Alberta Watercourse Crossing Guidebook

2024

AWC3

Alberta WaterCourse Crossing Collaborative

Alberta Watercourse Crossing Guidebook (PDF)

ISBN 978-1-7383447-1-0

March, 2024

Acknowledgements

We would like to thank all of the various stakeholders and rights holders who took the time to meet with us to inform the project from various perspectives. We would also like to thank the watercourse crossing practitioners who attended the March 2023 workshop to help refine the watercourse crossing BMP factsheets.

We would like to acknowledge the contributions of Fuse Consulting's Terra Simieritsch, Matthew Pyper, Amanda Ronnquist, and Christine Daly for the synthesis of information, guidebook writing and illustration, and project management.

We would also like to extend a special thank you to all of our funders who made this project possible:

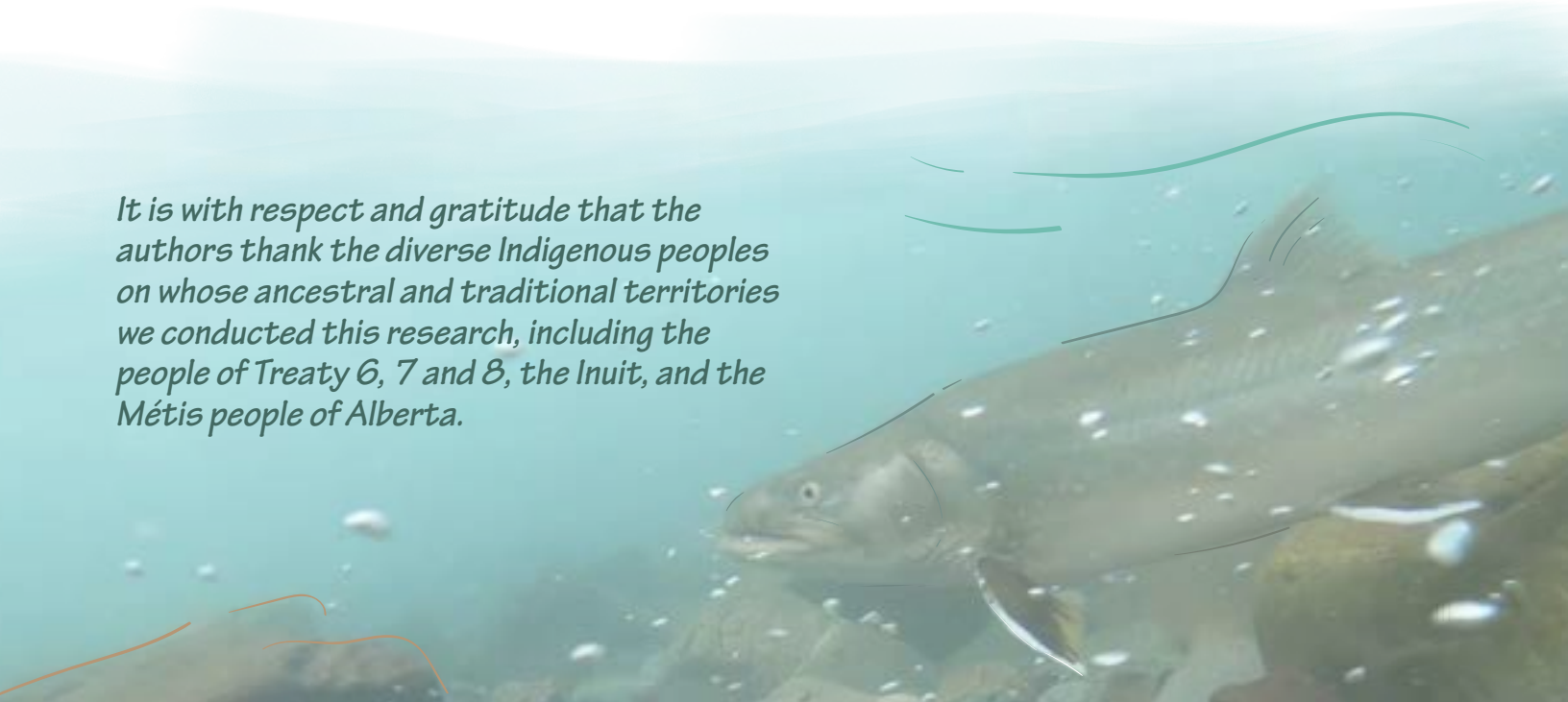
Fisheries and Oceans Canada
Pêches et Océans Canada
Foothills Forest Products
Cenovus Energy
Whitecap Resources Inc
Crescent Point Energy Corp
Alberta Pacific
kiwetinohk energy
Canadian Natural
Canlin Energy Corporation
Mercer Peace River
Canfor
West Fraser
Tourmaline Oil Corp.
Tolko

Sincerely,

The AWC3 Board of Directors:

Ben Poltorak, Bruce Nielsen, Michael Bender, Michael Wagner, Michael Hunka, and Jody Foster

It is with respect and gratitude that the authors thank the diverse Indigenous peoples on whose ancestral and traditional territories we conducted this research, including the people of Treaty 6, 7 and 8, the Inuit, and the Métis people of Alberta.



Foreword

The Alberta Watercourse Crossing Collaborative (AWC3) has created this Alberta Watercourse Crossing Guidebook to empower those involved in all aspects of watercourse crossing projects. This resource is a compilation of current Best Management Practices (BMPs) for the design, planning, installation and maintenance of watercourse crossings. This comprehensive resource provides direction so practitioners understand what legislation and regulations they need to adhere to, and how to ensure their project is as successful as possible over the entire project lifespan. Success includes ensuring fish passage, reducing erosion and preventing sedimentation, and maintaining natural water flow, as well as ensuring climate resiliency and healthy, connected habitats.

The Alberta Watercourse Crossing Guidebook provides a comprehensive look at all stages of a watercourse crossing installation and removal. The guidebook aims to empower practitioners with an understanding of the who, what, where and why of watercourse crossing projects. The guidebook is not intended to be a comprehensive regulatory manual or a detailed step-by-step guide, but the companies, practitioners and regulators who have contributed to this guide all believe the information it contains can create a legacy of improved watercourse crossing practices across Alberta.

The Alberta Watercourse Crossing Guidebook has three core audiences:

- **Watercourse crossing owners** can use the guidebook to understand the full lifecycle of their watercourse crossings and the reasoning behind the use of current BMPs.
- **Watercourse crossing designers** can use the guidebook to ensure they have the information they need to design watercourse crossings that will allow fish passage and have the ability to withstand various weather events, including high-flow events. The guidebook can also help crossing designers ensure crossings serve their purpose for the lifecycle of the project, while minimizing environmental impacts during installation and long-term use. Incorporating components from the guidebook into crossing designs may reflect positively in regulatory submissions, improve outcomes for fish species, and reduce lifecycle costs.
- **Watercourse crossing field practitioners** can use the factsheets included in the guidebook to better understand the best ways to install watercourse crossings with the least impact possible to the surrounding environment and associated fish habitat, while gaining an understanding of why specific BMPs are important.

It is recommended the Alberta Watercourse Crossing Guidebook be read in full by watercourse crossing owners and designers, who can then ensure appropriate sections are passed along to the practitioners implementing the work in the field. The installation, replacement, and restoration BMP sections of this guidebook can also easily be used as individual factsheets for sharing with field personnel and construction teams.

Disclaimer

This resource is intended to guide the use of BMPs for watercourse crossing projects; however, it remains the proponents' responsibility to meet all federal, provincial and municipal regulatory requirements that apply to any works, undertakings, or activities. Each watercourse crossing site is unique and an opportunity to examine what planning and techniques will work best. This manual provides guidance on the overall process and options that may be implemented, but it does not replace hiring or consulting experts with professional designations and specialized skill sets.

