hydraulic and hydrological design.

Table 4.1 Points for Review of Bridge Design Proposals

Bridge Location and Alignment	<ul style="list-style-type: none"> - Is the need for a bridge in this area economical and fully justified? - Do plans show the relationship of the bridge to the river, floodplain, valley, etc.? - Does the location and alignment appear appropriate, having regard to the nature of the stream and to routing requirements? - Has attention been given to effects on adjacent works and property or effects of existing works on the proposed structure?
Bridge Height and Waterway Opening	<ul style="list-style-type: none"> - How have design high-water level and discharge been determined? - Has adequate clearance been allotted in excess of the design high-water level? - How well would the bridge withstand a flood in excess of design flows? - What is the estimated velocity and scour through the waterway opening? - Is the bridge opening at least as large as the natural waterway? - Is blockage by ice or other debris possible?
Road Approaches	<ul style="list-style-type: none"> - Are approach embankments, guide banks, or other training works secure against erosion or sliding failure following erosion at the toe? - If approach roads are liable to submergence in extreme floods, has adequate protection against washout been provided? - Have possible backwater effects of the project been estimated? - Has allowance been made for possible future shifting of the channel? - Are materials and workmanship for erosion protection adequately specified?
Pier and Abutment Details	<ul style="list-style-type: none"> - Are foundations secure against general and local scour? - Are piers, abutments and foundations properly aligned with the principal direction of flow and are they adequately streamlined? - Do foundations require specification of backfill material, or scour protection aprons?
Construction	<ul style="list-style-type: none"> - Will construction procedures cause partial blocking of the waterway and if so, what would be the consequences of high flows or ice runs during the construction period? - Has provision been made for complete removal of temporary construction works such as cofferdams, sheet piling, berms, etc.? - Has attention been given to scour around cofferdams?
Approvals and Standards	<ul style="list-style-type: none"> - Have all statutory requirements been met and approvals obtained from all authorities having jurisdiction? - Does the project as a whole, meet desirable standards for environmental preservation and have possible alternatives been sufficiently considered and evaluated?

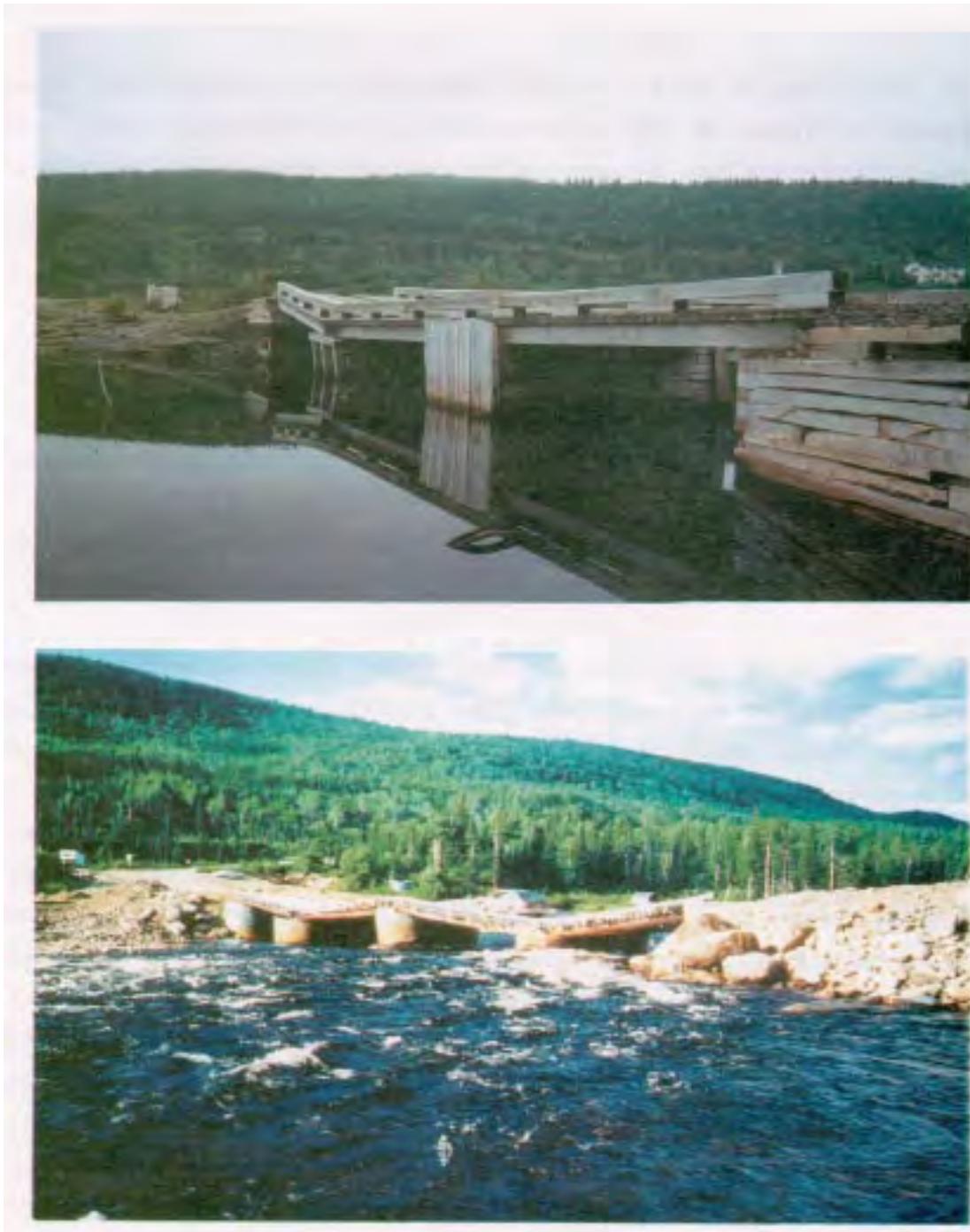


Figure 4.2

Bridge failures caused by scour around piers.

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4.2 Site Selection

The site selected should enable construction of a safe, economical, and easily maintained crossing, having regard to routing and approach requirements, to the nature of the waterway and its environment, and to minimize the use of such training works as may be necessary to deal with adverse natural channel features.

In selecting a site, it is important to examine the physical characteristics of the watercourse and its drainage basin. These characteristics are determined by geology, topography, climate, and land use, and may be divided into four groups. (Also see Figure 4.3).

- geographic: physiographic setting, geological history, channel pattern, etc.
- hydrologic: discharge patterns, water levels, ice etc.
- hydraulic: slopes, cross-sections, velocities, roughness, etc.
- geotechnical: boundary materials, erosion, scour and sedimentation, etc.

The complex interactions between these characteristics produce a wide variety of stream types. The general patterns of variation in all of these characteristics, and the relationships between them, are often referred to as the river's "regime", in the same sense that "climate" is used in considering meteorological variables. In regard to scour and erosion, behavior of a stream may fall within a wide range, from a very stable bedrock channel to a highly mobile alluvial river. Many rivers exhibit complex changes in behavior from point to point, because of the strong influence of local

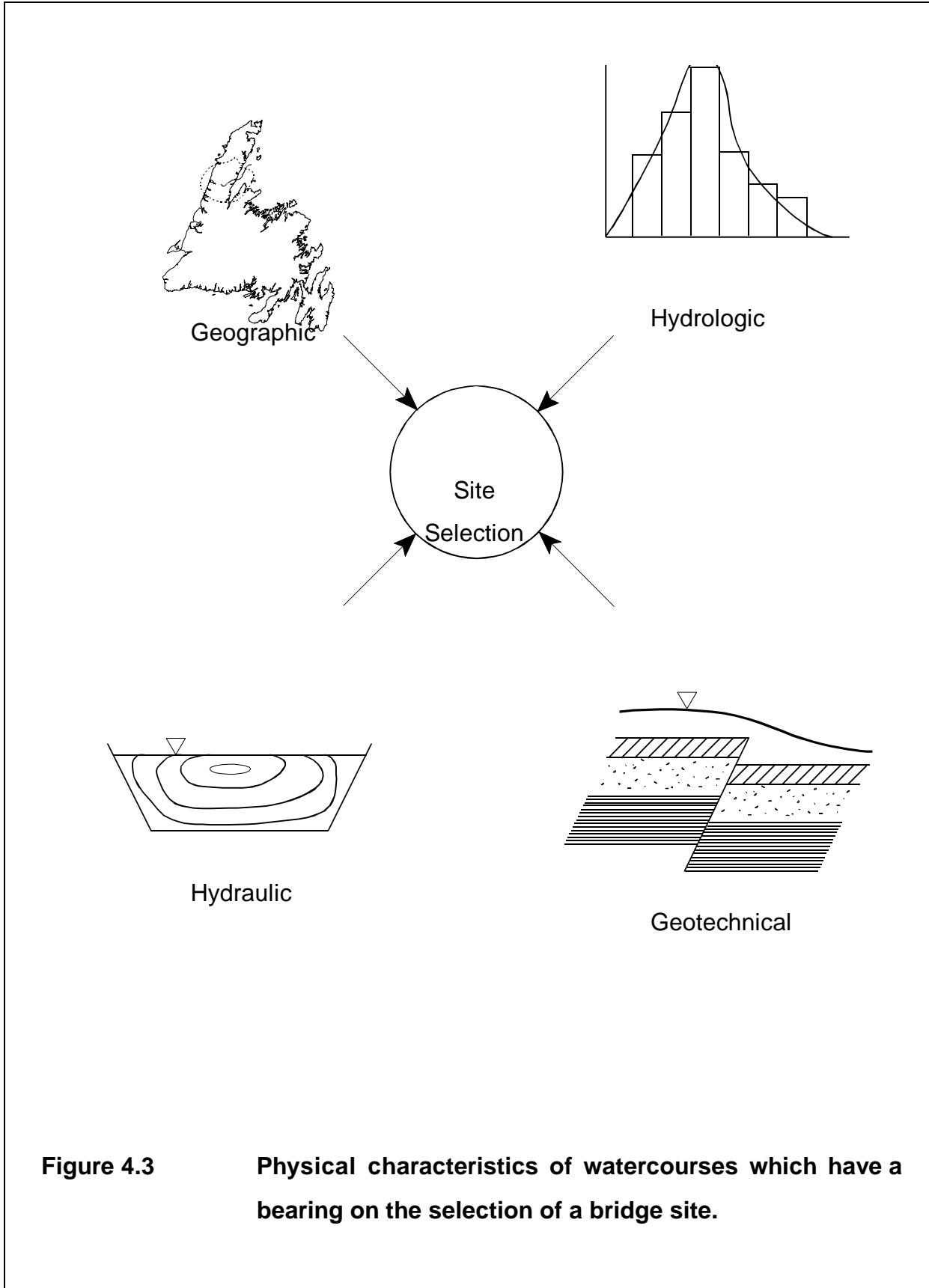


Figure 4.3 **Physical characteristics of watercourses which have a bearing on the selection of a bridge site.**

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features associated with glaciation. Careful investigation of past behavior at a particular site is therefore important. The choice of site may greatly affect the difficulties and expense of building a crossing as well as its long term performance, stability, and amount of maintenance required. It is therefore necessary that field studies be conducted during route selection to choose the best location for the bridge installation.

4.2.1 General Route Selection

Bridges are a significant component of any new road especially in terrain where streams or flood plains are numerous. A new route should minimize the number and length of crossings required, thereby keeping environmental disruption as well as overall costs to a minimum.

4.2.2 Suitable Site Characteristics

Stream characteristics and geology often vary significantly over short lengths of river. A suitable crossing site should be at a stable reach having good flow alignment. The liability of scour or bank erosion must be investigated and should be an important site selection criterion. When streams are braided, ie., split into two or more channels, a single channel location is preferred.

4.2.3 Bridge Alignment

The alignment of a bridge relative to the waterway should be at right angles. This will reduce the length of bridge required to cross. In meandering and shifting streams attention must be given to past trends to ensure that the stream at the selected location will not shift. In some instances it may be necessary to construct training works.

Straight lengths of channel are preferred for the crossing. Crossings on abrupt bends should be avoided except when the stream is in erosion resistant materials.

4.2.4 Alluvial Fans

Crossings of alluvial fans should be avoided because of the aggradation of the channel. The preferred crossing location is near the apex or head of the fan.

4.2.5 Sites of Flooding

Bridges should not be located in areas which are known to flood periodically. The presence of a bridge often aggravates the problem. One should also be aware of typical ice jam locations and these should be avoided.

4.2.6 Location of Other Structures

There are so many possibilities here that possible precautions can only be discussed in general terms. The presence of other structures can have a significant bearing upon site selection. For instance other crossings may affect or be affected by the proposed bridge. Dams, both upstream or downstream obviously have considerable bearing. In some cases other structures are not even built but are proposed and may influence a bridge site.

4.2.7 Approaches

Approaches to the proposed bridge must meet requirements of grade and alignment for safety reasons.

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4.3 Bridge Design

a) Design Flood Frequency - The hydrologic and hydraulic design of a bridge is essentially a two step process. The first step is to estimate all of the forces or quantities which would impact on the installation for an appropriate return period. The second step is to design all the structural components to accommodate these forces or quantities with some margin of safety. While such factors as the weight of traffic, earthquakes, wind and other forces are of great importance, these guidelines are primarily concerned with the flow and quantity of water, hence the hydrologic and hydraulic design.

Obviously no structure is designed to last forever. Equally true however, is the fact that the more valuable or important the bridge is, the longer it should be expected to last. The longer a bridge is expected to last, the more likely it is that it will be subjected to an extreme event or flood. The term "return period" is used to indicate a probability that a flood of a certain magnitude will occur. For example a 100 year return period flood is a flood whose flow would be exceeded on average once every 100 years.

The selection of an appropriate return period as mentioned above depends on the value of the bridge. This includes the cost of repair or replacement if the actual flows exceed the design flow and cause damage to the structure. However the selected return period must also reflect the importance of the reliability of structure, possible secondary damages to other property and environmental consequences of bridge failure. An

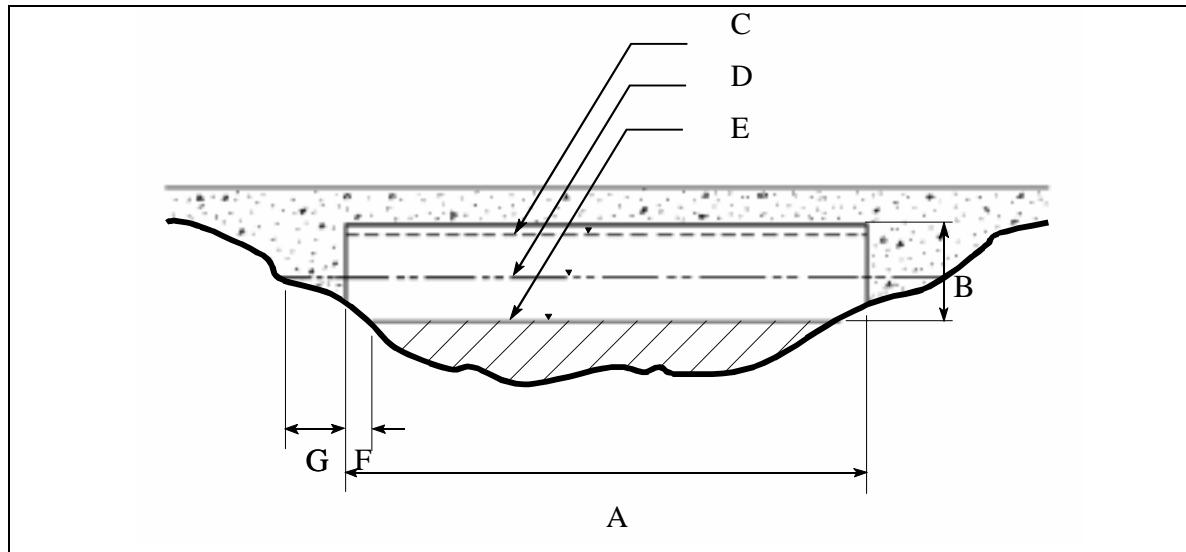
Table 4.2 Recommended Design Return Periods For Bridges

Road Classification	Return Period in Years
Freeways, (Trans-Canada Highway)	100
Urban Arterials	100
Rural Arterials	50
Collector Roads	50
Urban Local	50
Rural Local	25
Forest Access Roads	20
Any Bridge Exceeding 6.0 m Span	20

Modification of these recommended return periods should be considered in the following cases:

- If flood hazards in the area are known to be unusually severe.
- If the road is the only route to a community or essential service such as a hospital.
- If the road classification is likely to be upgraded.
- If there is property or facilities which apart from the bridge itself, could be damaged in the event of flooding, scour or other damage related to a bridge failure.
- If the bridge is located in a 1 in 100 year flood zone as designated under the Canada Newfoundland Flood Damage Reduction Agreement.

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A - Length = normal stream width + (2 x 0.5 m), or,
1:10 year stream width - 10%

B - Height = sufficient to pass design flow along with waves, ice and debris, without contacting the bridge

C - Maximum Design Flow

D - 1:10 year high water level

E - Normal water level

F - Abutment Placement = set back 0.5 m from normal water's edge

G - Permissible Flow Constriction = total flow constrictions of no more than 10% of the 1:10 year flow width

Note: Capacity of Bridge = (Length x Height) + (Shaded Area in Figure)

Figure 4.4 **Typical bridge dimensions to be determined in bridge flow capacity design.**

economic analysis or cost-benefit analysis should be considered in determining the most economical design of bridges.