This guidebook is not applicable to watercourse crossing structures located on the provincial highway network that are under the jurisdiction of Alberta Transportation and Economic Corridors. For TEC related projects, please refer to resources and requirements listed on alberta.ca/infrastructure-transportation

Contents

1. Introduction 1

2. Goals of a watercourse crossing 2
What do watercourse crossings need to achieve? 2

3. Legislation, regulatory approvals and permitting 10
Applicable legislation 10
Provincial overview 11
Federal overview 14
Indigenous consultation and engagement 17

4. Planning 19
Choosing a location for a crossing 20
Watercourse site assessment and survey 22
Hydrology and fish passage design 25
Selecting structure type 26
Hydraulic design 27
Environment protection plan and sediment and erosion control 28
Developing and communicating an engineering design or plan 31
Timing considerations 32
Unique planning considerations for watercourse crossings 33
Planning for a watercourse crossing within a wetland 33

5. Preparing your site 36
Fishery isolation and rescue 36
Site dewatering 37
Erosion and sediment control 41

6. Watercourse crossings: Installation, replacement, and restoration 49
Temporary watercourse crossings 50
Watercourse crossings 59
Other techniques 81

7. Wetland watercourse crossings: Installation, replacement, and restoration best practices 83
Knowing your wetlands: Classification and identification 83
Maintain wetland water flow and fish habitat 84
Wetland watercourse crossings 85

8. Crossing removal and restoration 95
Planning to achieve successful crossing removals and restoration 96
Developing restoration and construction plans 98
Effectively implementing a crossing restoration 98

9. Post-installation responsibilities 101
Linkages with the WCP and the Watercourse Crossing Management Directive 101
Monitoring programs and inspection frequency and scheduling 102
Watercourse crossing inspection data collection 103
Watercourse crossing inspection reporting 104
Remediation planning and actions 104
Maintenance of watercourse crossings 105

Appendix A: Letters of Endorsement 106

1. Introduction

Alberta is a province known for its diverse ecosystems and abundant natural resources. Development opportunities provide economic, environmental, social, and cultural benefits to the people of Alberta. Natural resource development has contributed significantly to the expansion of roads and associated watercourse crossings across our province.

Historically, watercourse crossing construction has not adequately addressed fish passage, habitat connectivity, and watercourse health. As a result, ineffective watercourse crossings have played a significant role in the decline of fish habitat and the subsequent decline of native trout and Arctic Grayling populations in Alberta.

The good news is that this is a very tangible challenge, and actions made to correct the course could have a profound and lasting impact. However, given the watershed scale of the issue, a collaborative approach by all resource road owners and watercourse crossing designers and practitioners is needed to ensure results are achieved across the landscape.

This guidebook was created as a result of the recognition that a solution can only occur if watercourse crossing owners, designers, and field practitioners clearly understand the goals, regulations, and Best Management Practices (BMPs) associated with watercourse crossings and have access to clear information that allows them to find solutions that work for their operations.

This guidebook has been created through the collaborative efforts of many individuals involved in the various aspects of watercourse crossings and is specific to the Alberta context. The information and BMPs provided have been compiled and reviewed by many contributors, many of whom have gone through facilitated dialogue with experienced practitioners to refine the content in this guidebook. The result is a compilation of ideas and resources packaged in a way that is accessible to all who have a role in addressing the legacy of watercourse crossings requiring remediation as well as ensuring that future watercourse crossings are meeting and exceeding standards. This can be accomplished through the use of planning, site preparation techniques, BMPs, and a deeper knowledge of the aquatic ecosystems we are trying to restore and protect.

You will find practices that help ensure fish passage, prevent sedimentation, and allow for aquatic health and proper water flow throughout the Alberta Watercourse Crossing Guidebook project.

2. Goals of a watercourse crossing

Clearly identifying and communicating the goals of a watercourse crossing is one of the most important steps in the design and installation process and determines the long-term effectiveness of the investment. This section of the guidebook provides clarity on what the goals of an effective watercourse crossing are, and why they are so critical when it comes to successful watercourse crossing design.

What do watercourse crossings need to achieve?

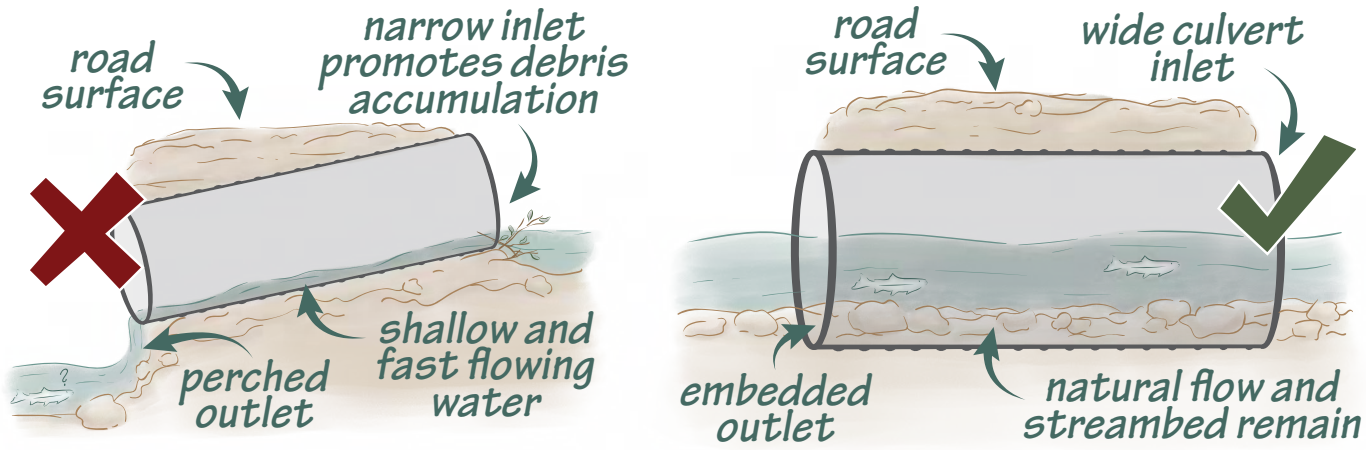
A core outcome of watercourse crossings is to have the least possible amount of impact on the watercourse. To achieve this, crossings should mimic the natural conditions of the watercourse as much as possible and create the least amount of disturbance throughout the construction process. More specifically, all watercourse crossings should achieve the following core goals:

- Ensure the passage of all fish.
- Reduce erosion and prevent sedimentation.
- Match the upstream and downstream water flow rate of the natural watercourse channel (i.e., water flow does not speed up or slow down at the crossing).
- Be resilient to changing climatic conditions (e.g., flooding and fire).
- Create the best possible conditions for healthy aquatic habitats.

The following sections explore each of these goals in more detail.

Ensure fish passage

Fish passage is one of the most important goals within fish-bearing watercourses because fish require access to habitat across an entire watershed to complete vital parts of their lifecycle. Fish travel to spawn and overwinter, find habitat for feeding and rearing, and to seek shelter from predators. Fish passage is, therefore, a mandatory requirement for all watercourse crossings within fish-bearing watercourses. If conditions do not allow for connected fish passage, fish cannot access the resources and habitats they need, resulting in population fragmentation and decline.



Poorly constructed and/or poorly maintained watercourse crossings are often a key barrier to fish passage, and therefore a threat to fish survival. Watercourse crossings can obstruct fish passage when structures are not designed or installed in a way that accounts for proper sizing, slope, water velocity, water depth, elevation, and embedment[1]. These obstructions can also occur over time (even when a crossing was installed properly), so it is important to inspect watercourse crossings regularly to ensure they are not preventing or obstructing fish passage. It is a regulatory requirement for watercourse crossings to allow for fish passage. If fish passage is impeded by a watercourse crossing, it is considered non-compliant and is obligatory to report. See *Duty to Report Section* of this guidebook.

Fish passage prevented by debris within the culvert

Fish passage prevented by a large vertical drop

Fish passage prevented by excessive water velocity

Watercourse crossings can impede the passage of fish in various ways, each with potential mitigations to be considered at the design and construction stages. Incorporating these mitigations can greatly enhance the quality and effectiveness of the watercourse crossing. In general, the more closely a watercourse crossing mimics the natural watercourse channel, the more likely the structure will ensure fish passage.

Impediments to fish passage	Mitigation to ensure fish passage
A significant vertical drop or waterfall effect caused by a perched or hanging culvert blocks fish passage due to the change in height and results in development of plunge pools.	Ensure the structure is embedded properly with no significant drop at the outlet.
Water is moving too quickly through the crossing due to the watercourse crossing structure being undersized.	Ensure the width of the watercourse crossing structure is as wide as the watercourse (bankfull width) to minimize changes in water speed and reduce the likelihood of debris clogging the structure.
Water levels are too low within the structure and there is no backwater in the watercourse crossing structure, causing the structure to run dry during periods of low water flow.	Ensure the structure is embedded properly and the gradient of the structure mimics that of the natural watercourse.

1 Fisheries and Oceans Canada. 2016. Guidelines for Watercourse Crossings in Quebec.

Impediments to fish passage	Mitigation to ensure fish passage
Excessive turbulence (water is not flowing smoothly).	Ensure there is substrate throughout the entire length of the structure, including a range of substrate sizes, to mimic natural habitat, minimize changes in water flow, and provide resting areas for fish.
Debris is caught in the crossing structure, thereby blocking passage.	Ensure structure size is large enough to prevent debris accumulation. Complete regular inspections and maintenance to ensure debris does not build up.
The gradient of the watercourse crossing does not match that of the natural watercourse, resulting in the outlet of the structure being perched above the water surface, changes in the water velocity, and/or scouring of the watercourse substrate below the structure.	Ensure the watercourse crossing structure is installed at a gradient that matches the gradient of the watercourse to minimize changes in water velocity and subsequent erosion.

Watercourse crossing blockages can also be caused by beavers, where beavers build dams that block watercourse structures at the inlet or outlet. There are specific regulations for beaver management, and if a beaver is using a watercourse crossing structure to tie in their dam, a different set of rules apply for managing the issue. If unsure, it is always best to contact a local regulator.

Fish have a "burst speed", a high swimming speed (sprint) they can use over short periods of time, requiring a high amount of energy. Fish often use their burst speed to travel through a watercourse crossing. Different fish species have different burst speeds, and watercourse crossing designs need to account for the lowest burst speeds to allow for passage of all fish. Adding cover, channel roughness, and irregularities in the channel will improve the ability of all fish to move through a newly constructed watercourse crossing.

Reduce erosion and prevent sedimentation

Erosion occurs when soil is displaced or portions of rocks are dissolved, and can happen by various means, such as moving water, rain, wind, and gravity[2]. The particles that are displaced are called sediment, and when those sediments enter watercourses and settle out, the process is called sedimentation.

Erosion and sedimentation occur naturally, but when these

2 FPInnovations. 2007. Erosion and sediment control practices for forest roads and stream crossings, A practical operations guide.

processes are accelerated by human activities, they can be harmful to water quality and aquatic habitat. Fish are particularly vulnerable to high levels of sedimentation as the sediments can damage their gills, prevent them from getting enough oxygen, decrease their food sources and feeding success, and prevent them from spawning successfully.

> *"Address erosion before it becomes a source of sediment"* – FP Innovations

Resource roads are one of the main sources of erosion and sedimentation in forest environments[3]. To prevent harm to the aquatic environment and ensure road stability is not compromised, it is critical that road drainage be designed and located to minimize erosion and prevent sedimentation. This is particularly important at watercourse crossings where riparian vegetation is disturbed and removed for installation. Ongoing erosion and sedimentation can cause watercourse crossing structures to fail.

There are site-specific characteristics that will affect how susceptible a site is to erosion, and in turn determine what type of erosion control measures would be best suited to the site. These factors include:

- *Weather and season: Rain and wind are key causes of erosion, and in a winter dominated climate, freeze/thaw cycles can influence soil properties, freezing and break-up can damage roads and watercourse crossings, and ice jams must be accounted for.*
- *Vegetation: Roots from vegetation help stabilize watercourse banks and channels, and plants filter sediment from upland areas. Native plant species are preferred because they are adapted to local conditions and often have attributes that are most effective for stabilization. Certain types of grasses are also preferred for their ability to create deep rooting networks.*
- *Topographical conditions: Steeper slopes erode more easily than shallow slopes or flat terrain.*
- *Soil types: Some types of soil are more susceptible to erosion than others.*

For more detailed best management practices related to erosion and sediment control, please refer to the ***Erosion and sediment control*** and ***Preparing your Site*** sections in this Guidebook. These topics are also discussed by crossing type in the ***Watercourse Crossings: Installation, Replacement and Restoration*** and ***Wetland Crossings: Installation, Replacement and Restoration sections.***

Existing land use practices and regional road density also have a cumulative effect on erosion and sedimentation, particularly if land practices have resulted in large areas of disturbance[4]. It is important to consider the larger picture when planning the number of watercourse crossings that are required and to factor in how the existing and future watercourse crossings can impact overall watercourse health and fish habitat.

One of the most impactful steps that can be taken to reduce erosion and prevent sedimentation is to simply leave as much existing vegetation as possible in place during the construction period. This enables vegetation to play a key role in trapping sediment before it can enter the watercourse. Vegetation is often removed during construction, as machines are used to pack down tracks to improve visibility for watercourse crossing project work. This can remove many years

3 United States Department of Agriculture. 2016. Effectiveness of Best Management Practices that Have Application to Forest Roads: A Literature Synthesis.

4 FPInnovations. 2007. Erosion and sediment control practices for forest roads and stream crossings, A practical operations guide.

of vegetation growth and often is not necessary. The long-term benefits of retaining this vegetation exceed any potential short-term gains that come from removing it.

Erosion around a culvert is contributing sediment to the watercourse.

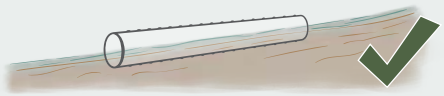
Riparian area vegetation helps prevent erosion and filters sediment.

Having an erosion and sediment control plan for a watercourse crossing project can save time and money over the lifecycle of the project.

Maintain natural water flow

Watercourses are dynamic systems which are constantly changing. Naturally, there are periods of time when water flow will be lower or higher depending on factors such as geographic location, season, weather, and large-scale events such as droughts and flooding. In a natural system, watercourses evolve with these changes over time.

To prevent issues over the long term, a watercourse crossing needs to match the gradient (or slope) of a natural watercourse and be embedded based on that natural gradient.



One key step to maintaining natural water flow is to ensure watercourse crossings are designed to maintain the natural watercourse width and gradient. Maintaining the natural system allows for proper water flow and for the watercourse to restore equilibrium as changes occur over time. Enabling this natural adaptation prevents negative consequences such as impeding fish passage and damage to the resource road infrastructure.

When a watercourse crossing structure is too small, the water channel becomes constricted, water flow becomes concentrated, and the speed of water movement (velocity) increases. This impedes fish passage, causes erosion and sedimentation, and can cause the crossing structure to become perched. The watercourse crossing and road can also be damaged or destroyed during peak flows if sizing does not consider high flow events such as floods.

Another common issue with watercourse crossing design and installation pertains specifically to culverts. When a culvert is placed either too high or too low and is not in line with the watercourse's natural elevation and gradient, it can increase the water flow, change the width of the channel through erosion[5], and cause the culvert to become perched. If the culvert is placed too low, sediment and woody debris can also accumulate in the structure, changing the rate of water flow and impeding fish passage.

The following indicators can be used to identify watercourse crossings that are not maintaining the natural watercourse effectively with subsequent negative effects on water flow:

- Water velocity is much faster at the outlet of the watercourse structure than the natural watercourse flow.
- Substrate is either absent or is building up and risking blockage within the watercourse crossing structure.
- The culvert is perched and scour pool has formed downstream of the outlet of the crossing.