4.3.1 Return Periods for Hydrologic Design

Return periods for bridges should be selected with reference to Table 4.2.

b) Capacity - The bridge opening is the product of the width and height plus the cross-sectional area of the stream as shown in Figure 4.4. The rate of flow that can pass through this opening without overtopping is referred to as the capacity. It must be noted however that width and height are independent of capacity requirements meaning that a bridge dimension may need to be larger than required by the design flow. For purposes of designing the bridge waterway opening and of calculating velocities, scour, and afflux, the design discharge arising from floods, tidal flows, or both in combination should be selected after due consideration of the following:

4.3.2 Historical Flows

The maximum historical flows as recorded at the site, or as calculated on the basis of recorded water levels, or as calculated on the basis of measured discharges at other points on the river from which corresponding site discharges can reasonably be inferred, may be used.

4.3.3 Flood Frequency Analysis

The discharge derived from a frequency analysis and corresponding to flood and/or tidal conditions of a frequency appropriate to the

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importance and value of the structure. Results of Regional Flood Frequency Analysis (RFFA) are available from this department.

4.3.4 Other Discharge Estimates

Where insufficient information is available to yield an estimate of the actual maximum discharge at the site over a historical period of reasonable length, or to provide an adequate frequency analysis, the design discharge may be estimated by any other reasonable method such as regional flood frequency, unit hydrograph, maximum probable storm, rational method, etc. Estimates may be made of maximum flow rates based on the area of the drainage basin, rainfall intensity-duration, and other appropriate data, which would indicate the flows that could be anticipated.

4.3.5 Anticipated Land Use Changes

The marginal cost of increasing a proposed design parameter may be small enough to warrant over sizing in order to be assured of good future performance. This is especially true if land use changes are likely to occur in the drainage basin upstream of the bridge.

4.3.6 Design Discharge Verification

When the design discharge is based on historical maxima, frequency analysis, or other empirical methods, it is advisable to check whether the historical record reflects trends or discontinuities in the flow regime resulting from land use changes, engineering works, or other causes; and to consider whether such changes are likely to occur in the foreseeable future.

4.3.7 Discharges Controlled by Reservoir Releases

Before counting on significant reductions in natural flood peaks because of storage reservoirs or other upstream works, the probable operating and routing procedures should be investigated. Where possible, a written statement should be obtained from the competent authorities.

4.3.8 Flow Duration

The probable duration as well as the magnitude of large flows may be significant, especially with reference to scour.

c) Bridge Height - The height of the deck should be such that the superstructure is not endangered by the action of flowing water, ice, floating debris, or waves, and the roadway is not rendered impassable except under clearly understood and permitted conditions. The selection of design values and safety margins for high water level and discharge raises difficult questions. The approach recommended here is to adopt design values which set limits of serviceability for the structure, and then ensure that under design conditions the margins of safety against structural failure are sufficient. This margin should be set by the engineer in each case, having regard to the reliability of the data on which the design values are based, to the probability of occurrence of greater values, to the consequences of failure, to the type of structure chosen, and to economic factors.

For the purpose of selecting a minimum height for the bridge superstructure, the design high-water level should normally be selected after due consideration of the following:

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4.3.9 Maximum Historical Water Level

The maximum historical water level as observed or recorded at the site, or as inferred from observed or recorded levels at another point on the river or waterway from which levels can reasonably be transferred to the site in question may be used.

4.3.10 Frequency Analysis

The water level derived from frequency analysis and corresponding to flood, tidal, or ice conditions of a frequency appropriate to the importance and value of the structure may be used for design parameters. The peak stage of flood flows may also be estimated using methods indicated in part (b) above.

4.3.11 Clearances

Additional height should be included if there is a history of ice accumulation, or if floating debris poses a potential problem. On navigable water courses sufficient clearance for vessels must be provided.

d) Bridge Length - The length of bridge works should be such that the opening is able to pass the maximum flows that may be expected without endangering the bridge or appurtenances by scour, without creating major maintenance problems, without causing unacceptable backwater effects upstream, and without causing currents, waves, or turbulence unacceptable to navigation or other legitimate interests. It should be possible to pass

expected quantities of ice, logs, and other debris without endangering the structure or adjacent property as a result of jams and accumulations.

4.3.12 Width on Regular Channels

Where a stream has a single, well defined channel of fairly regular width, and flood flows are more or less confined to the channel, the bridge should clear the entire channel with abutments set back 0.5 m from the normal high water edge. Also, in no case should the bridge reduce the channel width by more than 10% of the 1:10 year flood flow width.

4.3.13 Width on Flood Plains

In situations with low flood plains, where a substantial portion of the design discharge normally flows across the overbank areas, the question arises of whether to divert all the overflow through a single waterway opening in the main channel, or to provide relief spans on the flood plain. The former solution is usually more economical, but if the road crosses the valley at an angle, relief spans or culverts may be necessary to prevent excessive backwater effects.

4.3.14 Width on Irregular Streams

In the type of stream where the channel width varies greatly from point to point, the narrower sections may normally be used as a guide to determine a suitable bridge length, provided overbank flow is taken into consideration.

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4.3.15 Overtopping

In flat, low-lying terrain subject to widespread flooding it may be acceptable to allow overtopping of roadways in extreme floods, thereby reducing the discharge to be passed through the bridge waterway opening. In such design, provision must be made to prevent any road washout by having a designated overflow section which is suitably protected against erosion.

4.3.16 Existing Bridges

The hydraulic performance and capacity of existing bridge waterway openings should give valuable guidance on the required length of a new bridge at another site on the same stream. In some cases experience may indicate that an existing bridge has been too short, allowing approach washouts, overtopping of the approach roadways, or unacceptably deep scour to occur. The weight to be given to such evidence depends of course on how long the existing bridge has stood, to what extent it has endured severe floods and ice conditions, and to what extent stream bed conditions at the new site conform to those at the existing site. A new or replacement bridge will generally be larger than an existing bridge.

e) Bridge Type - Having selected a site for the bridge and having established height and width requirements of the superstructure, the designer must then choose a type of bridge. This choice depends on the functional requirements of the bridge in regard to the hydrologic and hydraulic regime, the economics of construction, live-load requirements, foundation conditions, environmental constraints, maintenance

considerations, policies of the owner, availability of materials, and preference of the project designer.

Some variables in bridge design include:

- the geometry and length of the approaches,
- the type and location of the abutments,
- the number and location of piers.

Commonly used bridges consist of fairly simple timber, steel or concrete spans. Certain applications may call for arch, truss or suspension design.

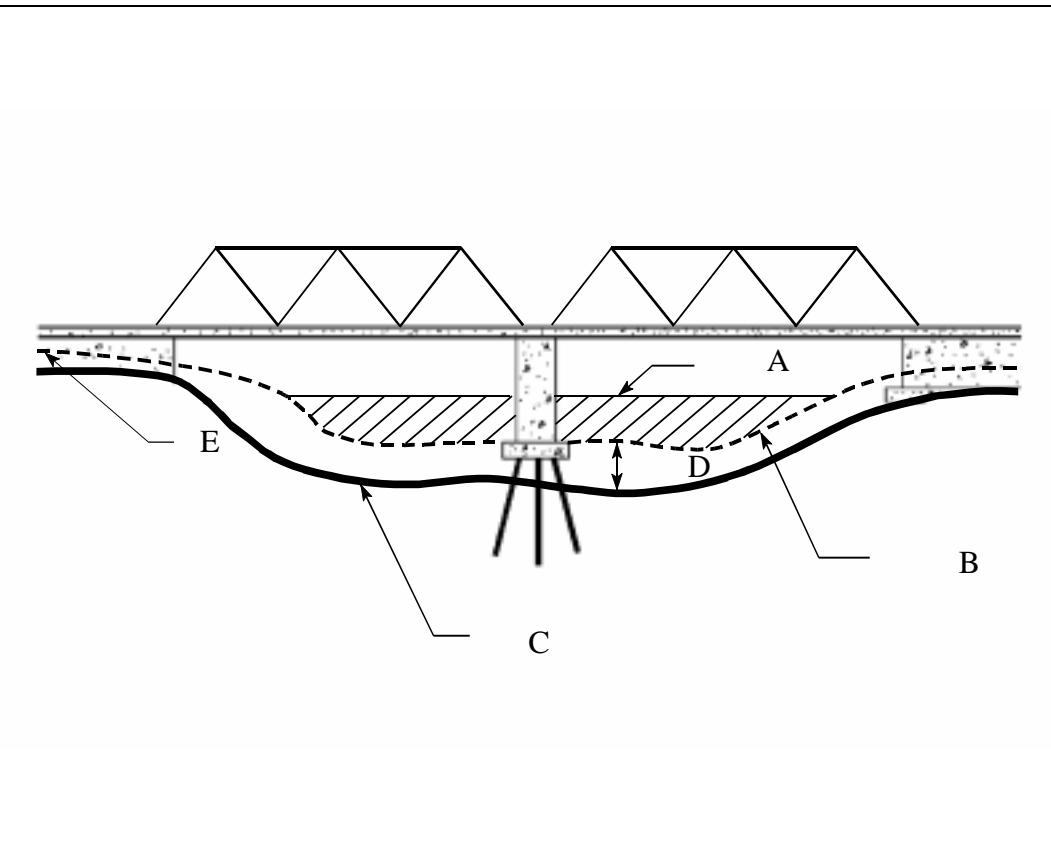
4.3.17 Environmental Impact of Bridge Type

The arrangement and details of piers, abutments, approaches, training works, and temporary construction facilities, so far as it is compatible with requirements of structural adequacy, safety, economy, and aesthetics, should be designed to minimize local scour, obstruction of flow, and inconvenience to legitimate interests.

4.4 Abutments and Piers

The erosive action of running water in streams resulting in the carrying away of material from around bridge piers and abutments has long plagued persons responsible for bridge design, construction and maintenance. Bridge embankments projecting into wide flood plains may cause concern because they can produce scour problems in two ways; first, by concentrating the flow at the upstream corners of the embankments, and

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A - Normal Water Level

B - Original Stream Bed

C - Scoured Bed at Flood Risk

D - Depth of Scour

E - Flood Plain

Figure 4.5

Bed load movement at times of high flow and general scour require careful consideration to prevent abutment or pier failure.

second, by constricting the flow with a resulting increase in water levels. (See Figure 4.5).

4.4.1 Abutment Location

Abutments should be set back from the normal wetted perimeter of the watercourse to avoid constriction of the channel and reduction of the flow area. For the same reason, the bridge design should use as few in-stream piers as possible and the width of the piers, perpendicular to the direction of flow, should not be in excess of what is necessary for safe and adequate structural support.

4.4.2 Foundation Depth

All foundations for abutments and piers should be set well into the substratum to provide a solid base for the structures. The foundations should also extend below the estimated lowest scour levels.

4.4.3 Hydraulic Design

Abutments and piers should be designed and constructed to provide the least amount of hydraulic resistance. Abutments should be constructed with tapered wing-walls upstream and downstream of the bridge and preferably be inclined into the embankment at a 1/16 angle to the vertical axis for increased structural stability. Piers should be constructed with ends which are tapered upstream and downstream in the direction of the main flow.

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4.4.4 Erosion Protection

Where scouring around abutments or piers may occur, erosion protection should be provided. For this purpose a protective apron of rip-rap or other suitable material may be installed, preferably at a depth below the expected general scour level. Simply heaping stones around abutments is often unsatisfactory because this type of protection tends to require continual replacement.

4.4.5 Concrete Components Vs. Wood Components

Where a solid rock foundation is available, concrete structures are strongest, most erosion resistant, and provide a longer term of service. Concrete abutments and piers are therefore preferred from an environmental standpoint to wooden structures.

4.4.6 Wooden Abutments and Piers

If wooden abutments and piers are to be used, squared timber is preferred to round logs. Squared timber can provide relatively tight, uniform surfaces which provide less hydraulic resistance. Filler timbers should be used between the corner lapped crib timbers to close all openings in the abutments or piers. The timber cribs should be filled with gravel and small rock and consolidated. Protection from ice damage should be provided where timber cribs are exposed to moving river ice, by surfacing vulnerable portions of the structure with steel plating.

4.4.7 Log Cribs

Log crib abutments and piers should only be used for temporary bridges and should be completely removed at project abandonment. Where possible, avoid the use of log cribs. Where log crib abutments and piers are used, such as on forest access roads, the following guidelines should be taken into account to mitigate environmental impact:

- Avoid constricting the watercourse between abutments or with large instream piers.
- Minimize crib pier width and ensure that the pier design prevents the accumulation of debris on the pier.
- Place the lower crib logs deep enough below the streambed to prevent undermining by scour.
- Backfill the lower section of the crib with clean, broken rock.
- Provide well graded rip-rap or armour rock around the structure for protection from scouring or erosion.
- Use "filler" logs between the timber crib logs to completely enclose the sides of the structure.
- All logs should be peeled.

4.5 Recommended Construction Practices

It is during the actual construction of a bridge that there is the greatest danger of causing environmental disruption. Common problems can be categorized as pollution, siltation or disruption of environmentally sensitive areas. Poor bridge construction practices having no regard for these potential problems are liable to cause destruction of habitat for fish, wildlife and vegetation as well as degradation of water supplies used for human

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consumption. These problems may be temporary or long term, or may not become evident until later. For instance, the loss of natural stream bank stability may cause erosion which in turn may create long term problems of channel instability.

The following guidelines cover the most typical areas of bridge construction where the engineer, contractors and site personnel must be made aware of good construction techniques and precautions. However, because of the similarity of all construction near water, the reader is directed to more detailed discussion of the various topics in the appropriate chapters.

4.5.1 Work in the Dry

Operation of heavy equipment should be confined to dry stable areas in order to reduce the amount of mud and heavily silted water at the construction site which could enter the watercourse.

4.5.2 Fording

The operation of heavy equipment in a watercourse or fording of watercourses with heavy equipment should be avoided wherever possible as this can contribute to destabilization of the channel bed and banks resulting in erosion and downstream deposition, and can also cause serious downstream siltation and water quality problems. If fording of the watercourse with heavy equipment is required this should be carried out according to the guidelines of Chapter 6, "Fording".

4.5.3 Use of Cofferdams During Channel Excavation

When excavation is required within the channel, as in the placement of footings for abutments or piers, measures should be taken to separate the excavation area from the flow by cofferdams. Chapter 13, "General Construction Practices", contains information on the construction and use of cofferdams.

4.5.4 Prefabricated Structures

Bridges do not have to be completely constructed on site. Prefabricated structures that can be transported to the site are preferred as they minimize the work adjacent to the watercourse. Precast or prefabricated superstructures also avoid extensive use of fresh concrete on site which can cause serious water quality problems and pollution.

4.5.5 Concrete Work

When fresh concrete is to be used in components of a bridge structure, all necessary precautions should be taken to prevent the fresh concrete from coming in contact with the watercourse and should be carried out according to the guidelines of Chapter 13, "General Construction Practices".

4.5.6 Use of Wood Preservatives

If creosoted or preservative treated wood is used in the bridge components, every precaution should be taken to prevent such toxic substances from entering a body of water. Any such substance should be applied to the wood at a site which is not environmentally sensitive and away from any water bodies. The treated material

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should be brought to the site and installed only after proper curing and drying has been achieved. Creosoted wood must not be used in bridges crossing over fresh water.

4.5.7 On Site Use of Petroleum Products or Hazardous Substances

Where fuels such as gasoline, diesel fuel, kerosene or any other petroleum distillates or other substances which could cause pollution are being handled, stored or applied, containers containing in excess of 20 litres should be kept a minimum of 60 m from any surface body of water. The storage and handling of gasoline and any petroleum derivative must be carried out according to *The Storage and Handling of Gasoline and Associated Products Regulations, 1982*.

4.5.8 Avoid Bank Disturbance

At all times, every necessary precaution should be taken to prevent the disturbance of channel banks, bank vegetation, and land within the high water zone, flood zone, or recommended buffer strip of any body of water outside of the land designated for construction of the roadway and bridge abutments. Further information is contained in Chapter 12 "Buffer Strips" and in Chapter 13 "General Construction Practices".

4.5.9 Containment And Treatment of Silted Water

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with *The Environmental*

Control (Water and Sewage) Regulations, 1980, which is included in Appendix A. Further information on reducing the amount of silted water generated by construction operations and methods for treatment are contained in Chapter 13 "General Construction Practices".

4.6 Site Rehabilitation and Stabilization

4.6.1 The Necessity of Site Rehabilitation

Toward the completion of the bridge installation, site rehabilitation should be carried out to stabilize slopes, disturbed areas and other areas vulnerable to erosion, to provide revegetation, and to ensure the site is left in a condition which is environmentally acceptable. Chapter 13, "General Construction Practices", contains detailed information on site rehabilitation.

4.6.2 Protect Bridge Abutments

Bridge abutments should be protected from erosion or scouring by the careful placement of armour stone or rip-rap at vulnerable areas upstream and downstream of the abutment wing walls.

4.6.3 Stabilize Road Embankments and Ditches

The roadside embankments and roadside ditches near the watercourse should be stabilized by providing low side slopes and low grade and by providing rip-rap.

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4.6.4 Protect Vulnerable Areas

Where river banks or other vulnerable areas have been disturbed, rehabilitation should be carried out to reinstate these areas and ensure adequate erosion protection. Protective rock or vegetative covering should be provided, as appropriate.

4.7 Inspection, Maintenance and Other Concerns

4.7.1 Frequent Inspection Needed

Bridges require frequent inspection to determine if they are performing satisfactorily without causing any environmental problem and to identify any problems which may threaten the bridge structurally.

4.7.2 Comprehensive Annual Inspection

A full inspection should be carried out annually after peak flow as well as periodic spot checks during times of high flow conditions. The annual inspection should involve examining the stream channel above and below the bridge to determine if any significant changes in the channel are evident. Sounding around piers and abutments to assess scour and deposition should be carried out.