5 FPInnovations. 2019. Streambed Simulation: Monitoring and Maintaining a Fish-Friendly Culvert Crossing: A Practical Guide for Forest and Resource Workers.

- There is little to no water flow in the watercourse crossing structure compared to that of the natural watercourse.

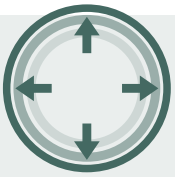
The photo on the left is an example of where a culvert has not been embedded properly, and this has resulted in a perched culvert that is impeding fish passage. The photo on the right shows a properly embedded culvert allowing for the natural watercourse width to flow through the culvert, thereby allowing for fish passage. The crossing on the right is also maintaining the natural water flow.

It is important that practitioners installing watercourse crossings are very familiar with the watercourse crossing design and are willing and able to get clarity from the designer and/or engineers if they have questions.

Consider climate resilience

Climate change is leading to a higher frequency and magnitude of extreme events such as flooding and wildfire. To retain the ability to function effectively over the long term, watercourse crossings need to consider the changes that are currently occurring and are more likely to occur in the future as a result of climate change.

Scientists have begun to detect changes in hydrology resulting from the changing climate, including increases in the magnitude of flood events and lower water flows in the summer[6]. These changes are in combination with an increase in wildfire frequency, season length and overall areas that are being burned as a result. These trends are expected to continue as scientists forecast increased temperatures and drought[7]. These changes can affect many aspects of how a watercourse functions, such as water quality and quantity and watercourse channel morphology.



Designers of new and replacement watercourse crossing structures should consider upsizing their designs to account for the hydrological effects of climate change. For more information on choosing and designing a watercourse crossing see the Planning section of this guidebook.

In terms of the applicability to watercourse crossings, the increased natural sedimentation from runoff after forest fires creates shallower watercourse channels, and in combination with the potential increase in flood water and associated debris, water movement may be constricted. This constriction can result in an impoundment upstream of the culvert, increased velocity through the culvert, and washout of the road. The increase in sedimentation and debris can also change watercourse bed composition and decrease valuable spawning and rearing habitat for fish. Increased water velocity and plunge pools are both known barriers to fish passage. Higher peak flows during flood events can also cause the watercourse crossing structure and road infrastructure to fail.

6 Washington Department of Fish and Wildlife. 2017. Incorporating Climate Change into the Design of Water Crossing Structures: Final Project Report.

7 United States Environmental Protection Agency. 2022. Climate Change Indicators: Wildfire: https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires. Accessed February 2023.

An example of a healthy riparian area adjacent to a watercourse with various types of vegetation.

The implication is that designers of new and replacement watercourse crossings need to consider larger watercourse crossings (particularly where culverts are used) and ensure proper installation. Taking the potential hydrological effects of climate change into consideration at the outset can reduce uncertainty, decrease lifecycle costs, and lower the risk that a watercourse crossing will be damaged or destroyed due to high flow events.

Maintain healthy watercourse habitats

Overall, the best way to protect watershed health is to avoid landscape disturbance. From a watercourse crossing perspective, this could mean minimizing the density of resource roads, and thereby minimizing the number of required watercourse crossings. In many cases, removing or restoring watercourse crossings can have minimal impacts on access while having significant benefits to overall watercourse health and fish habitat.

Watercourse crossing owners should consider the bigger picture to determine if there are existing resource roads that can be utilized for a project, which may involve collaborating with other companies or individuals who own those roads. Lower road density has many benefits to the ecology and habitat of any forested area. Fewer roads and crossings also help to lower construction costs and reduce the long-term risks and costs associated with crossing structures.

Where watercourse crossings are deemed necessary, minimizing disturbance includes retaining as much of the riparian area as possible around a watercourse. If the riparian area is disturbed, the area should be returned as closely as possible to its original state (e.g., by planting native species) immediately after the disturbance takes place. Planting native vegetation that has been salvaged and stored during the disturbance process is a cost-effective means of ensuring that the original species composition is matched. Re-establishing riparian areas is critical, since these areas provide key functions that are important to watercourse health, including:

- Maintaining watercourse banks
- Providing habitat and corridors for aquatic, riparian and terrestrial species
- Trapping and filtering sediment
- Providing a source of terrestrial insects for fish
- Storing water
- Helping to regulate watercourse temperature
- Reducing flood damage
- Maintaining and improving water quality
- Dissipating water flow[8]

Another key means of minimizing disturbance is to avoid working in the watercourse (instream) as much as possible during construction. There are various ways of avoiding instream work, and these include choosing certain types of watercourse crossing structures (e.g.,

Watercourse crossing owners can create remediation plans for existing issues or deactivation plans for removing crossings that are no longer needed. Prompt road deactivation and watercourse crossing removals are one of the best tools to achieve healthier watercourse habitats.

8 Cows and Fish. What Do Riparian Areas Do? https://cowsandfish.org/ecology-function/. Accessed February 2023.

bridges), or using specific equipment and techniques.

Specific BMPs outlined in this guidebook include ways of avoiding unnecessary instream access by equipment before or during construction. If it is not possible to avoid working in the watercourse, minimizing the impact to the watercourse can include minimizing the time spent in the watercourse, working on top of matting, using proper fish isolation and pump around techniques, and ensuring that work is occurring outside of the Restricted Activity Periods (RAPs) for fish. For more information see the *Watercourse Crossings: Installation, Replacement and Restoration*, *Wetland Crossings: Installation, Replacement and Restoration* and *Crossing Removals and Restoration* sections of this guidebook.

It is important to consult professionals who are knowledgeable in provincial and federal and regulations when instream work is necessary. Watercourse crossings should be removed as soon as they are no longer required.

3. Legislation, regulatory approvals and permitting

To place, construct, install, maintain, replace, or remove a watercourse crossing, owners are required to understand the legislation they must abide by and what associated authorizations may be required. Environmental codes of practice and permitting requirements are in place to ensure that practitioners understand legislative requirements and to ensure all watercourse crossings meet minimum standards. These standards help account for and minimize impacts to the environment, particularly related to fish, other aquatic organisms, and their habitat.

Photo: Trout Unlimited

Why do I need to understand the legislation and regulatory aspects of watercourse crossings?

- Ensuring a watercourse crossing project is in compliance with legislation and regulations will ensure there are no legal and financial repercussions for the watercourse crossing owner.
- Understanding monitoring and compliance requirements prior to project startup helps avoid costly delays that could result from the need to address non-compliance issues or replace the watercourse crossing structure.
- Authorizations, approvals, and permits are acquired faster when applications are robust, clear, and include all pertinent information required by the regulator.
- Clarifying risks early in the process helps identify where to pay close attention in the planning and operations of the project.
- The watercourse crossing owner is more effective at meeting requirements and process and practical errors are less likely if all aspects of the legislation have been considered.

This section of the guidebook helps clarify applicable legislation and clarifies requirements for watercourse crossing owners.

Applicable legislation

Watercourse crossings in Alberta have legislative requirements at both the provincial and federal levels. The most common applicable acts include:

- *Water Act*
- *Public Lands Act*
- *Environmental Protection and Enhancement Act*
- *Forests Act*
- *Fisheries Act*
- *Canadian Navigable Waters Act*
- *Species at Risk Act*

Watercourse crossing owners need to be aware of and adhere to provincial and federal legislation, as well as any other potential project-specific legislation that may be applicable. The main pieces of watercourse crossing legislation are covered in more detail below.

Provincial overview

There are two main pieces of provincial legislation that apply to watercourse crossings in Alberta:

- ***Water Act:*** In Alberta, the province owns the water, and regulates it through the *Water Act*. This Act outlines the rules to ensure water is being managed in a way that promotes the conservation of the resource and protects aquatic ecosystems. This includes planning and permitting for various uses, and water allocation and diversion[9]. In addition, there is a Ministerial Regulation that defines activities allowed under the *Water Act*[10].
- ***Public Lands Act:*** The *Public Lands Act* outlines the ownership rights of the province to all beds and shores associated with naturally occurring water bodies on private and public land in Alberta. This includes land under all water bodies, including wetlands, lakes, and rivers[11].

Other pieces of legislation that may also apply include:

- ***Environmental Protection and Enhancement Act (EPEA):*** *EPEA* outlines regulatory requirements for managing air, water, land, and biodiversity by designating the activities that require approval or registration[12]. This typically only applies to watercourse crossings that are embedded within larger project approvals, or in the case of watercourse crossings, creating environmental damage such as contamination or siltation.
- ***Forests Act:*** The *Forests Act* outlines the regulations for forestry operations in Alberta. This act enables the creation of regulations related to forestry planning and operations. The Timber Management Regulations under the *Forests Act* provide requirements such as those related to water and watercourse crossings for forestry[13]. This legislation is particularly important to understand for temporary watercourse crossings associated with forestry practices.

Master Schedule of Standards and Conditions (MSSC)

Activities that take place on public lands or require access through public lands require a disposition under the P*ublic Lands Act*. The Master Schedule of Standards and Conditions (MSSC) is a document that identifies standards and conditions that apply to these dispositions. The MSSC outlines desired outcomes and BMPs for various categories (e.g., watercourses and water bodies, vegetation, reclamation) and determines what conditions need to be applied for specific types of regulatory applications. The MSSC contains key information that watercourse crossing owners should be familiar with in advance of the design stage of watercourse crossings and throughout the entire watercourse crossing project such as, but not limited to, setbacks from various landscape features, protocols on processes such as decontamination of equipment, various regulatory requirements (including monitoring), and requirements that go above or beyond codes of practice[14].

What other key provincial regulatory requirements do I need to be aware of when undertaking watercourse crossing work?

An important provincial regulatory document to understand when it comes to watercourse crossings in Alberta is the

9 Government of Alberta. 2022. Open Government Publications, Water Act: https://open.alberta.ca/publications/w03#summary. Accessed January 2023.
10 Government of Alberta. 2021. Open Government Publications, Water (Ministerial) Regulation: https://open.alberta.ca/publications/1998_205. Accessed January 2023.
11 Environmental Law Centre. 2007. Factsheet: Water Rights and Property Rights. Environmental Law Centre, Edmonton, Alberta.
12 Government of Alberta. 2022. Open Government Publications, Environmental Protection and Enhancement Act: https://open.alberta.ca/publications/e12. Accessed January 2023.
13 Government of Alberta. 2021. Open Government Publications, Timber Management Regulation: https://kings-printer.alberta.ca/570.cfm?frm_isbn=9780779824311&search_by=link. Accessed January 2024.
14 Government of Alberta. 2021. Master Schedule of Standards and Conditions.

Code of Practice for Watercourse Crossings (COP WCC). This COP WCC, which falls under the *Water Act*, outlines all the standards and conditions that need to be met when installing, maintaining, replacing, or removing a watercourse crossing.

The COP WCC sets out the following:

- What to do in case of emergency
- Watercourse crossing planning requirements
- Maps and class of water body
- Watercourse crossing types (permanent and temporary)
- Restricted Activity Periods
- Certification and confirmation
- Reporting
- Record keeping and information availability
- Monitoring of works
- Guidelines

> ***How do I provide notice?***
>
> *For permanent watercourse crossings, a notification form must be downloaded from the Government of Alberta or Alberta Energy Regulator websites and submitted through the provincial application review process called Digital Regulatory Assurance System (DRAS) or OneStop. Temporary watercourse crossings for forestry operations are submitted as part of an Annual Operating Plan.*

Key features of note within the COP WCC:

- **Providing notice:** If the watercourse crossing work requires a COP WCC notification, the watercourse crossing owner must provide at least 14 days' notice before commencing any work. If the work does not happen within the period specified in the notice, a new 14-day notice must be submitted.
- **Standards:** The watercourse crossing project may need a *Water Act* approval if it does not meet the standards set out in the COP WCC.
- **Hired expertise:** The COP WCC indicates what portions of the watercourse crossing process require specific technical expertise (e.g., plans are to be prepared and authenticated by professional engineer or technical specialist).
- **Restricted Activity Periods (RAP):** A time period during which critical aspects of fish lifecycles are occurring in a water body (e.g., migration and spawning). Unless authorized by a Qualified Aquatic Environmental Specialist (QAES), work must not be conducted during this time of year. These time periods are indicated within the COP WCC and are specific to the water body classification and the type of work occurring.

Provincial Timber Harvest Planning and Operating Ground Rules

The Alberta Timber Harvest Planning and Operating Ground Rules (OGR) provide regulatory guidance and direction for forestry professionals involved in the implementation of forest management plans. This is where the requirements are laid out for all temporary watercourse crossings associated with forestry practices. These requirements include the submission of plans for watercourse crossing installation, maintenance, and reclamation. All temporary forestry watercourse crossings (with a lifespan of three years or less) are regulated under the Timber Harvest Planning and OGRs[15]. It is also important to note that "temporary" is defined differently in OGRs and the COP WCC which defines a temporary watercourse crossing as less than 6 months. Federal regulations define temporary as less than one year. These different definitions must be taken into consideration depending on authorizations required. It is important to hire an expert or contact applicable agencies if clarity is required on regulatory direction.

15 Government of Alberta. 2022. Alberta Timber Harvest Planning and Operating Ground Rules. Agriculture, Forestry and Rural Economic Development, Edmonton, Alberta.

For forestry operations that involve the construction of temporary access and harvest road watercourse crossings, the COP WCC identifies the Alberta Timber Harvest Planning and Operating Ground Rules (OGRs) as the regulatory requirements. Similar to the COP, OGRs are provincial regulations and need to be considered along with Federal requirements; for example, federally designated critical habitats. Therefore, it is important that forestry operators are aware of and adhere to all applicable requirements.

What other provincial requirements might be associated with a watercourse crossing project?

While each project is unique, some examples of additional approval requirements include (but are not limited to):

- An approved General Development Plan and Annual Operating Plan is required for forestry operations.
- An approved Annual Operating Plan when a temporary watercourse crossing is required for forestry operations.
- A *Water Act* approval when the work extends beyond the License of Occupation upstream or downstream of the roadway or disposition boundary.
- A *Water Act* approval for any work that could alter or remove a wetland as defined under the Wetland Policy.
- If instream works are to be done as part of the project (e.g., fish rescue, water isolation, etc.).
- A *Water Act* approval, Fur Management License, or Damage Control License where there is beaver activity in or around the watercourse crossing to be removed, replaced or on the site where a watercourse crossing is to be installed.
- Further assessment by a qualified practitioner is required if provincial/federal species at risk are involved or suspected to have habitat in the area where work is occurring.

Are there other provincial initiatives I should be aware of?

The Government of Alberta has created initiatives to assist in the coordination and resourcing of watercourse crossing installation, maintenance, replacement, monitoring, and restoration in the province. These initiatives include the Watercourse Crossing Program (WCP) and the Alberta Watercourse Crossing Inventory App which provide standardized monitoring and reporting methods.

The Watercourse Crossing Program

The Alberta WCP was created by the Government of Alberta to help address the decline in native fish populations by addressing the threats to fish resulting from trails and poorly constructed and maintained watercourse crossings. The program connects provincial and federal regulators with watercourse crossing owners and stewardship groups to identify and prioritize crossings that will have the best environmental outcomes. The WCP includes a Watercourse Crossing Management Directive to help watercourse crossing owners inspect, monitor, report, and develop remediation plans while adhering to the directive[16]. While participation in the Management Directive is voluntary, it comes with a host of benefits for watercourse crossing owners, including:

16 Government of Alberta. 2023. Watercourse Crossing Program: https://www.alberta.ca/watercourse-crossing-program.aspx. Accessed January 2023.