4.7.3 Periodic Spot Inspections

Periodic spot checks during peak flow should identify:

- The adequacy of the bridge's capacity to safely pass peak flows with sufficient freeboard to the bridge deck,

- The extent of backwater effects or flow constriction,
- Flow velocity,
- The high water mark,
- Locations where the hydraulic characteristics of the peak flow may induce scour or erosion,
- Locations where debris has caught on piers or abutments,
- If roadside and bridge deck drainage are working correctly and,
- Any apparent problem which may require further investigation or remedial measures.

4.7.4 General Maintenance

General maintenance work should be carried out as required from time to time. Grouting or resurfacing of structural components as well as the removal of debris which may become caught at piers, abutments, or locations upstream of the bridge will extend the useful life of the bridge and minimize the risk of failure.

4.7.5 Remedial Works

Where serious problems are evident such as extensive bed degradation, pier scour, bank erosion or considerable flow constriction, remedial measures may be required. Such problems are often the result of inadequate capacity or lack of erosion protection and preferably should have been addressed in the design stage. If, however, erosion control or river training works are to be carried out subsequent to the development of such problems, a comprehensive investigation or evaluation of the problem should be conducted. Prior to the installation of such works the effectiveness and the implications of the hydraulic changes must be determined. The use of scaled

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hydraulic models may be appropriate. Usually, a new environmental approval will be required because the work may be carried out by different contractors and because of the stream flow alterations involved.

4.7.6 Recreational Use

Some bridges are located at a junction of a major watercourse and a major transportation route. These sites may attract people who wish to gain access to the watercourse for fishing, boating, or other recreational activity. It is therefore desirable to provide off-road parking at a safe location near the bridge along with a foot path to provide ease of access and reduce the slumping of roadside embankments by foot traffic.

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF ENVIRONMENT AND LABOUR



CHAPTER 5
Environmental Guidelines for
CULVERTS

WATER RESOURCES MANAGEMENT DIVISION
Water Investigations Section

Chapter 5
Environmental Guidelines For
CULVERTS

Water Resources Management Division
Water Investigations Section

February 20, 1992

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5.1 General

Culverts are often used to provide access across drainage ditches, intermittent streams and small watercourses. Culverts can provide an efficient and inexpensive means of crossing provided they are properly designed and properly installed at suitable locations. Often culverts are also necessary to provide drainage where roads or other structures would interfere with the otherwise normal flow of surface runoff. Temporary or permanent culvert stream crossings are preferred to fording of small watercourses where extensive fording may give rise to channel destabilization.

On some streams it is environmentally desirable to construct bridges instead of culvert crossings because bridge installations can avoid extensive alteration of the flow regime which is inherent with most culvert installations. Bridges are also preferred to culverts in crossing all streams which support fish populations. Culvert installations usually result in more substantial alteration, or loss of sections of the natural channel bed and can cause a partial or total barrier to fish migration. Installation of culverts in major watercourses and rivers, instead of bridges, is not considered a good environmental practice.

Many types of culverts are available from suppliers, the most popular being corrugated steel pipe. Reinforced concrete culverts, and plastic pipe culverts, are usually available in round sections only. Corrugated steel culverts are available in a large variety of cross sectional shapes and sizes to suit varying stream conditions or requirements, the most popular shape being round or arched.

All culvert installations of significant size, including multiple or gang culvert installation, should undergo thorough hydraulic and hydrologic analysis. Factors such as channel gradient, flow velocity, channel cross section, channel roughness, discharge patterns, peak water levels, quantity of flow and ice formation must be considered.

The completed culvert installation should safely accommodate reasonably predictable levels of flow and adequately resist the erosive action of moving water without creating any adverse environmental impact at the crossing or in upstream or downstream areas. Flow quantity may be predicted through a variety of methods including the rational method, unit hydrograph, SCS Method, or Regional Flood Frequency Analysis. In addition to utilizing any of these methods a relevant amount of data must be collected on the stream and its watershed such as:

- historical streamflows
- velocity distribution in stream
- high water marks
- ice shove marks

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- precipitation data
- potential river scour data
- ice formation and ice jamming areas
- rating of erosion hazard
- surface drainage patterns
- floodplains
- surface area of rivers, lakes, bays, wetlands

While it is not always necessary or possible to determine all of the source data listed above it is generally advisable to have sufficient data to check expected flood flow by at least two independent methods.

The following sections of this chapter provide helpful information for culvert design and installation to ensure that the width and depth of flow expected in the stream under natural conditions is not significantly altered by the installation of culverts. Construction procedures should follow these guidelines with the primary objective being to prevent environmental damage such as pollution and siltation. These guidelines are intended to provide explanatory information and guiding principles but do not provide a complete code for design because certain design criteria such as load bearing capacity should be derived from appropriate texts. Engineering advice should be sought by lay people who wish to purchase and install their own culverts.

5.2 Culvert Location and Shape

The location of culverts is perhaps the most important consideration in installing an environmentally satisfactory culvert crossing. While the location of the road will probably be the primary consideration, it is important to realize that minor changes in road alignment may be necessary to avoid problem areas as far as culvert installations are concerned.

5.2.1 Select a Stable Location

Avoid locations where there are abrupt or short radius bends in the stream channel and areas where erosion, undercutting, or fine soils are evident. These areas are often subject to greater erosive force which could create problems for a culvert installation.

Heavy erosive action can lead to undercutting of the culvert and structural damage. In addition, these areas are often unstable and the channel may be shifting. If the stream bed is mobile it may eventually bypass the culvert, rendering the installation useless. Culvert crossings should be located on straight, stable channel segments with no evidence of heavy erosive action.

5.2.2 Select a Site With Uniform Channel Gradient

Select a culvert site where the channel gradient is uniform for a distance upstream and downstream in the channel. This will avoid areas where there may be sudden increases in water velocity immediately upstream or downstream of the installation. The gradient must be constant at the crossing itself. Culverts should never be installed with bends in them.

Steeper channel gradients result in higher flow velocity. This could mean that the installation would be subject to greater risk of erosion and washout caused by the momentum of water striking the culvert inlet area. Areas of low gradient should therefore be given preference.

5.2.3 Location With Regard to Ice

A culvert should not be located where large quantities of solid sheet ice are formed upstream. During spring runoff such ice may break loose and block the culvert. Outlet areas of small pools or ponds should therefore not be culverted.

5.2.4 Culvert Shape

The shape of a culvert should conform to the site conditions and to the flow regime at that location. While round culverts are the most popular, a variety of shapes are available (see **Figure 5.1**). Design options are limited by flow characteristics and highway alignment. Where elevation is restricted the designer may select a shape which is horizontally elongated to produce the same cross sectional area with less height.

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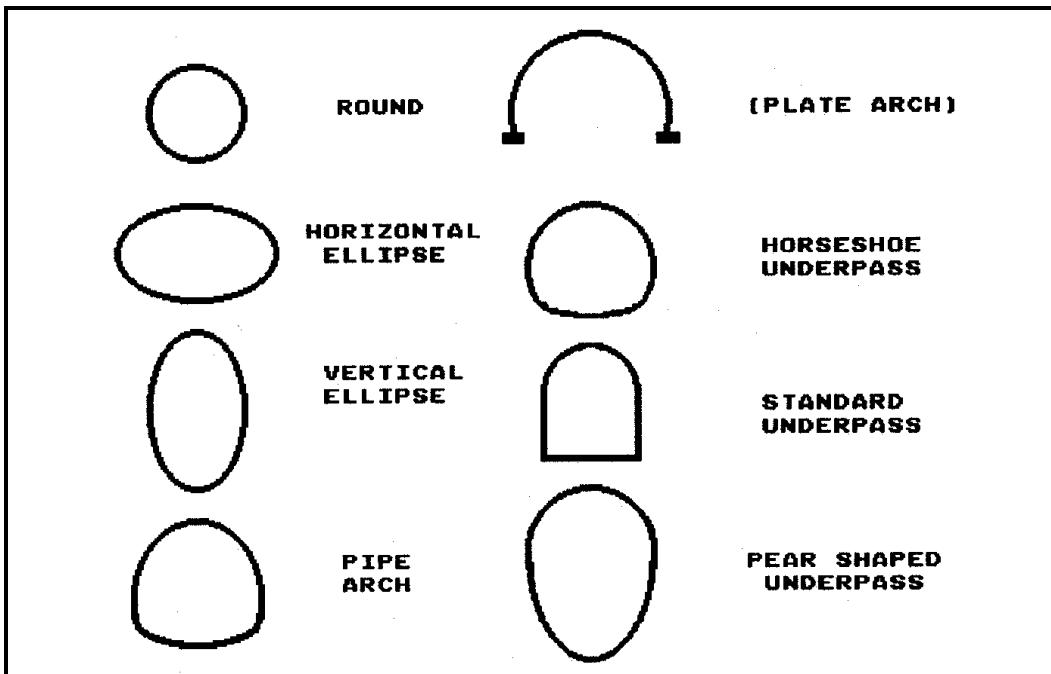


Figure 5.1 Common Shapes for Corrugated Steel Culverts

Although an open bottom arch is shown in **Figure 5.1**, arch "culverts" can be treated as bridges and are discussed in *Chapter 4, "Bridges"*.

Wider culverts result in lower flow velocity. At low flows wider culverts may have insufficient water depth to allow fish passage.

Generally, arch shapes are useful to reduce the elevation of fill, but they are more difficult to install. Elliptical shapes provide better low flow characteristics. Multiple barrels of the same size or different sizes may be easier to install and conform to the stream shape, but these installations are generally less efficient hydraulically when compared to larger single size pipes.

5.3 Culvert Capacity

All culvert installations should be designed to safely accommodate peak flow volumes estimated for that section of channel during the expected life of the culvert. This means that the size or capacity of a culvert should be commensurate with its expected serviceability. For instance a culvert installed under an infrequently used forest access road would not be expected to give the same degree of performance as a culvert installed under a major highway. Nevertheless all culverts must be installed in a manner which is acceptable from an environmental standpoint. When culvert

capacity is exceeded by a very large volume of flow or the capacity is reduced by blockage, there is a danger of:

- overtopping, damage to the roadway and traffic interruption
- consequential threats to human safety
- damage to adjacent property or the environment
- unsafe outlet velocities
- injurious deposition of bed load

Excessive headwater depth can contribute to a "piping effect" through the backfill material surrounding culverts. This can undermine culverts and result in a major washout.

Surcharge conditions can cause flooding upstream of the culvert and/or scour and erosion at the culvert inlet.

5.3.1 Provide Adequate Capacity to Prevent Surcharge

Culverts should be designed with adequate capacity to carry maximum design flows without creating surcharge or backwater conditions. In this regard culverts should be designed to carry the design flow with a headwater depth not greater than the vertical dimension of the pipe. Large culverts (over 2.0 m) should have a freeboard.

Small culverts under 2.0 m can use the California Balanced Design Method (see **Figure 5.2**), which specifies (1) a 10 year return flood can be carried without static head at the inlet, and (2) a 100 year return flood will be carried utilizing the full head available at the inlet.

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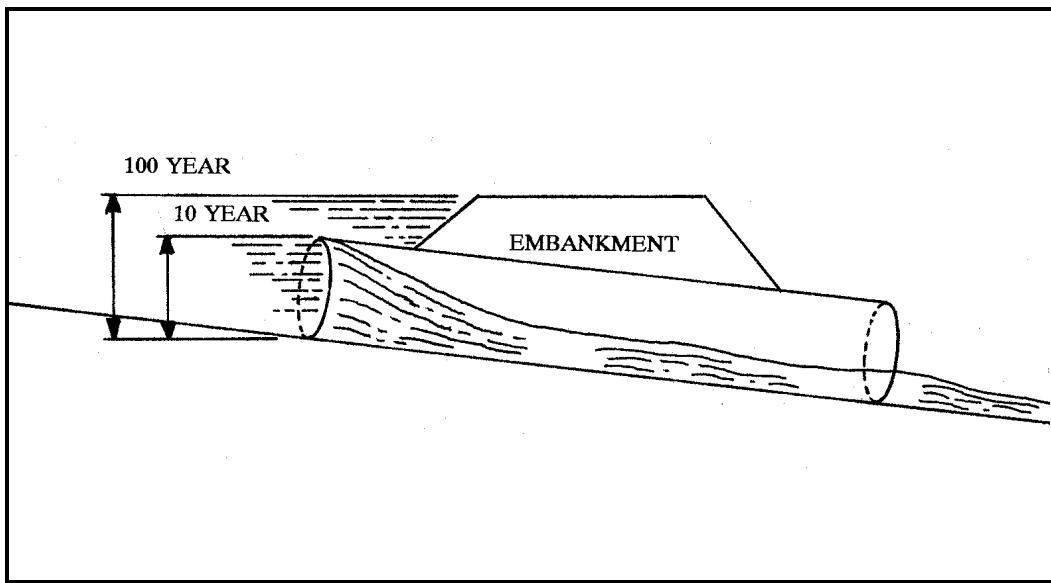


Figure 5.2 California Balanced Design Method

Where overtopping can be tolerated (ie. if none of the previously mentioned consequences of inadequate capacity apply except overtopping itself), the 100 year return period can be reduced to:

Freeways	50 year
Arterials	50
Urban local and collector streets	25
Rural and forest areas	20
Driveways and farm lanes	10

Typically, in Newfoundland, stream widths are greater than the culvert opening. The flow may become constricted, causing critical conditions at the inlet, a case called inlet control. The discharge of the culvert is controlled by the entrance conditions, which are:

- headwater depth
- cross sectional area
- type of inlet edge

The roughness, length, and outlet conditions of the culvert do not influence culvert performance. The entrance of the pipe acts as an orifice and is governed by the equation:

$$Q = C_d * A_o * (2gh)^{0.5}$$

where

Q = flow

C_d = experimental coefficient

A_o = area of orifice

h = height from centre of orifice to headwater surface

g = gravity constant (9.81 m/s^2)

C_d has a wide range and is primarily an indicator of the roughness of the opening. The influence of the edge roughness of the culvert decreases as the culvert diameter increases.

It is important to remember that under inlet control, the slope of the culvert does not affect the flow capacity. However, at high slopes the flow velocity in the pipe will be increased and may result in undermining at the outlet, downstream bed scour and damage to control structures.

5.3.2 Allowance for Limited Gravel Deposition

Culvert capacity should be designed to include provision for limited gravel deposition within the culvert if required for fish habitat reasons. (See **Figure 5.3**). This gravel should be sufficient to mimic a natural type of stream bed within the culvert, if the stream is a natural habitat for fish. Typically, the depth of allowable gravel deposition is $1/3$ of the diameter for culverts under 0.75 m diameter, and 0.3 m for culverts over 0.75 m diameter. Because the gravel deposition reduces the cross sectional area of the pipe, the diameter of the culvert must be selected to produce sufficient flow capacity even with gravel deposition.

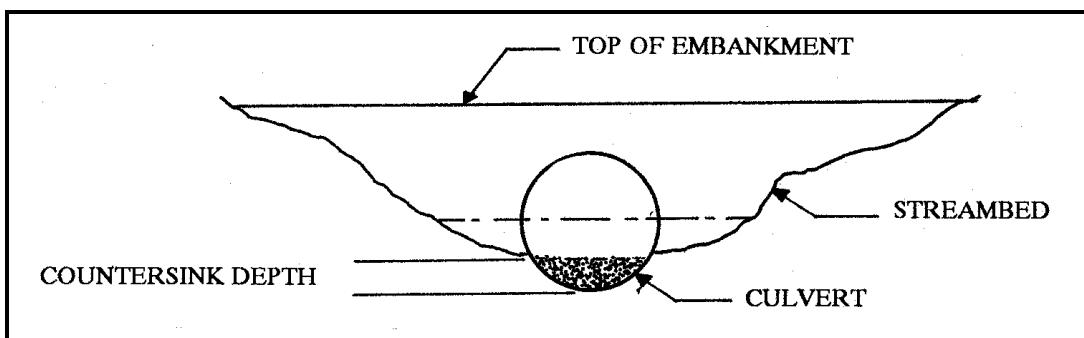


Figure 5.3 Countersunk Culvert

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Size selection is further complicated because the flow actually has three distinct hydraulic stages:

1.	Weir or open channel flow	$H = 0$ to $D/2$
2.	Flow known experimentally	$H = D/2$ to D
3.	Orifice flow	$H > D$

where

H = depth of water at inlet
 D = diameter of culvert

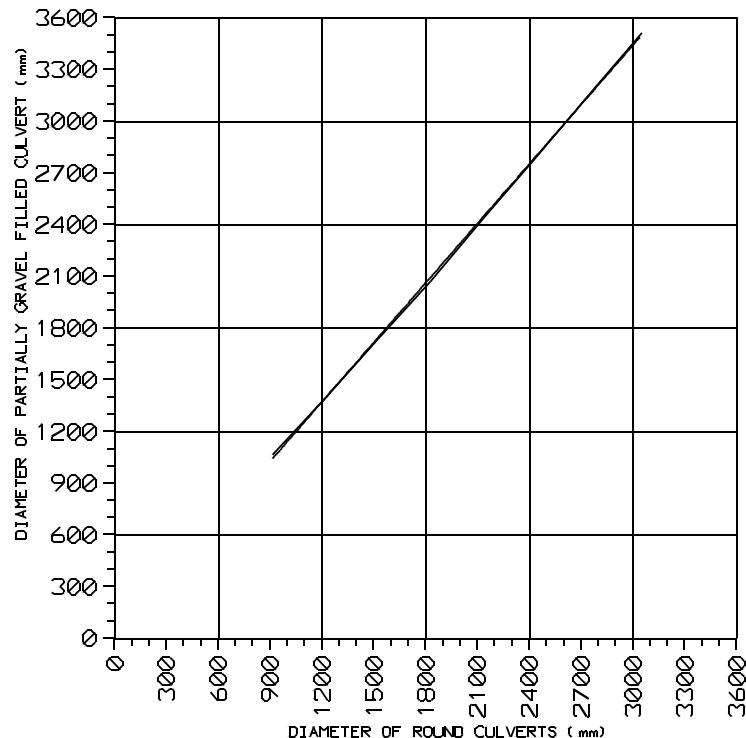


Figure 5.4 Conversion of Normal Round Culvert to Countersunk

Gravel deposition affects channel roughness, orifice roughness, and opening size. Consequently, in sizing a culvert allowance must be made for the reduced capacity resulting from this installation feature. Having used normal culvert design methods to estimate the appropriate size of culvert, **Figure 5.4** may be used to select the proper larger sized culvert to provide for countersunk installation.