- Providing crossing owners with information sessions, updates and training opportunities with regular access to regulators.
- Enabling crossing owners to inventory watercourse crossings and create plans to complete remediation projects rather than react to non-compliance issues.
- Enabling crossing owners to collaborate on a risk-ranked watershed-based scale with other watercourse crossing owners to reduce costs.
- Enabling crossing owners to stay proactive in efforts to maintain and restore fish habitat fragmentation issues across Alberta.

To be in compliance with the directive, watercourse crossing owners must:

- Inspect their watercourse crossings.
- Report inspection data.
- Provide remediation plans for all watercourse crossings that are not in compliance.

Alberta Watercourse Crossing Inventory App

Documentation and monitoring of watercourse crossings can be done using the Watercourse Crossing Inspection Form in ESRI based ArcGIS mobile app called Survey123. The data collected through the form will contribute to a provincial database of watercourse crossings and will help prioritize and manage remediation efforts, in turn helping to improve fish habitat and optimize fish population recovery. Watercourse crossing owners are able to submit their mandatory inspection requirements through the form. Inspection reports include details such as watercourse name, location, crossing type, whether erosion is present, culvert concerns, and fish passage assessment. It is preferred that inspections occur regularly as part of a robust monitoring program to ensure fish passage is being maintained and any issues are corrected. See the *Post-Installation Responsibilities* section of this guidebook for more information on inspections and monitoring.

More information can be found on the Government of Alberta's Watercourse Crossing Program webpage.

Federal overview

What pieces of Federal Legislation need to be considered for watercourse crossing work?

There are several pieces of federal legislation that apply to watercourse crossing work in Canada:

- ***Fisheries Act:*** The *Fisheries Act* provides a framework to effectively manage fisheries and ensure the conservation and protection of fish and fish habitat in Canada[17].
- ***Canadian Navigable Waters Act:*** The *Canadian Navigable Waters Act* lays out the requirements for any work being done in, on, over, under or through navigable waters in Canada[18]. Navigable water is defined as any body of water that is used or could be used by a vessel (a vessel can be as small as a kayak).
- ***Species at Risk Act:*** The *Species at Risk Act* (SARA) is designed to prevent the extinction of wildlife species. The act focuses on the recovery of species that are extirpated (no longer exist in Canada), endangered, or threatened as a result of human activity. The act also outlines management approaches for species of special concern to ensure they do not become extirpated, endangered or threatened. It also includes management and permitting of activities in critical habitat and works impacting residences (i.e., it is illegal to damage or

17 Government of Canada. 2023. Justice Laws Website, R.S.C., 1985, c. F-14 (Fisheries Act): https://laws-lois.justice.gc.ca/eng/acts/f-14/page-1.html. Accessed January 2023.

18 Government of Canada. 2023. Justice Laws Website, R.S.C., 1985, c. N-22 (Canadian Navigable Waters Act): https://laws.justice.gc.ca/eng/acts/N-22/page-1.html. Accessed January 2023.

destroy a residence of a species of concern or a species at risk)[19].

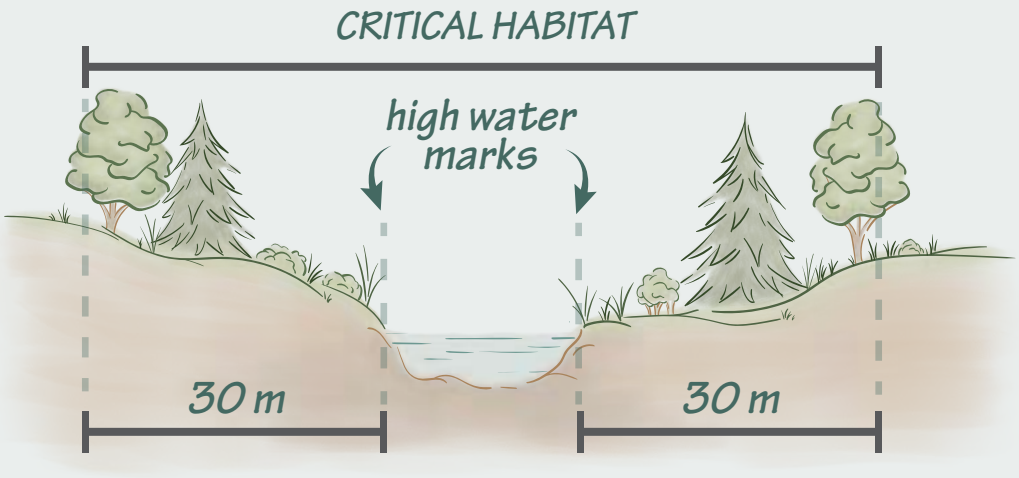
Proponents should be aware of which species at risk recovery strategies and action plans apply to the area they are working in.[20] This helps ensure proponents are aware of critical habitat and potential species at risk distribution to meet all federal requirements and protect these fish species. Awareness also helps ensure the proponent has clarity on key steps required when submitting federal applications or notifications, planning projects and ensuring appropriate qualified professionals have been engaged throughout the process. The species at risk registry can be found on the Government of Canada website.

The species at risk registry can be found on the Government of Canada website:

What is critical habitat?

Critical habitat is habitat that is necessary for the survival or recovery of certain species identified under the *SARA*. For some aquatic species at risk (such as Alberta Native Trout Species at Risk) this includes spawning grounds and areas used for cover, rearing of young, food supply, or migration. It can include habitat that species at risk rely on directly or indirectly (for example riparian areas close to watercourses provide shade, food and shelter, and help maintain water quality and quantity). Under the *SARA*, it is illegal to destroy any part of the critical habitat and restrictions may be imposed on development if deemed necessary to protect critical habitat. Critical habitat may be identified in the federal recovery strategy for specific species at risk. This habitat can include areas where aquatic species at risk formerly ocurred and have the potential to be introduced, or can represent an area of suitable habitat for recovery stocking. One example of protected critical habitat is an area where groundwater is welling up, as it provides cool, clean water that is required for all trout species in Alberta.

Critical habitat extends to the riparian zone on either side of identified critical habitats for the protection of species at risk and their habitats (for Alberta native trout this distance is 30 m). Note there are species-specific differences to this rule; for example, Athabasca Rainbow Trout require a 30 m zone plus areas of groundwater recharge up to 100 m above the high-water marks. For more information proponents should consult with applicable species recovery strategies and contact the Government of Canada for advice.



19 Government of Canada. 2023. Justice Laws Website, S.C. 2002, c. 29 (Species at Risk Act): https://laws.justice.gc.ca/eng/acts/s-15.3/page-1.html. Accessed January 2023.

20 General public aquatic SAR info (DFO page): https://www.dfo-mpo.gc.ca/species-especes/sara-lep/index-eng.html
Species specific SAR Registry links: S-N BLTR: https://species-registry.canada.ca/index-en.html#/species/1204-867
WA BLTR: https://species-registry.canada.ca/index-en.html#/species/1202-869
ARTR: https://species-registry.canada.ca/index-en.html#/species/1258-912
WCTR: https://species-registry.canada.ca/index-en.html#/species/861-605

Other federal initiatives of note include:

- **Fish and Fish Habitat Protection Program:** The Fish and Fish Habitat Protection Program ensures the compliance of projects in and around fish habitat that fall under the *Fisheries Act* and the *SARA*. The program also includes planning, funding and educational opportunities to conserve, protect and restore fish and fish habitat[21]. The Fish and Fish Habitat Protection Program includes a triage unit that provides initial reviews of all project proposals to determine any likelihood that the activities would cause death of fish, harmful alteration, disruption, or destruction (HADD) of fish habitat. This triage review also determines if the *SARA* is triggered (i.e., harm, harass, or capture of fish; damage or destruction of a residence or destruction of critical habitat)[22]. These proposals are forwarded to Regulatory Review Units for further review, as needed.
- **Codes of Practice:** A watercourse crossing project must implement all possible measures to protect fish and fish habitat under the *Federal Fisheries Act* (find these measures here: https://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures-eng.html). It is important to understand the federal COP that apply and understand that they are not applicable in areas of SARA listed critical habitat (works, undertakings, or activities that destroy or have potential to cause HADD require regulatory review). The COP outline mitigative actions that can be put into place to avoid fish death or HADD. Federal COP exist for:
    - Beaver dam breaching and removal
    - Clear span bridges
    - Culvert maintenance
    - Ice bridges and snow fills
    - Routine maintenance dredging for navigation
    - Temporary fords
    - End-of-pipe fish protection screens for small water intakes in freshwater
    - Temporary cofferdams and diversion channels[23]
- **Swim Performance Online Tools:** These are tools, collectively referred to as the Swim Performance Online Tools (or SPOT), that can be used to design structures to ensure fish passage occurs by calculating how fish perform while swimming. These tools include a swim speed and swim time tool, a swim distance and water velocity tool, a length at maturity tool, and an end-of-pipe screen size tool[24].

HADD

HADD or the "harmful alteration, disruption or destruction of fish habitat" is foundational to the *Fisheries Act*. It is interpreted as any change that impairs the ability of the habitat to support one or more life processes of fish, either directly or indirectly. This change can be temporary or permanent in nature. The avoidance of death of fish and HADD are what the Department of Fisheries and Oceans (DFO) examines in requests for review for works or activities to be done in watercourses, and it is what determines the level of risk associated with a project and, in turn, what type of regulatory approval will be required. Activities that can be considered as HADD include:

- Disturbing vegetation in the riparian area around water bodies
- Placing fill or permanent structures below the high water mark
- Erosion and sedimentation
- Depositing deleterious substances in a water body

21 Government of Canada. 2023. The Fish and Fish Habitat Protection Program: https://www.dfo-mpo.gc.ca/pnw-ppe/ffhpp-ppph-eng.html. Accessed January 2023.

22 Fisheries and Oceans Canada. 2019. Fish and Fish Habitat Protection Policy Statement. Fisheries and Oceans Canada, Ottawa.

23 Government of Canada. 2022. Projects near water, Codes of Practice: https://www.dfo-mpo.gc.ca/pnw-ppe/practice-practique-eng.html. Accessed January 2023.

24 Government of Canada. 2022. Welcome to SPOT Swim Performance Online Tools: http://www.fishprotectiontools.ca/. Accessed January 2023.

Upcoming and noteworthy:

- DFO is currently developing a tool called the rapid **F**ish p**A**ssage **S**creening **T**ool (**FAST**). This tool, which is planned for release in 2024, will enable users to efficiently assess fish passage in culverts and other crossings. This tool can also be applied in the field to assess existing watercourse crossings. Once the tool has been completed by DFO, it will be shared with practitioners and revised over time as more data is gathered and field trials progress[25].

Do I need federal authorization to perform a watercourse crossing project?

If impacts to fish and fish habitat cannot be avoided, or when an aquatic species at risk, its residence, or critical habitat is, or could be involved, the proponent is advised to submit a Request for Review (referred to as an RFR) to the Department of Fisheries and Oceans. In order to check if a watercourse crossing project needs to submit an RFR, the proponent can refer to the steps outlined on the Government of Canada's *Projects Near Water* webpage[26].

What does a federal Request for Review entail?

An RFR is a submission of information about the watercourse crossing project and any measures being put in place to avoid and or mitigate impacts on fish or fish habitat. This includes details about the project, the habitat (description of the aquatic environment), the avoidance and mitigation measures to be used, and any other potential effects of the project. Once the RFR is submitted to the Fish and Fish Habitat Protection Program, it is reviewed to determine if the project is in compliance with the *Fisheries Act*, or if an approval under the *Fisheries Act* or a *SARA* permit is required. A letter from DFO is provided to the proponent with the decision.

Tell DFO the whole story! It is important to include as much information in the RFR as possible about the project and project site for DFO to make their decision. Let them know about all site conditions, what is upstream and downstream, and all considerations that have been made as part of the site selection and project design. Photos are a great way to illustrate what is being presented in the RFR. If the information provided is not robust enough at this stage, it can result in delays. It is recommended that RFRs be submitted 4–6 months in advance of the construction date to ensure the review process is complete in time for watercourse crossing work to begin.

Indigenous consultation and engagement

Watercourse crossing owners should understand when there is a duty to consult. Best practice is to establish communications with Indigenous peoples early in the planning process. It is important to note that there is a difference between Indigenous engagement and consultation. Engagement is not a regulatory requirement but is intended to build relationships with Indigenous communities. Engagement involves understanding and respecting history, worldviews, culture, traditions[27].

Under the Fisheries Act, DFO must consider any adverse effects that a decision may have on the rights of the Indigenous Peoples of Canada. Watercourse crossing owners are therefore encouraged to collaborate with local Indigenous communities as early as possible to allow for input and accommodation, as this can ensure the project review process goes smoothly when an authorization is deemed necessary.

25 Information from DFO's Monitoring, GIS and FCSAP team, personal communication.

26 Government of Canada. 2022. Fisheries and Oceans Canada, Aquatic ecosystems, Projects near water: https://www.dfo-mpo.gc.ca/pnw-ppe/reviews-revues/request-review-demande-d-examen-003-eng.html. Accessed January 2023.

27 Indigenous Corporate Training Inc. 2017. Four Phases of Indigenous Engagement: https://www.ictinc.ca/blog/4-phases-of-indigenous-engagement. Accessed January 2023.

Consultation is a process that involves understanding and considering the potential adverse impacts of an anticipated Crown decision on First Nations and Metis settlements, with the intent to significantly address them[28].

For more information contact the Alberta Aboriginal Consultation Office.

Duty to Report

If an emergency occurs and requires immediate action, or if a non-compliance is found, it is the duty of anyone undertaking watercourse crossing work (or responsible for the work) to report the activity to the appropriate regulator. The duty to report is a requirement under provincial and federal legislation. This could include any activity that involves work performed without notice, approvals, authorization or permits, that resulted in death of fish, alteration, destruction or disruption of habitat or any other occurrences or incidents that contravene various other pieces of legislation. This work must be reported and corrected as soon as possible after discovery. There are both provincial and federal emergency response lines:

Alberta Multi-Agency 24-Hour Energy and Environmental Response Line: 1-800-222-6514

Fisheries and Oceans Canada (DFO) Reporting Line: 1-855-852-8320

National Environmental Emergencies Centre (Environment and Climate Change Canada): 1-866-283-2333