5.3.3 Maintain Natural Stream Channel Capacity

Culvert installations should provide capacity equivalent to that of the existing natural channel. In this regard infilling of the channel or reduction of the natural cross sectional area of the channel due to the culvert placement and backfilling should be avoided. Pipe arches are a preferred shape over circular pipe in wide and flat bottomed streams.

5.3.4 Debris Control Structures and Culvert Capacity Should Address Maintenance Requirements

Many debris barriers or trash racks require cleaning after every storm. The expected frequency of debris removal should be considered in selecting the debris control structure. If a low standard of maintenance is anticipated, the designer should choose to pass the debris through the structure by ensuring adequate capacity.

5.3.5 Anticipate Reduced Capacity

Whereas the design capacity for a culvert installation may indicate an adequate installation purely from a hydrologic point of view, the possibility of reduced capacity must be anticipated. This is particularly important where there is ice, debris from logging or other forestry operations or debris from vandalism and littering. A culvert may require dramatic over sizing to allow passage of debris.

5.4 Flow Velocities in Culverts

5.4.1 Choose Design Velocities to Suit Existing Flow Conditions

The design flow velocity in culverts should be chosen to conform with existing natural upstream and downstream flow velocities. All factors which determine flow velocity through a culvert should be examined. These include:

- The slope of the culvert (grade on which it is placed),
- the roughness of the inside of the culvert,
- the design of the culvert inlet and outlet,
- the flow volume,
- the level or head of water at the inlet,
- backwater effects from downstream controls, and,
- the culvert type or more specifically the cross sectional shape which determines the perimeter in contact with the flowing water.

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Low inlet and outlet flow velocities are preferred for all culvert installations. High velocity flow can result in undermining, erosion, and washouts of culverts and can also create an impasse to migrating fish. The flow velocity at times of normal flow conditions should not exceed 0.9 m/s except in instances where very steep natural channel grade and high velocity flow in the channel dictate a high flow velocity through the culvert.

5.4.2 Results of High Velocities

The downstream results of higher velocities may involve:

- bed scour
- bank erosion
- structural damage or overtopping of control structures
- undercutting of culvert.

If the velocity is dissipated quickly by the stream the main problems will be bed scour and undercutting in the immediate vicinity of the culvert. The flow velocity causes sufficient shear force to overcome the gravitational and frictional forces holding bed material in place. Transport velocities for streambed materials are given in **Table 5.1**.

Table 5.1: Transport velocity for various sizes of streambed materials

MATERIAL	PARTICLE SIZE (mm)	VELOCITY (m/s)
silt	0.005 - 0.05	0.15 - 0.30
sand	0.25 - 2.5	0.30 - 0.65
gravel	5.0 - 15	0.80 - 1.20
pebble	25 - 75	1.40 - 2.40
cobble	100 - 200	2.70 - 3.90

5.4.3 Choose Correct Gradient

In most cases, culverts should be installed such that the gradeline coincides with the average streambed gradeline. Attempts to control flow velocity by changing the grade will have the following consequences:

- a) Culvert grade greater than stream; inlet will be elevated causing upstream ponding or outlet will be submerged and the barrel will act as a silt and gravel trap, eventually becoming blocked.

b) Culvert grade less than stream; inlet will have a drop or outlet will be hanging.

Both cases will act as an obstruction for fish passage.

While some deviation from the stream grade may serve to decrease flow velocity in a culvert, calculations justifying this deviation must be performed. If the desired flow velocity cannot be achieved this way, then it is obvious that a bridge, rather than a culvert, is required.

5.5 Culvert Installation and Construction Practices

Improperly installed culverts are a waste of the owners money, a threat to aquatic life, and may be a threat to the users of any structure built over or adjacent to them. A photograph of a poor culvert installation is shown in **Figure 5.5**.



Figure 5.5 Poorly Installed Culverts

Figure 5.5 illustrates several obvious problems encountered with culvert installation. The pieces of corrugated metal lying in the water indicate that sections of culvert

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have failed under load and collapsed onto the stream bed. The culverts are projecting from the fill.

There is no end protection to resist erosive action. It appears that the culverts have been placed haphazardly with very little concern for hydraulics, aesthetics, fish passage, or embankment protection. The embankment is poorly constructed and unstable.

Hopefully these guidelines will help installers avoid situations like the one pictured above.

5.5.1 Installation to Manufacturer's Specifications

The installation of all culverts should comply with the specifications prescribed by the manufacturer of that product, particularly in regard to pipe zone bedding material quality, degree of compaction, and minimum or maximum pipe cover for design loadings.

5.5.2 Operation of Heavy Equipment

The use of heavy equipment in waterbodies should be avoided. The operation of heavy equipment should be confined to dry stable areas.

5.5.3 Work During Times of Low Flow

All work involving minor alterations to the stream channel to permit culvert placement should be carried out at a time of low flow conditions. It is prudent however to be prepared for increased flows by scheduling work according to the weather forecast and to have a contingency plan for unexpectedly large runoff from a sudden storm.

5.5.4 Avoid In-Stream Excavation, Work in the Dry

In-stream excavation can cause considerable siltation and pollution of watercourses. If excavation of bed material or other extensive in-stream work is necessary, to make a level bed for the culvert for example, all flow should be diverted or confined to a section to allow the work to be carried out in the dry.

5.5.5 Control of Stream Flow for Culvert Placement

Streamflow may be controlled in any of a number of ways in order to provide a dry working area. Four methods which may be used include the following:

1. A temporary diversion channel. (See *Chapter 7, "Diversions, New Channels, Major Stream Alterations"*).
2. A temporary culvert(s).

3. Pumping. (See *Chapter 13, "General Construction Practices"*).
4. Confining flow to a channel section by use of cofferdams. (See *Chapter 13, "General Construction Practices"*).

5.5.6 Culvert Gradient to Follow Stream Gradient

The gradient of all culverts as far as possible should follow the stream channel gradient and should be placed in line with the direction of the main flow.

5.5.7 Multiple Culvert Installations

In multiple (gang) culvert installations, one culvert should be set at an elevation lower than the others to provide adequate flow depth and velocity for fish passage during low flow conditions.

5.5.8 Place Culvert at Correct Elevation

Culverts should be placed at such an elevation that there is no ponding of water at the upstream inlet of the culvert and there is drop or hydraulic jump created at the outlet of the culvert. Similarly, outlets should not be submerged.

Large culverts may be countersunk into the channel bed. This also permits some gravel deposition in the culvert which creates a natural type of bed within the culvert.

5.5.9 Quality of Bedding and Backfill Material for Culverts

Suitable material of good quality should be used in backfilling culverts to ensure a good culvert installation. A compactable granular material "Granular Class B" quality or better is suitable for most installations. Cohesive soils or material containing large amounts of sand, fine silt or clay should not be used, because erosion of the material may result. Well graded granular material also provides better load carrying capability than poorly graded material or cohesive soils. Small culverts may be backfilled with the same material used to construct the road. Provided that the material meets road construction standards. Larger culverts should be backfilled more carefully, using select material if necessary.

5.5.10 Procedure for Backfilling Culverts

Backfill material placed under the haunches of the pipe should be in intimate contact with the entire bottom surface of the structure. Pre-shaping the bedding material to match the culvert curvature may assist in this regard. Backfill material should be placed in layers not exceeding 300 mm in thickness and compacted with suitable hand operated compacting equipment. Backfilling should be done in a manner that will prevent any deformation or

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displacement of the culvert. Proper compaction is necessary to provide adequate load bearing capacity above the culvert, and is necessary to reduce the voids which can cause "piping effect". The soil compaction around the culvert should achieve 90% standard Proctor density or better. The major factors which influence soil compaction and which should be taken into consideration include the following:

- moisture content of the soil,
- nature of the soil, its gradation and physical properties,
- type and amount of compaction effort required.

Granular soil types are best compacted by applying a continuous vibratory action.

5.5.11 Removal of Shipping Supports

Large diameter culverts are often shipped with bracing to prevent deformation of the culvert during transport and installation. These braces should be removed upon completion of the work as they may contribute to blockages by debris or ice.

5.6 Culvert Inlet and Outlet Structures

Culvert end structures, pre-built or constructed in place are attached to the ends of culverts to reduce erosion, retain the fill, inhibit seepage, improve the aesthetics and hydraulic characteristics and make the ends structurally stable.

Headwalls may be made of concrete, lumber, steel sheet piling or rock either grouted or cemented or simply left plain. Headwalls are sometimes skewed relative to the culvert to fit the angle of crossing. Wingwalls may be used to aid in funnelling the approaching flow of water directly into the inlet and to prevent erosion on the stream banks adjacent to the culvert. **Figure 5.6** shows a masonry headwall and wingwalls



Figure 5.6 Pipe Arch Culvert with Masonry Headwall and Wingwalls

Larger culverts may be provided with specially shaped inlets. These inlets provide a smooth transition from a wide channel to a slightly narrower culvert barrel with the result that entrance losses are reduced and the culvert will effectively be able to carry a larger quantity of flow.

Special outlets or spill aprons are used to prevent erosion where high velocity flow re-enters the channel downstream. Trash Racks are an optional end structure which serve to remove debris and also prevent unauthorized access.

5.6.1 Headwalls Required

Small sized culvert installations such as drainage culverts do not always require headwalls provided the fill is stable and is placed at a very mild slope. The necessity of providing headwalls generally increases with the culvert size.

5.6.2 Use of Armour Rock

Attractive, long term, economical and efficient protection of culvert inlet and outlet areas can be provided with rock when properly installed. Rock of sufficient size to form a permanent stable structure should be used. The foundation rocks should be set below the bed of the watercourse to prevent undermining. Wingwalls and headwalls of fitted rock should be leaned into

5.0 CULVERTS

the embankment at an inclination of at least 1/6 from the vertical axis to ensure stability. Joints can be pointed with concrete or mortar to provide a more uniform or water tight surface but the structure should not be dependent on the jointing material for structural stability. Where irregular or rubble rock is used to protect inlet and outlet areas, the rock should form a slope no steeper than one horizontal to one vertical and it should be well consolidated.

5.6.3 Use of Slope-Tapered Inlets

A tapered inlet slope provides less inlet head loss and thus can provide greater capacity and efficiency for culverts installations. Projecting culvert ends can be cut with a tapered slope to conform to the finished embankment slope and provides a neater and more aesthetically pleasing installation. Slope tapered inlets also provide less likelihood of serious blockage of the inlet by debris. However, special measures must be employed to prevent uplift of the projecting lip.

5.6.4 Use of Steel End Sections

A variety of steel end sections which are shop fabricated for assembly in the field, are available for attachment to corrugated steel pipe. These can provide better hydraulic inlet and outlet conditions and protection from erosion or scour of the road embankment and bed material, and can provide protection to the culvert ends as well.

5.6.5 Use of Concrete

Headwalls, wingwalls, spill aprons or other end structures constructed of cast in place concrete should be installed in accordance with the guidelines on use of concrete in *Chapter 13, "General Construction Practices"*.

5.6.6 Trash Racks Should be Sloped

Where a trash rack is used to catch debris and prevent it from entering a culvert, the rack should be installed with a low incline to prevent floating debris from being held against the rack by the flow (as with vertical trash racks) as this can cause serious flow constriction flooding, or washouts. An inclined rack allows debris to be pushed up to the top of the inlet structure where it will not seriously constrict flow and where it can be easily removed.

5.6.7 Use of Spill Aprons for Scour Protection

An apron of fitted rock, or rip-rap can be installed at the outlet of a culvert to provide protection to the stream bed and prevent scour or undermining. Such a structure can also provide a sufficient roughness factor to reduce the velocity at the outlet thus providing further protection from erosion or scour.

This is preferred to concrete or steel aprons which do not significantly reduce outlet velocities and which often cause scour of the bed material at the apron lip.

5.7 Inspection and Maintenance

5.7.1 Inspect Culverts Regularly

Culvert installations should be inspected regularly so that immediate action can be taken to clear blockages caused by ice or debris and to identify any apparent problems, such as erosion, which may require remedial action.

5.7.2 Inspect Culverts During and After Major Floods

An inspection of culverts should be made during and after major floods to observe the culvert operation and record high water marks. Conditions which require corrective maintenance should be noted including debris accumulations, silting, erosion, piping, scour, and structural damage. Performance information that reflects a need for design or construction changes due to unexpected large flood peaks should be submitted to the regulatory authority or owner for further action.

5.7.3 Establish a Culvert Maintenance Program

Culvert failures can be both disastrous and expensive. A comprehensive program for maintaining culverts in good repair and operating condition will reduce the probability of failures and prove to be cost effective. The program should include periodic inspections with supplemental inspections following flood events.

5.7.4 Mark Culvert Inlets and Outlets for Identification

All culvert inlets and outlets should be clearly marked so as to be identified during snow clearing and road grading operations.

5.7.5 Protect Inlets and Outlets

Inlet and outlet areas of culvert installations must be adequately protected by placing rip-rap, or fitted stone, or concrete headwalls to prevent bank had channel erosion.

5.7.6 Replace Damaged Culverts

Culverts which have been damaged by ice or debris, by improper installation or construction procedures, or are in a condition which could impair their proper functioning should be replaced immediately to prevent overtopping, erosion, or flooding.

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5.7.7 Maintenance Access

Provisions for maintenance access are necessary especially where debris control structures are installed. A parking area for equipment such as a crane may be necessary in order to remove debris without disrupting traffic. Also such access should not disrupt the site rehabilitation efforts.

GOVERNMENT OF NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF ENVIRONMENT AND LABOUR



CHAPTER 6
Environmental Guidelines for
FORDING

WATER RESOURCES MANAGEMENT DIVISION
Water Investigations Section

Chapter 6
Environmental Guidelines For
FORDING

Water Resources Management Division
Water Investigations Section

May 17, 1988
Reprinted February 20, 1992

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6.1 General

Under certain circumstances, properly designed and constructed fords may be used as watercourse crossings. *Chapter 3, "Watercourse Crossings"* provides information on choosing between a fording installation or other methods of watercourse crossing. The use of a fording site is usually limited to periods when low flow conditions prevail. The appropriateness of fording may depend upon the type of vehicle using the site. While vehicles with low pressure tires may ford a stream with little disruption, tracked machinery may cause severe environmental damage and as such may not be generally suited for fording watercourses.

Installation of a fording site should entail minimal disturbance to the stream channel and surrounding vegetation. Concerns normally associated with culverts or bridges, such as size of waterway opening, provisions for debris passage and the need for channel or embankment rip-rap are largely avoided. In addition, the degree of maintenance required is normally less than for other types of crossings. In hilly or mountainous terrain, fords are particularly useful for crossing streams subject to dramatic increases in water level or flash floods, where installation of a rarely used bridge or culvert would be very expensive.

There are, however, several disadvantages of fording a stream. Crossing on an unstable stream bed or unstable approaches will cause direct disturbance of the stream. Mud holes can form on the approaches and subsequent rains combined with traffic travel will discharge sediment into the stream. In addition, the washing of pollutants from equipment travelling through streams can cause water quality degradation. Very frequent use can result in channel destabilization and problems of bank or bed erosion and siltation of the watercourse.

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6.2 Selection of Fording Sites

Fording sites chosen for crossings should be least vulnerable to disruption of land, vegetation, and physical features of the channel.

6.2.1 Choose a Location with Stable Bed Material

A channel bed consisting of bed rock is preferred but a stable channel bed consisting of cobbles or coarse gravel may be satisfactory. Areas containing sandy or silty deposits are not considered satisfactory locations for fording.

6.2.2 Choose a Location with Low Graded Banks

Choose a location where existing approach grades and bank slopes are low, to permit movement of equipment into and out of the channel without extensive excavation or alteration of the channel banks and riparian land.

6.2.3 Confine Fording to Specific Locations

All fording should be confined to specific locations which have been identified as appropriate sites and have been approved. The fording sites should be made clearly visible to equipment operators by markings and the equipment should be confined to within those narrow corridors which have been identified.

6.3 Enhancing a Fording Site

A certain amount of work may be required to prepare a fording site. Such work is intended to make the crossing easier, to protect the stream from disturbance and to simplify restoration measures that may be required.

6.3.1 Preparing Access to The Watercourse

Access to the fording site should be approached at right angles to the stream. Any clearing of vegetation should be restricted to a width of not more than 3 m within 15 m of the stream bank. All slash must be removed from the area and under no circumstances should it be disposed of near the watercourse. It is important to try to maintain as much vegetative ground cover on the approach area as possible.

6.3.2 Approach Roads

Should grading of the approach be required, a back-blading technique should be used but only to the extent absolutely necessary. The approach road, especially if it is on a steep incline to the watercourse, should be cross ditched to prevent surface runoff along the travelling surface which could cause severe erosion and sedimentation problems.

6.3.3 Stabilize and Protect Vulnerable Areas

Where areas such as bank sections or approach roads contain loose material that could be subject to erosion, adequate stabilization and erosion protection should be carried out. Brush mats, log ramps or placement of rock may be appropriate depending on the circumstances and the type of material readily available.

6.3.4 Use of In-Stream Rock

If in-stream rock placement is required for fording sites, the crossing should not constrict flow in the river to cause flooding conditions upstream. The material used should be clean blasted rock free of fines. Under no circumstances may such rock be excavated from the stream. Furthermore all material placed in the stream must be completely removed from the channel when the fording site is no longer required.

6.3.5 Avoid Infilling of Channel

Avoid pushing bank sections into the channel or any infilling of the channel which could constrict flow or contribute to flooding, erosion, or siltation.

6.4 Proper Use of Fording Sites

6.4.1 Condition of Vehicles Using Fording Sites

All vehicles using fording sites must be kept reasonably clean and free of mud to prevent siltation or water quality deterioration. The vehicles should also be maintained in good repair, free of oil, gasoline, hydraulic fluids or other deleterious substances which could impair water quality. It may be necessary to have vehicles steam cleaned prior to fording.

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6.4.2 Avoid Channel Disturbance and Downstream Siltation

Fording must be carried out in such a manner as to cause the least amount of disturbance of channel bed and bank material which could cause erosion, siltation and pollution of downstream areas. The channel should be approached and forded by vehicles moving slowly in low gear.

6.4.3 Limit Use of Fording Sites

Fording sites should be used as infrequently as possible. If frequent use is required, a bridge or culvert installation may be necessary.

6.4.4 Fording During Low Flow Conditions

Fording should be carried out only during low flow conditions to avoid unnecessary disturbance of the channel or siltation. It may be necessary to undertake an assessment of the flow conditions for a stream to ensure that the water depth and the flow velocity will be such that the stream can be safely forded without having the vehicles stall due to flooding of the engine or even having the vehicle overturned by the current.

6.5 Removal of Fording Works

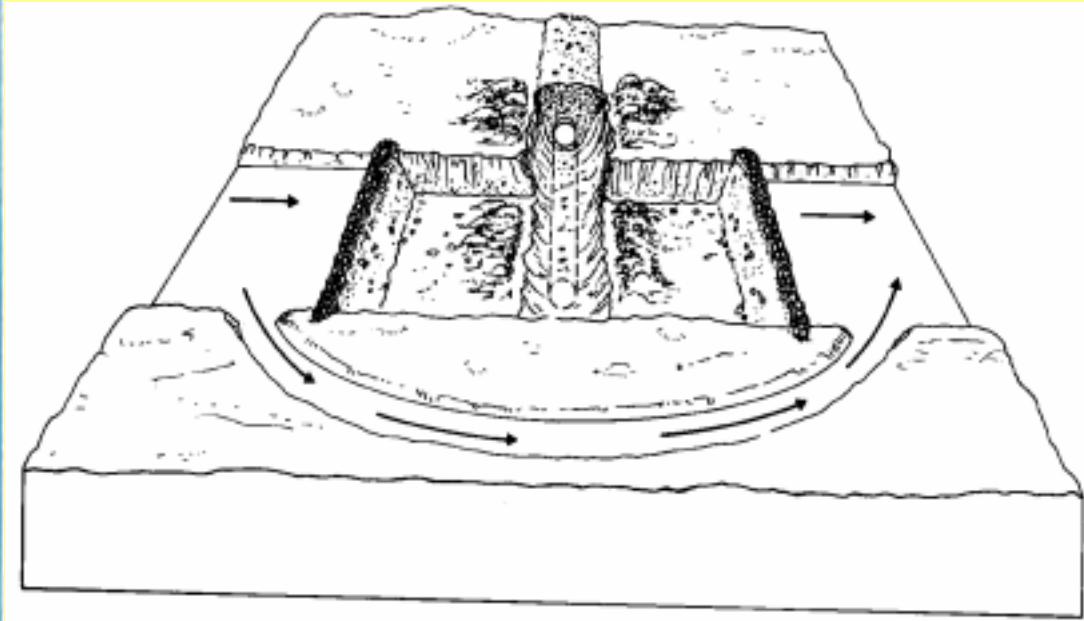
When fording sites are no longer required all constructed works such as in stream structures, rock fill, approach ramps, corduroys, etc. should be dismantled and removed from the site.

6.5.1 Site Restoration

In far as possible fording sites should be returned to their previous condition. Low bank sections should be reconstructed and stabilized through placement of rip-rap and revegetation. See *Chapter 14, "Restoration and Stabilization"*.

6.5.2 Ensure Fording Site is Left Inaccessible

Further to the removal of fording works, measures should be taken to ensure the site is not left readily accessible to illegal fording. Such measures should include cross ditching the access road and placement of large boulders across the road.



CHAPTER 9
Environmental Guidelines for
PIPE CROSSINGS

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PIPE CROSSINGS

Water Resources Management Division
Water Investigations Section

March 14, 1997

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9.1 General

Almost always, as land is developed for residential, commercial and industrial purposes, the need arises to provide water and sewer services across a watercourse or a body of water. Water and sewer services are, of necessity, buried and therefore, they must normally cross under the body of water. Where grades permit a choice, buried crossings are preferred over aerial crossings (i.e. via bridges) because they are subjected to less exposure, accidental damage or vandalism. Pipe crossings can include water pipe crossings, sanitary sewers, gas pipelines or other pipes but these guidelines are equally applicable to any conduit crossing under a watercourse (ie. electrical or communications cables).

Consideration of factors, such as the hydraulic and hydrologic characteristics of the stream, substrate material and stream bank characteristics, are important in the selection of a suitable site for pipeline crossings. The number of pipeline crossings, if given a choice, should be kept to a minimum during construction in order to reduce the risk of causing any adverse impacts. The potential for streambed scouring and bank erosion must be determined in order to provide the necessary depth and length of burial required to prevent exposure. Pipeline exposure, as well as subsequent scour downstream, could create an obstruction to the upstream movement of fish. In order to provide adequate channel stability, it is necessary to account for channel migration, high velocity flows during peak runoff, ice jamming and scour, and any future stream alterations which may be anticipated during the design stages of a pipeline crossing.

This chapter is intended to provide helpful information for the installation of pipe crossings to ensure that streambed stability is maintained under natural conditions and that construction does not cause unnecessary environmental damage.

9.0 PIPE CROSSINGS

9.1.1 Regulations and Regulatory Bodies

Watercourse crossings are regulated under provincial legislation through Section 11 of the *Environment Act*. Federal and municipal statutes and regulations also apply in most situations.

The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife or any other alteration. Prior written approval must be obtained from the Department of Environment and Labour for watercourse crossings because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply to watercourse crossings, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

A certificate of environmental approval for a pipe crossing includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department of Environment and Labour as per Section 11 Subsection (1) of the *Environment Act*.

9.1.2 Other Applications of the Guidelines

Within these guidelines, the term pipe or pipeline can be substituted to accommodate any type of crossing under a body of water. Most commonly these include ductile iron, PVC and HDPE pipes which are used in water systems, storm and sanitary sewers and drainage applications. In addition, the guidelines also apply to gas and

slurry pipelines, electrical conduits, fibre optic cables as well as other communication lines which must be buried under ground and subsequently under streams. Although each product may have a different set of manufacturer's specifications for installation, they all present similar potential for environmental damage to water resources.

The term "watercourse" is used in relation to stream alterations throughout this chapter but these guidelines may also pertain to any body of water in Newfoundland (beaches, marshes and bogs, rivers, lakes, etc.). Therefore, the following guidelines should be taken into consideration wherever an undertaking involves the placing of a pipeline or similar apparatus beneath the substrate of a waterbody.

9.2 Design Considerations

When installing a pipe crossing under a watercourse, the general contractor is responsible for the quality of work done at the site, but the contractor's work is subject to the design constraints of the system to be installed. The designer must ensure that safeguards can be implemented to provide protection of the body of water. The designer must also make the design as efficient and cost-effective as possible while adhering to environmental guidelines and habitat preservation procedures.

9.2.1 Potential Low Scour Point

When designing a pipe crossing, one must consider the potential low scour point which is caused by shifting currents. It is generally necessary to maintain a level trench or specified grade for the full length of the crossing in unconsolidated substrates to prevent a pipe from being exposed due to lateral shifts in the low scour point (See Figure 9.1). If this is not compensated for in the design, the pipe may

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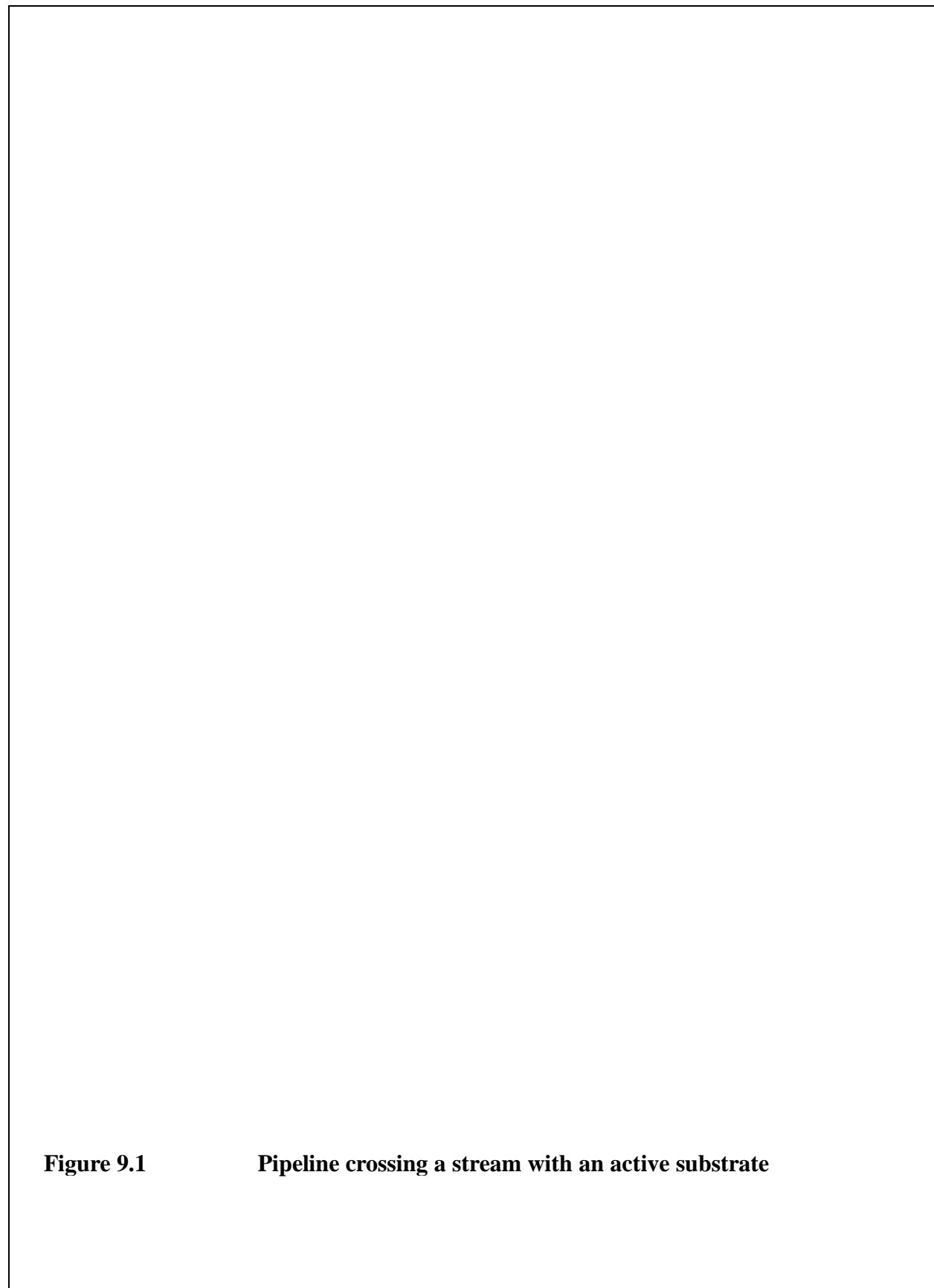


Figure 9.1

Pipeline crossing a stream with an active substrate

become exposed which will greatly increase the risk of pipe failure and alteration of the natural substrate of the watercourse.

9.2.2 Ditch Plugs

During the excavation stage, a ditch plug should be left in place on both sides of the stream until the pipe is ready for installation. It is important to leave plugs in place until the last possible moment to ensure that little or no flow from the ditch can enter the stream and that no stream flow can enter the ditch (See Figure 9.2). All work should be carried out in the dry as much as possible to reduce pumping and minimize the need to treat water for removal of silt.

9.2.3 Buoyancy Control

If buoyancy control at a stream crossing proves to be inadequate, then the pipe will tend to float and have to be repaired. Buoyancy control weights are required at river crossings. Where pipe exposure is inevitable under design flow conditions, these weights must be adequately secured to prevent them from slipping off the pipe. Once the pipe has been backfilled, the soil will have a sufficient internal resistance to prevent movement of the weights.

9.2.4 Scheduling

The scheduling of work that deals with stream alterations is an important consideration in the implementation stage of an undertaking. Proper scheduling is important from the standpoint of environmental and fish habitat protection, and can be economically advantageous as well.

9.0 PIPE CROSSINGS

Figure 9.2

Leaving a plug to isolate the trench from the main channel during excavation.

From the standpoint of the Department of Environment and Labour, the ideal time of year to construct a pipe crossing is when:

- the lowest possible flow rate occurs. This makes it easier to restore the streambank and there is less sediment generated; and when
- the seasonal rainfall period is at its driest because this reduces the chance of flash flooding.

These guidelines mean in practice that the best time to install pipe crossings is during the season lasting from June 1st to October 30th.

Although the Department of Fisheries and Oceans scheduling guidelines are governed by a different set of circumstances, their ideal construction season closely corresponds to that of the Department of Environment and Labour. The Department of Fisheries and Oceans generally states that the June 1st to September 30th construction season would not severely affect the spawning, incubation and hatching of fish in inland waters. (Note: This is a general guideline. These times may vary from river to river and specific scheduling of work should be discussed with a Department of Fisheries and Oceans Regional Habitat Coordinator.)

The amount of time spent constructing a crossing can have an increasingly adverse effect on water quality. The longer the stream bed is disturbed and left exposed, the larger the amount of sediment that will be introduced into the watercourse and the further the sediment will be able to travel within the watercourse.

9.2.5 Site Location

With a given undertaking, there may be some flexibility regarding choice of a route. Every water crossing represents increased costs for construction, maintenance and environmental protection requirements. Therefore, whenever possible, one should minimize the number of water crossings and avoid sensitive wetland areas or routes immediately adjacent to watercourses.

9.0 PIPE CROSSINGS

When designing a tentative route that includes a pipe crossing, the final location should be:

- downstream from areas such as fish spawning sites or water use intakes
- upstream of natural fish barriers such as waterfalls
- where the stream is straight, unobstructed and well defined
- on an existing right-of-way, if one exists
- where stable geological and soil conditions are present
- where a minimum of scour, deposition or displacement of sediments are expected to occur at or near a crossing
- where it is possible to minimize the risk of damage from environmental hazards such as floods, landslides, etc.

It is highly unlikely that any one stream crossing will meet all of these criteria. The more criteria that can be met, the more efficient the installation will be and the less chance that problems will arise in the future.

9.3 Pipe Crossing Installation Practices

Pipe crossings can vary in size from a major trunk sewer with a diameter greater than one metre to an 18 millimetre diameter domestic water pipe. Regardless of size, there are a number of general procedures to follow which can limit the potential of causing sedimentation as a result of in-stream or near-stream activities. These vary depending on specific site conditions.

9.3.1 Site Preparation

Clearing and grubbing removes trees and shrubs from the banks of the stream to provide a right-of-way for the pipe crossing. It is important to maintain a minimum 15 metre undisturbed buffer along the approach on both sides of the stream until the pipe installation across the stream is ready to begin. Once the protective covering has

been removed, the potential for sedimentation increases. The area to be cleared and grubbed must follow the proposed route of the pipe and the width of the disturbed area should be kept to a minimum.

Wherever possible, the site should be accessed from either side of the stream to reduce the need to have equipment ford the stream.

9.3.2 Trench Excavation

Once clearing and grubbing has been completed, selective removal and stockpiling of topsoil from the buffer zone is required. All stockpiled material must be located further than 15 metres from the high water mark. The stockpiled topsoil must be reapplied to promote revegetation once the pipe crossing has been completed.

Occasionally, blasting is required in order to excavate the trench to the desired elevation and size. The section of the stream channel where blasting is to be carried out should be isolated by diverting or pumping flows around it. If poorly executed, blasting can be detrimental to fish by destroying their swim bladders.

The excavated trench must be carefully graded in order to evenly support the pipe along its entire length. In some cases, it may be necessary to over excavate the trench and backfill it with a granular material to achieve a proper bedding.

During trenching operations, it is important for the contractor to be extremely careful to prevent sedimentation by strictly adhering to the terms and conditions of the environmental approval.

9.0 PIPE CROSSINGS

9.3.3 Isolation of Work Area

The method used to cross a stream with a pipeline depends on size of the stream, channel hydraulics, cost effectiveness and timing of the project. It is important that the installation be carried out as quickly and efficiently as possible in order to minimize any disturbance to the streamflow, water quality and aquatic environment. A pipeline crossing may involve a diversion of flow around the trench by using pumps and/or cofferdams, fluming small streams over the trench by using culverts and, in some instances, it may be economically feasible to install the pipe by drilled or slip boring procedures. Chapter 13, *"General Construction Practices"*, contains additional information on procedures used to isolate a work area.

9.3.4 Pipe Installation Procedures

From a nearby stockpile, the quantity of pipe required to complete the pipe crossing is hauled in and placed in an end-to-end fashion adjacent to the trench. The sections of pipe are then joined by mechanical joints (ductile, iron, PVC, HDPE) or thermal fusing (HDPE only). Either of these types of construction will ensure that the crossing is both flexible and water tight. When it is necessary to provide a sag in the pipe, it should be located outside the limits of any possible channel meander.

Valves should be located at both ends of the water crossing so the section can be isolated for testing or repairs and to prevent them from flooding. The valve closest to the supply source should be in a manhole. Permanent taps should be made on each side of the valve to allow insertion of a small meter for testing to determine leakage and for sampling purposes.

9.3.5 Backfilling

During the backfilling operation, the stockpiled material is selectively placed in the trench. This prevents material capable of damaging the pipe from being placed against it. If the excavated material contains boulders, frozen soil, organic material or other materials which do not meet the required specifications, it may be necessary to replace it with granular material. The material must be able to withstand erosion and scouring and must not extend above the original grade of the channel.

To prevent possible damage or failure to a pipe crossing, resulting in severe pollution, it is required that a minimum cover of 0.6 metres of stable compact soil be provided. Where the pipe crossing is located in bedrock, a minimum cover of 0.3 metres is acceptable.

In areas where high groundwater occurs, pipe zone cutoff walls, or other means, are required to prevent drawdown of the water table due to groundwater flow through the porous pipe zone material.

9.3.6 Pressure Testing

As a final step to ensuring a water tight pipeline, pressure testing is done. The pipeline is pressurized (by pumping water into it) to a test pressure of 1.25 times the working pressure. The line is then left for at least two hours. If a leak is encountered through a loss of pressure, it is located and repaired and the line is retested.

9.0 PIPE CROSSINGS

9.4 Site Rehabilitation and Restoration

As with any stream alteration, it is necessary to carry out site rehabilitation in order to stabilize slopes, disturbed areas and other areas vulnerable to erosion, to provide revegetation and to ensure the site is left in a condition which is environmentally acceptable. Chapter 13, *"General Construction Practices"*, contains detailed information on site rehabilitation.

9.4.1 Erosion Control

Once the backfilling has been completed, some form of erosion control must be implemented. If not, the banks of the stream will quickly erode especially when there are higher flows later. This will introduce sediment into the watercourse and could ultimately alter the substrate of the watercourse.

One of the most effective methods of erosion control is to return the disturbed right-of-way to as close to its original condition as possible and then to seed or sod the affected area. Replacement of vegetation will only work however, if the vegetation can get proper root before higher flows occur. Other things that can be done to prevent erosion are rip-rapping the bank to one metre above the high water mark, installing diversion ditches, etc. (See Figure 9.3).

9.4.2 Fish Habitat Preservation

The installation of a pipe under a watercourse has the potential to impede or block fish migration and destroy fish population or fish habitat. These installations, if carried out improperly, can result in siltation and pollution which can kill fish or incubating eggs and ruin spawning locations.

9.0 PIPE CROSSINGS

Figure 9.3

Erosion control on sloped approached to streams

9.0 PIPE CROSSINGS

The *Fisheries Act* contains sections which govern the alteration of fish habitat. Therefore, approval from Fisheries and Oceans Canada may be required in addition to approval from the provincial Department of Environment and Labour.

9.5 Inspection and Maintenance

Once the initial construction and clean-up of a pipeline crossing is completed, the potential for environmental damage is not eliminated. Through incorrect construction procedures or inefficient design, unforeseen factors could cause damage to the pipe system or the crossing site itself. However, the effect of these problems can be minimized by simple periodic inspections, routine general maintenance and some remedial work, if necessary.

9.5.1 Periodic Inspection

Pipeline crossings require periodic inspections in order to determine:

- The effectiveness of the erosion control measures used to stabilize the streambed and stream banks
- Evidence of scouring around pipeline structure
- Evidence of lateral migration of the channel
- Signs of pipe movement caused by buoyancy or frost heave
- Signs of leakage in the pipe
- Changes in water quality
- Signs of channel constriction.

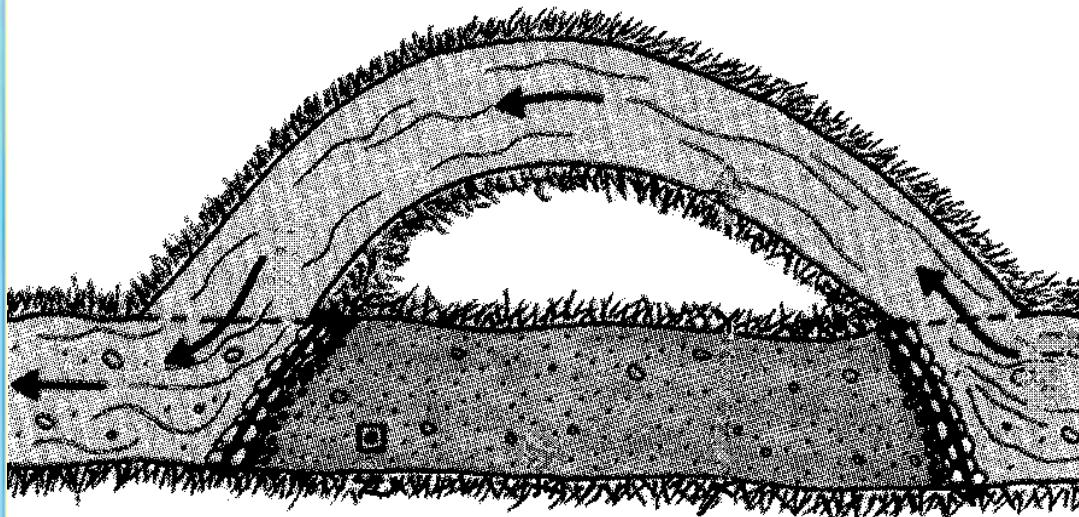
9.5.2 General Maintenance

General and minor maintenance work should be carried out from time to time. Minor flaws in a pipeline could be temporarily repaired during sensitive periods using a low

impact procedure with more permanent repairs to be made during non-sensitive periods.

9.5.3 Remedial Work

Where serious problems are evident, such as streambed instability, pipe failure or systems malfunction, remedial measures may be required. Such problems are often the result of inadequate installation procedures or lack of erosion protection which should have been addressed in the design stage. If, however, erosion control or river training works are to be carried out subsequent to the development of such problems, a comprehensive investigation or evaluation of the problem should be conducted. A new environmental approval will be required to carry out remedial work to a pipeline.



CHAPTER 7
Environmental Guidelines for
**DIVERSIONS, NEW CHANNELS,
MAJOR ALTERATIONS**

Chapter 7
Environmental Guidelines For
**DIVERSIONS, NEW CHANNELS,
MAJOR ALTERATIONS**

Water Resources Management Division
Water Investigations Section

March 14, 1997

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7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

7.1 General

The need for new channels, diversions, and major watercourse alterations often arises from land development such as urban, residential, industrial and commercial land use. In areas where such developments are proposed, new channels may be required to accommodate increased volumes of flow from developed areas, to lower the water table, to accommodate drainage and storm water systems, and to maximize land use. In many instances the restoration of existing watercourses can accommodate the needs of storm water management in developing areas.

Many other needs arise where major watercourse alterations are required. Watercourse diversions or new channels are sometimes required to temporarily reroute flow so that work in the original channel may be carried out in the dry. New channels may be constructed adjacent to existing watercourses to act as overflow channels to safely contain high flows and help prevent erosion or overtopping in the original channel. New channels are sometimes constructed to provide controlled conditions for agriculture and fish enhancement strategies. Hydro electric projects often require diversions and new channels.

Extensive manipulation of natural watercourses can cause very serious and costly problems due to unforeseen circumstances even if carried out properly. In many instances alternatives to diversions can accomplish the same objective, avoiding major disruption of natural channels. The provision of undeveloped buffer strips on watercourses, overflow channels, and storm water detention facilities, can provide beneficial, convenient, low cost and environmentally satisfactory results, especially in urban areas. For these reasons proposed alterations to watercourses should be properly justified.

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It has been demonstrated in the past that inappropriate and shortsighted planning often results in improper and sometimes unnecessary alterations to natural watercourses. This has been displayed most noticeably in areas where extensive "channelization" has resulted in the total removal of the stream side vegetation and natural channel bed and bank material. Serious long term problems in bank and bed erosion, downstream deposition and costly maintenance are but a few of the problems associated with such work. Such watercourses are virtually lost as a natural resource and are unsightly. When properly protected and maintained watercourses in both rural and urban settings are a valuable resource and an amenity in providing storm water control, and attractive and useful space for leisure or recreational activity.

7.1.1 Regulations and Regulatory Bodies

Diversions and major watercourse alterations are regulated under provincial legislation through Section 11 of the *Environment Act*. Federal and municipal statutes and regulations also apply in most situations.

The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife or any other alteration. Prior written approval must be obtained from the Department of Environment and Labour for diversions and watercourse alterations because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

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A certificate of environmental approval for watercourse alterations includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department of Environment and Labour as per Section 11 Subsection (1) of the *Environment Act*.

7.2 Planning

7.2.1 Alternatives to Watercourse Alterations

Before a decision is made by a proponent to seek approval for any alteration of a watercourse, other possible alternatives should be examined which would mitigate environmental impact and maintain the features of the natural watercourse. Existing bodies of water within a proposed development area should be included in the overall development concept and adequate protection provided. Chapter 12, *Buffer Strips Adjacent to Bodies of Water*, provides further information in this regard.

Flood protection may be provided on watercourses without substantially altering existing channels. The preferred approach is the construction of elevated banks or levees set well back from the existing channel which would provide an outer channel or flood plain to safely hold and convey flood water during times of very high flow conditions.

7.2.2 Ensure Proper Channels are Provided for All Flow

A watercourse should not be diverted into an undefined channel. The flow must be diverted into a properly designed and constructed channel which has been

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adequately stabilized. Diverted streams not confined within a proper channel can cause serious erosion and siltation downstream.

7.2.3 Maintain Watercourses Through Existing Property

The relocation of watercourses outside existing property boundaries to provide more easily developed land, accommodate development of property, or other such purposes, is not considered a proper environmental approach. Watercourses passing through a property must be maintained through that property and not rerouted so as to cause any adverse affects on adjacent properties.

7.3 Design of New Channels

7.3.1 General

It is important that new channels be properly designed according to established engineering principles. The hydrologic and hydraulic design parameters must be based on the physical geographic features of that particular drainage basin. The climatic conditions, geology and drainage basin features will determine such factors as quantity of flow, peak water levels, discharge patterns, ice formation, etc. These factors will then determine what specific channel dimensions and features will be required to provide a stable channel which can safely accommodate predicted flow conditions from that drainage area. The completed channel must also adequately address aesthetic and ecological concerns in reinstating fish habitat, vegetation, and features which blend attractively with the surroundings.

Where a simple diversion is proposed which involves the rerouting of a section of a watercourse, extensive hydrologic design may not be necessary. In such cases, the

7.0 DIVERSIONS, NEW CHANNELS, MAJOR ALTERATIONS

hydraulic design must at least ensure that capacity equivalent to or greater than the capacity of the original channel is provided.

Tributaries that feed into the original channel must be made to tie into the new channel. The same design and construction procedures used for the diversion must also be used for altering these tributaries.

7.3.2 Capacity of New Channels (Hydrologic Design Criteria)

The term "return period" is used to indicate the probability that a flood of a certain magnitude will occur. For example a 100 year return period flood is a flood whose flow would be exceeded on average once in 100 years. The return period for a diversion is often determined in conjunction with other related works that are being undertaken. A diversion as part of a dam construction, for instance, must be designed to the same return period as the dam to be able to handle the design outflow from the dam. If there are no significant works associated with the diversion, the designer should use his discretion in determining the appropriate return period. A 100 year return period should be used as the hydrologic design criteria of a diversion unless there is a valid reason for using a lesser return period.

In general, this hydrologic design criteria means that the channel must be able to safely convey the flood flow without overtopping. The selected return period must take into account possible damages to adjacent properties and environmental consequences of overtopping of the channel. An economic analysis or cost-benefit analysis should be considered in determining the most economical design of diversions.

New channels should provide adequate capacity to safely discharge the design flow. In determining the channel capacity the drainage basin should be examined in regard

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to land use zoning and plans for future development of land within the basin. Adequate capacity should be provided to safely accommodate future flow conditions, as land development often results in increased volumes of storm water and higher stage of flow within natural or existing channels.

7.3.3 Specified Channel Dimensions

New channels should be designed and built to predetermined dimensions which specify the following:

- Bottom width
- Depth of channel
- Bank slope
- Flow area
- Bed slope
- Freeboard

A new channel need not be uniform throughout its length. In fact it is desirable to recreate natural channel variabilities, if possible. The performance of a channel can be determined using Manning's Equation if the channel is uniform. Channels with variable dimensions should be modelled using an appropriate computer model such as HEC-2 or HEC-RAS.

7.3.4 Specified Channel Features

New channels should be designed and constructed with specific features that address hydraulic, aesthetic considerations, and where applicable, fish habitat requirements. These may include but are not limited to the following:

- channel banks and bed with a compacted substratum
- lower channel banks stabilized with protective rock
- upper banks stabilized and revegetated with topsoil, seeding or sodding and shrubs or trees

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- channel bottom of clean coarse gravel
- in-stream rock placement
- pools, falls or riffles, meanders, etc.

7.3.5 Flow Velocity in New Channels

New channels should provide flow velocities which are similar to those that occurred in the original channel. High flow velocity contributes to sediment transport and erosion. If the new channel reduces the velocity, sedimentation will occur and eventually the new channel may become blocked. Alternatively, where low velocities occur in the natural channel, the new channel may be designed to provide higher velocities to reduce the probability of flooding.

7.3.6 Freeboard Required

An adequate freeboard must be provided between the design high water level and the top of the embankments to prevent overtopping. The amount of freeboard to be provided is developed with consideration of the design flow volume, return period, future flow conditions in the channel, and the potential impact of an overtopping on surrounding properties and lands.

7.3.7 Channel Embankment Slope

To ensure adequate stability and prevent slumping of bank materials, the channel embankments should be no steeper than two horizontal to one vertical. Where fine grained or erodible soils are present, bank slopes should not exceed three horizontal to one vertical.

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7.3.8 Emulate Existing Flow and Channel Conditions

Major channel alterations may disrupt the natural system regime. The effect of these changes may vary from negligible to significant. The time/effect relationship depends on the magnitude, duration and frequency of floods, stream morphology, and the nature or extent of the alteration. When dealing with channel modifications, the preferred procedure is:

- establish the nature of the present regime (slope, section, meander pattern, stage-discharge relationship)
- determine thresholds for changes in the various regime parameters
- duplicate the existing regime, where possible, or keep within the established tolerances for change, where duplication is not practical or possible.

In short, the discharge and velocity at either end of the diversion should be the same as that of the old channel at the same locations.

7.3.9 Channel Length and Storage Capacity

Channel realignment or diversion should result in no net loss of channel storage capacity or channel length. The new alignment or new channel should provide equivalent or greater storage capacity and channel length, as existed in the original channel. "Cut off" channels or straight line diversions have a shorter length than the original channel resulting in loss of storage capacity and increased flow velocities as well as larger volumes of flow in downstream areas. This can result in destabilization of banks or overtopping and flooding in downstream areas (See Figure 7.1).

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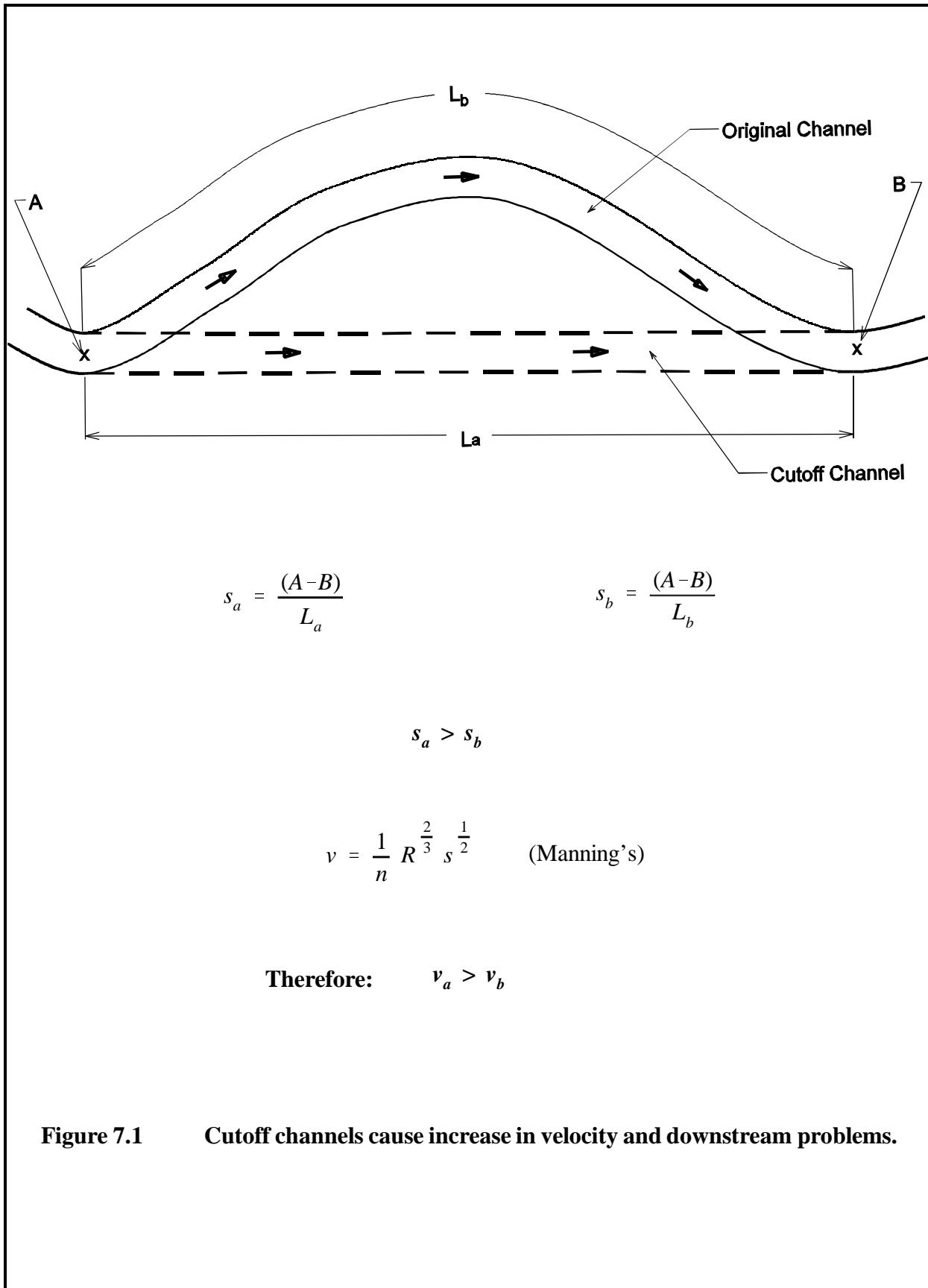


Figure 7.1 Cutoff channels cause increase in velocity and downstream problems.

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7.3.10 Channel Gradient

Stream realignment or diversions, and especially cut off channels always increase the channel gradient. This may induce channel responses which can create problems upstream and downstream of the project. A cut off channel usually results in abrupt changes in the channel slope which can cause erosion and degradation of the upstream channel section and aggradation downstream. This increase in gradient will also tend to increase the flow velocity, further contributing to the problems of degradation and aggradation.

7.3.11 Meandering Channel

New channels should be designed with a meandering pattern which would simulate or reinstate the original channel as opposed to a straight channel. This provides a more beneficial flow regime of convergence and divergence which more closely emulates natural watercourses, facilitates the development of pools and riffles and increases aesthetic quality.

7.4 Erosion Control, Stabilization, and Protective Works

New or altered channels usually require appropriate erosion control works to ensure that adequate stability of the channel is maintained.

Channels can be affected by erosion in a number of ways which can cause serious and costly damage to property. Channel bed erosion or "degradation", the undercutting of the toe of channel embankments, or the erosion of the upper portion of channel

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embankments are common forms of erosion in watercourses. The erosive process, once started, will progress rapidly.

Properly designed and constructed channels which are engineered to resist erosion are necessary, coupled with frequent inspection for early identification of potential problems so that appropriate remedial measures can be taken. The causative factors of an erosive process are usually complex and require detailed examination for effective solutions. "Quick and easy" solutions to such problems are often ineffective or of short duration.

A number of design features and stabilization or erosion control structures are used to ensure channel stability. Stabilization and erosion control in channels should be examined and addressed on a site specific basis.

7.4.1 Low, Non-Erosive Flow Velocities

An important factor to consider in planning a new channel in regard to concern over erosion is providing a low flow velocity which is not capable of eroding the channel bed and bank material. Coarse gravel and cobbles can withstand moderate velocities but exposed fine or light materials require lower velocities to ensure stability.

7.4.2 Channel Linings

New or man made channels should be designed and constructed with appropriate non-erosive material. In most cases the use of a coarse gravel over a well compacted substratum will provide an adequate channel bed. For steeper channel grades coarser rock may be used which will resist erosion and provide greater channel roughness to reduce flow velocity. The use of concrete, asphalt, gabions, or similar materials for lining channels is not preferred. Such materials usually provide a flow regime

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inconsistent with that of the natural channel, result in maintenance problems and loss of the ecological amenity of flora and fauna, and are aesthetically inferior.

7.4.3 Channel Banks at Drainage Ditches

Where drainage ditches or streams enter a channel, adequate erosion protection is required. Low approach grades in the ditches or streams are preferred. In-stream rock placement or protective rock may be required to prevent erosion of bank areas where steeper approach grades are present.

7.4.4 Surface Runoff From Adjacent Areas

Where extensive surface runoff is likely to enter the channel, the runoff should be confined and allowed to enter the channel through properly protected drainage ditches. Other means such as rip rapped bank sections or half-culvert sections can be used to prevent erosion or slumping of the channel embankment.

7.4.5 Protective Rock at Toe of Channel Embankments

Protective rock should be installed at the toe of channel embankments to prevent undercutting of the embankments and erosion due to rapid or high flows. The size of rock used will be dependant upon the velocity and direction of flow in relation to the bank, the flow stage, and volumes of flow anticipated in the watercourse. The size of rock used will vary from "one-man-stones" to armour stone.

7.4.6 Armour Stone

Where the potential exists for bank erosion, particularly where flow is directed toward an embankment, velocity and stage are high, and erodible bank material is

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present, large rocks should be installed which will safely resist erosion. These rocks should be set into the bed and bank material so as to resist undermining. The rocks should also be leaned into the bank at an inclination of at least 1/6 from the vertical axis to ensure stability.

7.4.7 Gabions

Where gabions are used for stabilization of channel embankments the structures should be installed according to the manufacturer's specifications. The structures should be set on a solid foundation, adequately anchored and leaned into the embankment at an inclination of at least one horizontal to six vertical, to ensure stability. The structures should be surfaced with soil and revegetated.

7.4.8 Deep-Rooted Plants

Deep-rooted type plants such as trees and shrubs should be planted along channel embankments to provide stability for the channel, shade for water temperature control, ecological value, and aesthetic value in creating an attractive watercourse. Willow and alder are fast growing plants, which develop substantial root systems, helping to prevent slumping of embankments. Alder is also a nitrogen fixing plant which makes it a good starter shrub for other plant succession. See Chapter 14, *Restoration and Stabilization*.

7.4.9 Seeding, Hydro-Seeding and Sodding

The upper section of channel embankments should be stabilized with fine rooted plants such as grasses and clovers to bind the topsoil and prevent surface rutting and deposition in the watercourse. Details on the application and use of seeding,

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hydro-seeding, and sodding are provided in Chapter 14, *Restoration and Stabilization*.

7.4.10 Rock Filled Timber Cribs

The use of rock-filled timber cribs or timber retaining walls for channel bank stabilization is not recommended as these structures contribute to watercourse siltation and deposition, and do not provide long term stability.

7.5 Construction Procedures

The construction of new channels, diversions and major alterations to bodies of water has the potential to cause environmental damage and create serious problems in siltation, pollution, erosion and deposition. Many of these problems occur during the construction phase of the work and are often the result of inappropriate construction procedures. These problems can be mitigated or prevented by following preferred construction procedures and techniques. Further detailed information on construction practices is presented in Chapter 13, *General Construction Practices*.

7.5.1 Heavy Equipment

The use of heavy equipment in streams or bodies of water is generally not permitted. The operation of heavy equipment should be confined to dry, stable areas.

7.5.2 Excavate in the Dry from the Downstream End

New channels should be excavated in the dry, beginning at the downstream end and working in the upstream direction to the point of diversion.

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7.5.3 Maintain Upstream and Downstream Cofferdams

Upstream and downstream cofferdams should be maintained during construction to prevent flow from entering the new channel under construction and to prevent silted water from entering the watercourse downstream.

7.5.4 Prevent Water from Entering the Channel Under Construction

Small drainage courses and surface runoff should be intercepted and diverted around the construction area by such means as pumping or temporary culverting, to allow construction to take place in the dry.

7.5.5 Containment and Treatment of Silted Water

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with the *Environmental Control Water and Sewage Regulations*, which is included in Appendix A. Further information on reducing the amount of silted water generated by construction operations and methods for treatment are contained in Chapter 13, *General Construction Practices*.

7.5.6 Divert Flow After All Work is Complete

Flow should be diverted into the new channel only after all excavation, lining, and bank stabilization work has been completed. Flow should be introduced into the new channel gradually and the channel should be monitored visually for any indications of failure, excessive siltation or other problems.

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Care should be taken when diverting flow from the old channel that any fish that are stranded be relocated to the new channel.

7.5.7 Closure of Old Channel

Where flow is completely and permanently diverted from an old channel to a new channel, the old channel should be completely closed to all flow of water. The fill material or structure diverting flows into the new channel should be adequately constructed and protected to prevent erosion or washout and an adequate freeboard be provided to prevent overtopping of the structure.

The old channel should be backfilled with good quality fill, compacted and provided with a vegetative cover to prevent erosion.

7.6 Inspection and Maintenance

7.6.1 Frequent Inspections

Diversions, new channels and reconstructed channels require frequent inspection to ensure they are performing satisfactorily. Subsequent to visual monitoring of the initial introduction of flow into the channel, frequent spot checks should be carried out to ensure that the stability of the channel bed and bank is such that erosion is prevented.

7.6.2 Annual Inspections

Annual inspections should be carried out after the spring runoff or after the major peak flow in the channel during that year, to determine:

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- if the channel is functioning properly;
- if erosion is being adequately prevented in all areas; and
- where maintenance may be required.

7.6.3 Comprehensive Inspections to Verify Design Parameters

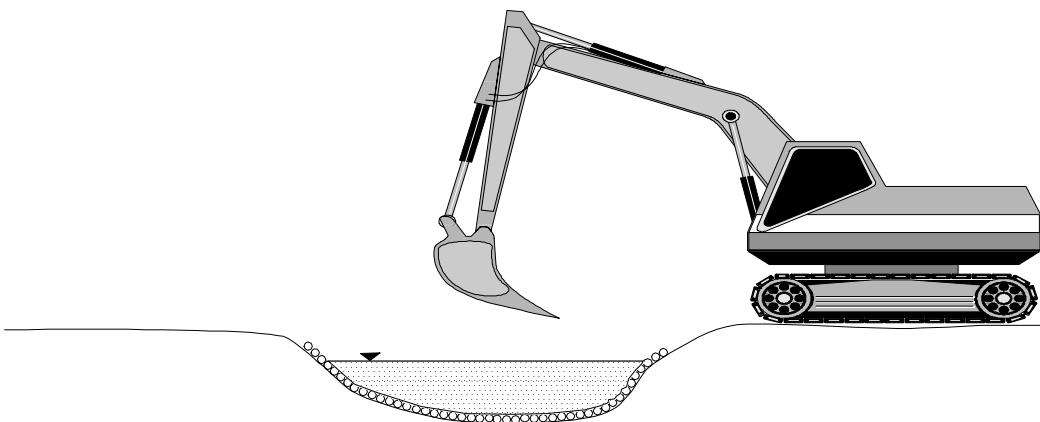
A comprehensive inspection should be carried out during the first major high flow event to determine if flow characteristics are according to design, with particular regard to flow velocity, stage, flow direction, etc.

7.6.4 Regular Maintenance

Regular maintenance such as removal of debris in the channel should be carried out to ensure there is no flow blockage or constriction which could cause erosion or washout. Debris removal should be carried out by hand to prevent destabilization of the channel.

7.6.5 Areas Vulnerable to Erosion

Any bank sections which have become exposed and appear vulnerable to erosion should be immediately protected in an appropriate manner so as to prevent or arrest the erosive process before further damage to the channel can occur.



CHAPTER 13
Environmental Guidelines for
**GENERAL CONSTRUCTION
PRACTICES**

Chapter 13
Environmental Guidelines For
GENERAL CONSTRUCTION
PRACTICES

Water Resources Management Division
Water Investigations Section

March 24, 1997

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13.0 GENERAL CONSTRUCTION PRACTICES

13.1 General

All too often construction sites are a significant source of pollution to natural waterways. Soil erosion from the site can result in stream degradation and turbidity miles downstream. Stream channels may become unstable because of higher rates of runoff from surrounding land stripped of vegetation. Toxic wastes from construction materials and equipment can impair water quality and thereby interfere with downstream uses. For these reasons, properly planned and implemented controls are essential during the construction period, if detrimental changes to the surrounding water bodies are to be minimized. Proper site preparation procedures are required to minimize sedimentation and eliminate the need for costly remedial actions.

Many serious construction problems arise because important drainage and water-related factors were overlooked or neglected in the location and planning phases of the project. Adequate soils, geologic and hydraulic studies will provide much guidance in solving erosion, drainage and landslide problems as well as being helpful in minimizing or avoiding these problems during construction. Risk of damage by siltation of ponds and reservoirs during construction often can be reduced by studying flood and precipitation records and proper scheduling of work.

Time of construction is important. A structure or embankment is usually most vulnerable to damage from heavy rain or floods when partially complete. The onset of winter or spring break-up may pose unique difficulties, thus the timing of proposed construction requires due consideration.

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13.1.1 Regulations and Regulatory Bodies

Alterations to bodies of water and construction adjacent to bodies of water are regulated under provincial legislation through Section 11 of the *Environment Act*. Federal and municipal statutes and regulations also apply in most situations.

The Province has the mandate to protect all water resources from potential impact such as pollution, changes to domestic, municipal or industrial water supplies, flooding, aesthetic damages, changes in the flow regime, impact to wildlife or any other alteration. Prior written approval must be obtained from the Department of Environment and Labour for alterations because of the potential to adversely affect water resources or the environment in general. In addition to this, the Department of Fisheries and Oceans retains direct management of fisheries and, accordingly, their regulations apply, but only if fish habitat is affected; and the Canadian Coast Guard requires approval of all construction in navigable waters under the *Navigable Waters Protection Act*.

A certificate of environmental approval for alterations and construction adjacent to bodies of water includes terms and conditions which are binding on the proponent and any persons working for the proponent. An application for approval must be completed by the proponent or the proponent's agent or consultant and submitted to the Department of Environment and Labour as per Section 11 Subsection (1) of the *Environment Act*.

13.2 Preconstruction Preparation

13.2.1 Environmental Reconnaissance of Site

Early in the planning stages, a joint engineering and environmental reconnaissance of the site should be conducted to locate and identify all bodies of water which may require special attention during construction. All small feeder streams or intermittent watercourses must also be included in the assessment.

Specific mitigative and protective measures to be taken at particular locations should be identified. Naturally, the specific measures to be taken depend on the activity and their potential impacts. An example of a well laid out construction site can be seen in Figure 13.1.

13.2.2 Scheduling

The scheduling of work that deals with stream alterations is an important consideration in the implementation stage of an undertaking. Proper scheduling is important from the standpoint of environmental and fish habitat protection, and can be economically advantageous as well.

From the standpoint of the Department of Environment and Labour, the ideal time of year for construction near a body of water would be during:

- low flow (makes it easier to restore stream bank and the sediment will carry slower and settle out quicker)
- the low rain fall period (reduces the chance of flash flooding).

These guidelines roughly translate to a season lasting from June 1st to October 30th.

13.0 GENERAL CONSTRUCTION PRACTICES

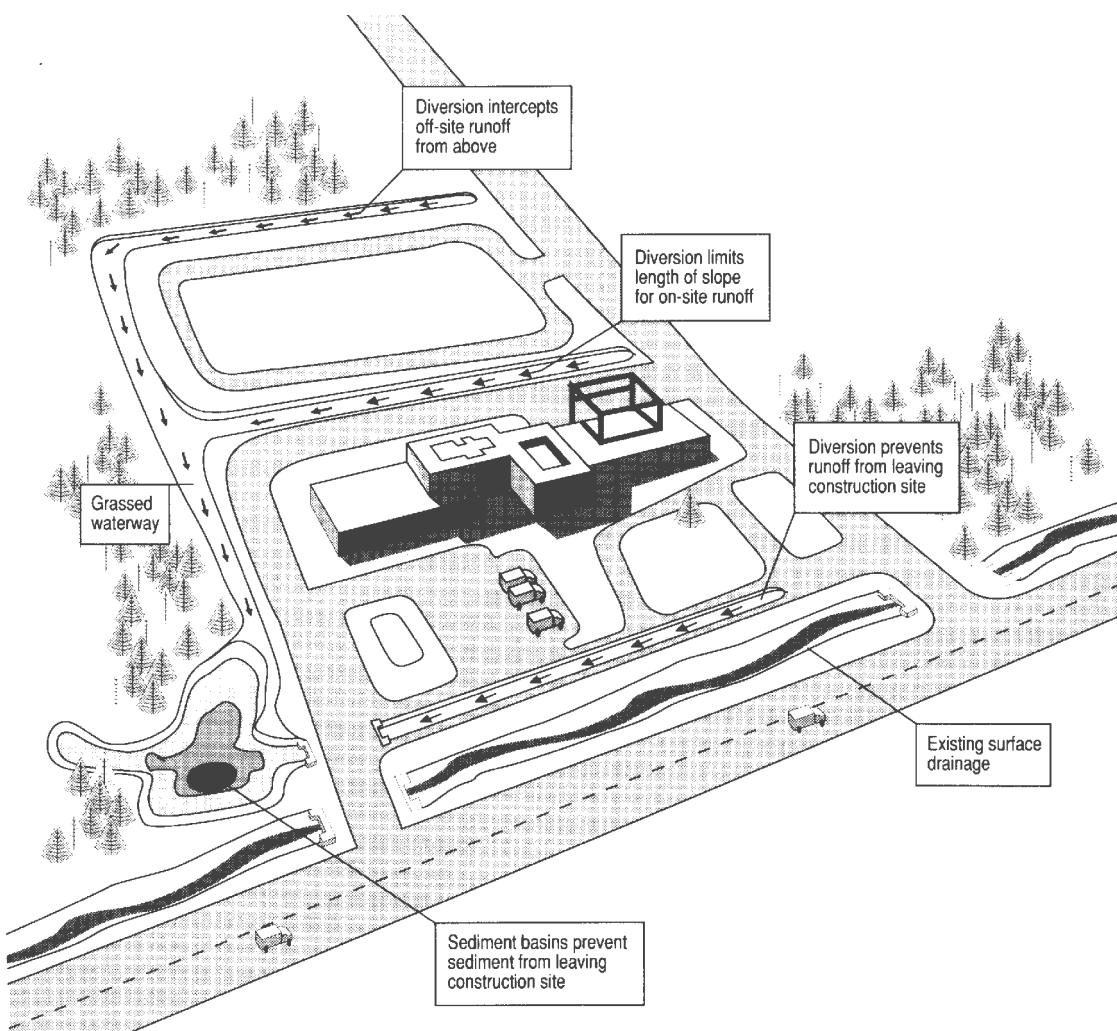


Figure 13.1 A Well Laid Out Construction Site

13.0 GENERAL CONSTRUCTION PRACTICES

The amount of time spent on construction can have an increasingly adverse effect on water quality. The longer the stream bed is disturbed and left exposed, the larger the amount of sediment that will be introduced into the watercourse and the further the sediment will be able to travel within the watercourse.

13.2.3 Construction Methodology

Prior to the operation of heavy equipment or deployment of labour forces at or near a body of water, the construction methodology and procedures to be used should be planned so as to minimize any impact of the project on the body of water and adjacent lands. This would include the preparation of clear instructions for the use of contractors and their equipment operators.

13.2.4 Conveyance of Regulatory Requirements

All important details or procedures which would be necessary to mitigate environmental impact or which are required by a municipal, provincial, or federal regulatory authorities must be clearly conveyed to site personnel and those actually carrying out the work.

13.2.5 Site Access

Wherever possible, the site should be accessed via existing roads. Where no roads exist, fording of streams by vehicles other than one man ATV's should be limited to one trip in / one trip out. For further details on fording, refer to Chapter 6, *Fording*.

13.0 GENERAL CONSTRUCTION PRACTICES

13.2.6 Site Layout

The construction site should be planned and "laid out" with prominent markers to clearly indicate designated areas such as:

- The outer boundary or limit of the project site or area to be cleared, stripped, grubbed or excavated.
- Spoil areas or areas where topsoil and other material may be stored for later use.
- Protected or no entry areas such as areas outside the designated site, buffer strips on bodies of water or on site features such as drainage ditches, culverts, settling basins, etc. which require protection.

13.3 Clearing and Grubbing

Before starting to clear and grub in preparation for construction, all environmental protection measures must be in place. To reduce the exposure of erodible soils, appropriate scheduling should be arranged so that grubbing, stripping and excavation will be quickly followed with the remainder of required construction work. All infilling, compaction, grading and surfacing must then be completed as soon as possible to stabilize and protect exposed soils.

13.3.1 Salvage Useable Materials

Where extensive removal of tree cover is required, salvage of useful wood such as saw logs, pulp wood, and firewood should be carried out. Under no circumstances should wood or slash be dumped into or near a body of water.

All topsoil and/or organically rich soils which are stripped or removed, must be stored at or near the construction site and protected from erosion so that the material may be subsequently used to help revegetate disturbed areas.

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If armour stone or rip-rap is required as part of the project, suitable rock which could be used for this purpose should be set aside for subsequent use.

13.3.2 Equipment Operation

All vehicles and equipment working near a body of water must be clean and in good repair, free of mud and oil or other harmful substances.

Suitable measures must be taken to prevent or reduce the generation of silted or muddied water in the operation of heavy equipment. Heavily travelled areas must be kept well drained to prevent the formation of mud puddles which can contribute to siltation. Generous use of gravel or installation of roadside drainage culverts may be required.

Heavy equipment such as bulldozers, front end loaders, backhoes and cranes must be kept outside the high-water mark of all drainage courses and bodies of water. The operation of all heavy equipment must be confined to dry, stable areas to reduce the production of mud and silted water.

Fuels, chemicals or deleterious materials must not be stored near a body of water. No vehicles or equipment shall be serviced near a body of water.

13.3.3 Temporary Culverts or Bridges

Small streams or drainage courses which must be crossed frequently by heavy equipment should be provided with a temporary culvert or bridge at the proposed crossing location. Chapter 3, *Watercourse Crossings*, Chapter 4, *Bridges*, Chapter 5, *Culverts*, and Chapter 6, *Fording*, provide detailed information on stream crossings and the use of bridges and culverts.

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13.3.4 Surface Water Diversion

Peripheral ditching should be provided to intercept surface water where such water would enter the site and then divert it around the area of construction. Keeping such water clean reduces the amount of silted water which will require treatment.

Separate peripheral ditching or a low basin should be provided along the lower boundary of the construction site to intercept and contain silted or muddied surface water from the site. Silt fences and/or straw or rock check dams (See Figure 13.2) must be used to slow the flow of water in the ditches, allowing the sediment to settle.

13.3.5 Dust Control

Measures must be taken to control dust that may impair the quality of an adjacent body of water. Water and wood chips are safe methods of controlling dust. Calcium chloride and oil based suppressants must not be used near a body of water.

13.3.6 Waste Material Disposal

All waste materials must be disposed of at a site approved by the Department of Environment and Labour.

Where slash and debris are burned, the location must be a sufficient distance from any body of water to prevent pollution by cinders or ash.

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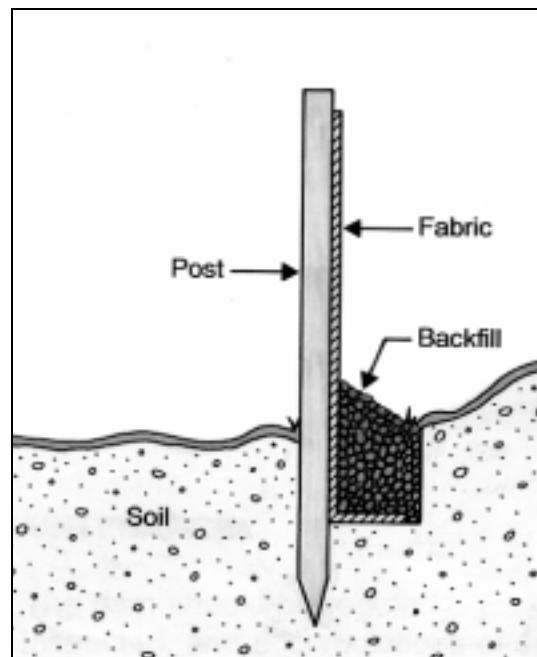
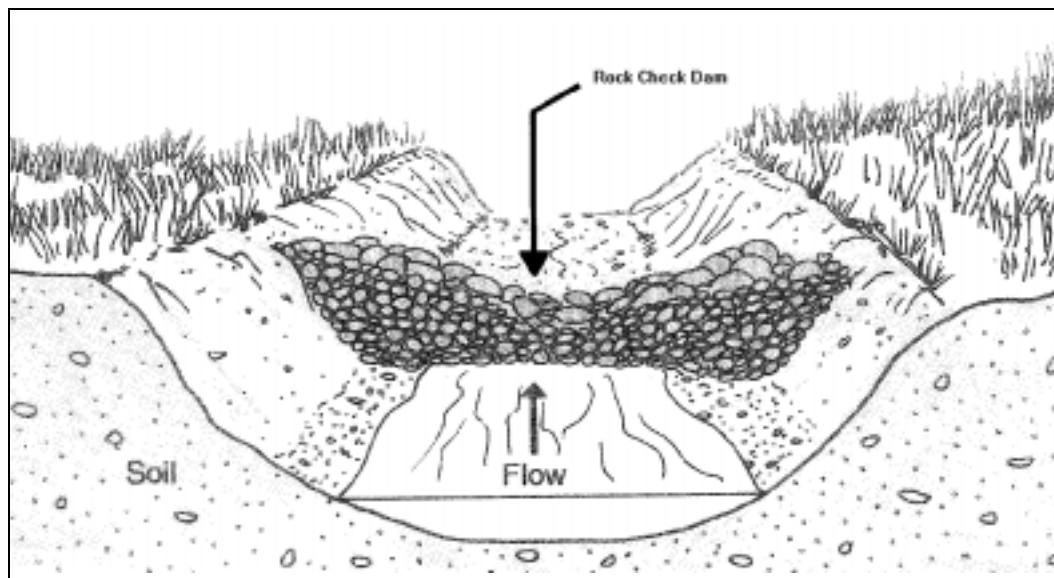


Figure 13.2

Rock Check Dam and Silt Fence Installations Reduce Flow Velocity Reducing Erosion and Allowing Silt to Settle

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13.4 Working in the Dry

13.4.1 Use of Cofferdams

Where excavation or other extensive in-stream work is to be carried out, properly designed and constructed cofferdams must be used to separate the work area from the water so that work can take place in the dry, minimizing the generation of silt.

Cofferdams may be used to completely cut off flow through a section of a small stream or drainage course in order to isolate the construction area while the flow is diverted around the site by temporary culverting or pumping.

When a watercourse is too large to divert by pumping or temporarily culverting, part of the width of the stream may be blocked off to allow work to take place in the dry. Not more than one third of the width of a watercourse should be blocked at any time in order to ensure efficient remaining capacity in the channel to safely accommodate flow without causing excessive high velocity, erosion or overtopping of banks.

Cofferdams should be constructed of non-erodible material to prevent washout of the structure which may result in downstream deposition and siltation. Cofferdams must be constructed tightly to prevent or reduce the amount of seepage into the work area. This also reduces the amount of silted water and mud which would have to be pumped from the work area and be treated prior to release into bodies of water.

Sheet metal or wood panel cofferdams are preferred to cofferdam constructed of till or pit run material as they can provide a tighter structure and do not create problems

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of siltation and erosion. Sandbags are also a preferred method as they can be removed easily.

Upon completion of the instream work, the cofferdam structure must be removed from the channel carefully and completely, to prevent disturbance of the channel and downstream areas.

13.4.2 Use of Pumps

Pumps may be used to divert very small streams or drainage courses around an area of construction to prevent the water from becoming silted by contacting disturbed areas and to maintain the site in a dry condition. Where pumps are used to divert flow, cofferdams must be maintained above and below the area of construction. The upper cofferdam should prevent any water from entering the construction area and should provide a sump area from which the water may be pumped. The lower cofferdam should prevent any silted water or mud in the construction area from draining directly into the watercourse as well as prevent clean water from entering the work area.

Pumps of adequate capacity must be maintained at all times, to safely accommodate the volumes of flow occurring in the stream. In the event of pump breakdown, back-up pumps must be immediately available or an alternate method to accommodate the flow around the construction area must be provided without causing siltation in downstream areas.

Pump intakes should be set just below the surface of the water in the sump area to avoid sucking up bottom sediments. This will prevent or reduce silt being transported to downstream areas. The discharge point should be located an area of

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vegetation or an area with rock where the flow can be returned to the natural channel without causing erosion or picking up further sediment.

Silted water which is pumped to receiving waters must comply with the *Environmental Control Water and Sewage Regulations*, with particular regard to suspended solids. All necessary measures such as settling and/or filtering must be carried out to remove suspended solids from heavily silted water prior to release into receiving waters.

13.4.3 Temporary Diversion Channels

Another means of isolating the work area is to construct a temporary diversion channel. The channel should be large enough to handle the predicted flows and should be lined with plastic sheeting or another suitable material which will prevent erosion of the channel.

Upon completion of the instream work, flow should be reinstated to the original channel and the diversion should be backfilled. For further details on diversions, refer to Chapter 7, *Diversions, New Channels, Major Alterations*.

13.5 Treatment of Silted Water

13.5.1 Water Quality Requirement

Where silted or muddied water has been generated, settling ponds, filtration or other suitable treatment must be provided to remove silt and turbidity before discharging into a body of water. Effluent discharged into receiving waters must comply with

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the *Environmental Control Water and Sewage Regulations*, which are included in Appendix A.

13.5.2 Settling Basins

A properly designed and constructed settling basin is preferred to other methods of silt removal because it provides more effective hydraulic parameters for the separation of heavier particles from the water.

Settling basins must be properly designed taking into consideration such factors as the loading of suspended solids in the water, the particle size gradation, the volume of water to be treated, the rate of inflow and outflow from the settling and the surface area available.

Settling basins should be located in low lying areas where they will not contribute to high ground water conditions and where the water may be either returned safely to the body of water or recharged to the water table. For treating heavily silted water or where large amounts of residual silt are anticipated, an area should be set aside which is accessible by heavy equipment for removal and disposal of the silt. The area may subsequently be upgraded and landscaped.

13.5.3 Use of Other Low Lying Areas or Wetland

For treating lightly silted water or smaller quantities of water, natural low lying areas with some minor modifications can be utilized. Very light organic materials and very fine sediments are more effectively settled in areas where there is active vegetation such as marsh land where biological processes provide natural separation. Such areas can often be utilized effectively with only minor modifica-

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tions required and can be easily restored without significant detrimental impact on the natural flora and fauna of the marsh or lowland.

Pumping smaller quantities of water into such an area and allowing it to percolate into the ground or gradually make its way back to the body of water is a low cost method of filtering suspended solids.

13.5.4 Other Methods for Removal of Suspended Solids

In some circumstances chemical or mechanical processes may be used to separate suspended solids. The addition of alum (aluminum-potassium sulphate), or similar flocculating agent helps precipitate very fine or colloidal particles. Hydro-dynamic separators or similar mechanical processes can provide a fast method for separating heavy particles. Filtration may be used when the quality of water involved is small and adequate provision is made for periodically cleaning the filters.

13.6 Use of Concrete Near a Body of Water

Where cast-in-place concrete is required, all fresh concrete must be kept from coming in contact with the watercourse until adequate curing is achieved. The formwork must be constructed with tight joints to prevent leakage and all necessary precautions taken to prevent spillage of concrete in or near a body of water.

Tools and equipment which have been used for working fresh concrete must not be washed in any body of water or stream.

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13.7 Control of Slumping and Erosion

13.7.1 Inspections

Inspections of the construction site and surrounding areas must be carried out periodically and after heavy rains to identify any areas subject to erosion.

13.7.2 Remedial Measures

Where erosion or slumping has already become evident, immediate and appropriate remedial measures are necessary to stabilize the area. Such action can often prevent more serious and extensive erosion problems before the erosive process becomes well established.

13.7.3 Embankment Grading

Final embankments, including roadside and stream embankments, must have finished grades no steeper than two horizontal to one vertical. More gradual slopes will be required where the type of material is extremely fine and subject to washout. Long slopes should be provided with intermittent benching to interrupt the flow of water and prevent cuts and surface erosion.

13.7.4 Protection Of Fill During Construction

Fill material should be placed in layers not exceeding 400 mm and each layer adequately compacted or consolidated to resist slumping or erosion.

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Exposed embankments or any unstable material which is vulnerable to soil erosion should be protected, as appropriate, by any of the various methods of temporary surfacing including but not limited to:

- plastic sheets
- economical anti-erosion mats
- mulches (such as wood chips).

13.7.5 Site Restoration and Stabilization

Site restoration and stabilization must be carried out in accordance with the guidelines provided in Chapter 14, *Restoration and Stabilization*.

13.8 Energy Attenuation for Erosion Control on Water Courses

Streams which have a small channel capacity with steep banks, will have high flow velocities during storm runoff and are very susceptible to erosion. Streams which flow through areas of very erodible soil (common in low lying areas adjacent to watercourses) and streams having sharp meanders or bends are also prone to erosion. In general, whenever exposed erodible soil along a stream bank is found, especially in conjunction with a restricted channel, or sharp turns, corrective measures must be taken if the resulting construction will itself result in an increased peak flow.

Any mechanical technique that will slow the water velocity is an energy attenuation device. Common examples are the use of rip-rap in steep ditches and grass linings in ditches with a lower gradient. The rocks or the blades of grass serve to slow the velocity of water and prevent the transfer of energy to soil particles.

Where long, steep gradients are involved, energy attenuations are commonly constructed by imbedding bricks, concrete blocks or rocks into the natural stream bed or into concrete or asphalt ditch linings so that the force of water will be retarded and its energy attenuated. The use of check dams, weirs and drop spillways made of a variety of materials, both temporary and permanent, will reduce channel grade and dissipate the energy of flowing water.

13.8.1 Design of Energy Attenuation Structure

Special care has to be taken that the energy attenuation device will adequately dissipate the energy of the water so as not to damage banks or the toe of the structure. Energy attenuation devices frequently result in a concentration of the volume of the water flow with a consequent increase in water velocity at the structure, therefore, banks around grade control structures often require additional stabilization measures.

13.8.2 Reduce Slopes

In those circumstances where steep slopes will result in an unacceptable level of erosion, the flattening of those slopes should be considered as an erosion control practice. The use of retaining walls incorporated into a slope will allow the flattening of slopes above and below the structure within the same horizontal cross section. The use of a grade control structure in a stream not only provides energy attenuation but reduces stream gradient upstream and downstream of the structure.

A major disadvantage of energy attenuating structures used to reduce channel grade is that they can obstruct the passage of fish. The Area Habitat Coordinator at the Department of Fisheries and Oceans should be contacted before a decision is made on the use of these devices.

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13.8.3 Protection of Adjacent Properties

The protection of adjacent properties from accelerated erosion and sedimentation is an important concern. A developer has a legal, as well as a moral responsibility to ensure that his work is of sufficient high quality so as to not create erosion or sedimentation problems on adjacent properties.

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