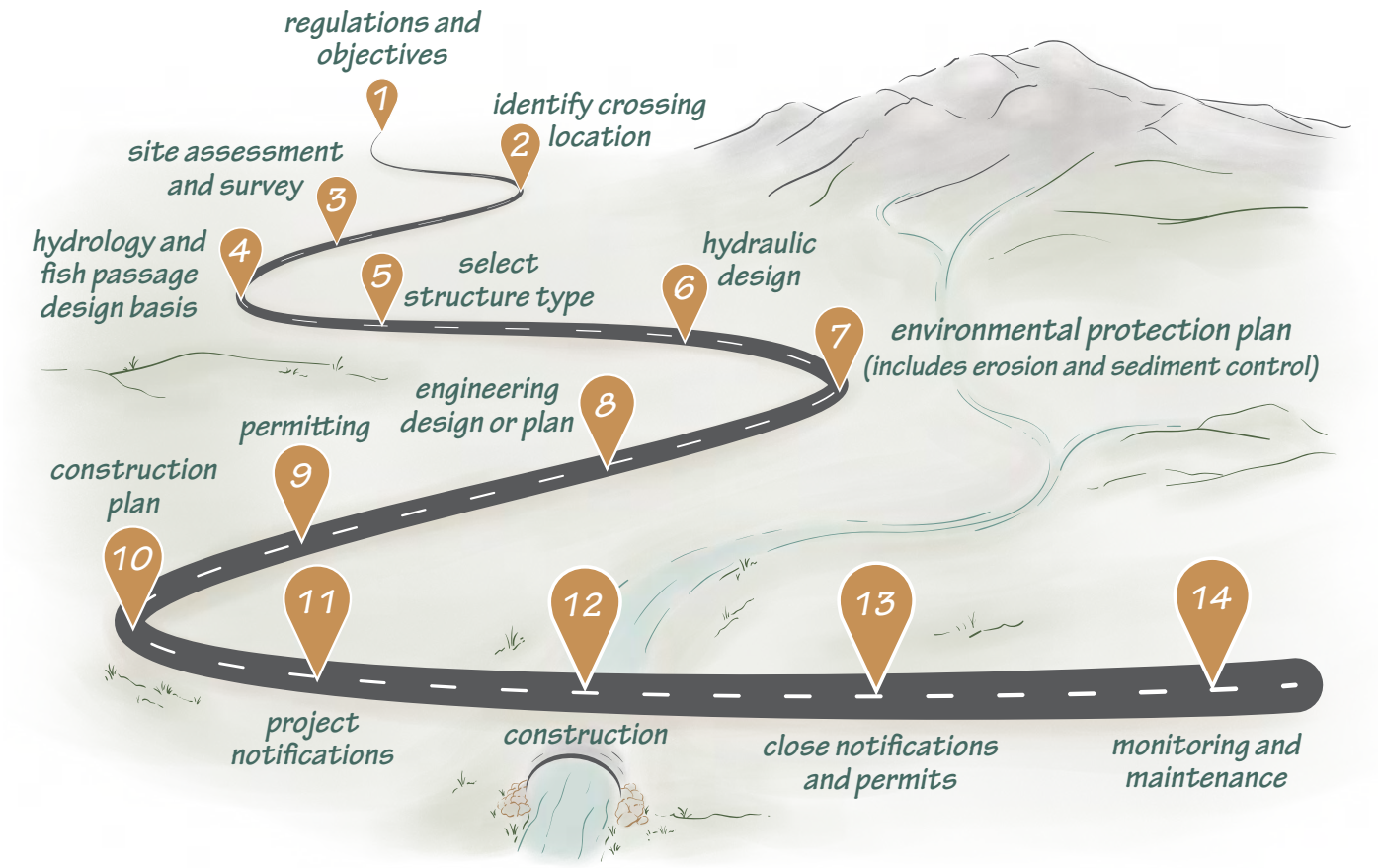
Proponents should be aware that there are specific reporting requirements that must be met where Duty to Report conditions apply. In addition to provincial and federal duties to report, forestry activities approved under the Forests Act have additional requirements identified in the Timber Harvest Planning and OGRs.

28 Government of Alberta. 2024. Indigenous consultations in Alberta: https://www.alberta.ca/indigenous-consultations-in-alberta#jumplinks-0. Accessed January 2024.

4. Planning

This section provides watercourse crossing owners and designers with information on the planning and design phases of a project. This includes considerations for crossing placement, installation, and replacement in watercourses and wetlands.

One way to describe the planning and design process for new or replacement watercourse crossings is as a roadmap. The journey begins with identifying project goals and ends in an engineered plan. This is then communicated to the field practitioner team as a construction plan. Following installation, routine monitoring, maintenance and repair will occur throughout the life of the crossing.



The first planning step is to understand the needs and perspectives for the crossing project. This includes:

- Identifying the interests of local stakeholders and Indigenous communities.
- Understanding and adhering to the applicable watercourse crossing legislation and regulations at a provincial and federal level.
- Clearly specifying all requirements and expectations to the watercourse crossing project team, including contractors and project operators.

The diverse needs and perspectives need to be incorporated in a clear project goal. A watercourse crossing must ensure that fish passage and water flow are maintained. However the project goal could also incorporate specific interests of local stakeholders and include measures to increase cost effectiveness.

Careful planning also involves establishing a team of multidisciplinary experts capable of offering professional advice and executing key steps in the planning and design of the watercourse crossing project. Crossing owners should consider hiring experts specializing in:

- Regulations and permitting
- Engineering
- Hydrology
- Watershed geomorphology
- Fish ecology
- Species at risk
- Other environmental considerations (e.g., a Qualified Aquatic Environmental Specialist or QAES)

This planning section is primarily focused on crossing structures for watercourses that are not located in wetlands. For guidance on design and planning for wetland watercourse structures see Planning for a Watercourse Crossing within a Wetland, and the Wetland Crossings: Installation, Replacement and Restoration sections.

Being proactive and leveraging the diverse skills and perspectives of these specialists will help maximize the efficiency and effectiveness of the project.

Choosing a location for a crossing

An example site map that could be used to plan a crossing location

The work associated with choosing a water crossing location should be integrated with the road design to select the best alignment for the road, road approaches, water crossing location, and the water crossing structure. This includes avoiding frequent water crossings and steep approaches, and it includes choosing a water crossing structure with traffic safety in mind. When choosing a location for a watercourse crossing, gaining access to information about the site is critical. The use of mapping, such as topographic, geologic, water table, Light Detection and Ranging (LiDAR), aerial photos, and databases for project planning is essential. Maps and photos can help identify natural and human-made features such as watercourses, wetlands, existing roads, and other structures that will assist in planning the proposed project. Many project owners and consulting firms have existing watercourse crossing databases with watercourse and crossing structure locations, structure types, inspection data, and other information.

There are two scenarios in which new watercourse crossing installations are needed:

- An inspection identifies that an existing watercourse crossing requires replacement.
- A new road that crosses a watercourse needs to be constructed.

In the case of watercourse crossing replacements, the location is already known. The location for a new watercourse crossing structure is dictated by road planning consideration, but can be influenced by mapped features such as hydrography (i.e., the location of watercourses), topography, geology, land cover, fisheries database information, and information on the local hydrological characteristics. A series of key factors can be used to identify the ideal location for a new watercourse crossing[29,30]:

29 New Brunswick Department of Environment and Local Government. Watercourse Alternation Certification Manual.

30 Newfoundland Labrador Water Resources Management Division. 2017. Chapter 3: Environmental guidelines for watercourse crossings. https://www.gov.nl.ca/ecc/files/waterres-regulations-appforms-chapter3-2.pdf

Siting Factor	Rationale
Species at risk awareness	Where possible, plan the structure location to avoid and minimize disturbance within sensitive areas that support species at risk. Be aware of species at risk recovery strategies, action plans, or critical habitat restrictions that may apply to the area.
Avoid valued fish habitat	Avoid crossing watercourses at locations where valued fish habitat (pools, spawning riffles, etc.) are present. Wherever key fish habitat features exist, it is important to move the crossing location upstream or downstream accordingly.
Drainage basin	Wherever possible, select watercourse crossing locations at the head of drainage basins because the risk of affecting fish passage is lower in these areas.
Hydrography	An efficient road network should consider the locations of watercourses that may be fish-bearing. Consult the provincial AltaLIS hydrography maps for more information.
Watercourse soils	Identify unstable and erodible streambed soils and slopes and, where possible, avoid locating a structure in these areas. Instead, choose a watercourse section where the streambed has stable, coarse granular substrate. Areas composed of erodible soil types should be avoided as they are prone to sedimentation, pose safety hazards during construction, and may lead to structural and road failures, and costly maintenance.
Watercourse banks	Ideally, watercourse banks will have slopes with stable soil, low risk of erosion, and be well covered with native vegetation.
Alignment	Locate the structure so it crosses at a right angle/perpendicular to the road to help prevent the redirection of the channel flow. Alignment is made easier when crossings are placed on a straight section of the watercourse that has no braiding.
Width and depth	Cross at the narrowest part of a straight channel and, if possible, avoid areas of very deep water (>1.5 m). This helps to avoid construction challenges that occur with larger water crossing structures.
Gradient and velocity	Select a section of the watercourse with a near-zero gradient and a uniform water velocity (i.e., water speed). This will make it easier to install a crossing with the same characteristics as the natural watercourse and minimize the crossing's impact on fish.

Road approaches	The road approach should be straight and stable with a minimal slope within 30 m upstream or downstream of the watercourse crossing. A lower road grade allows surface runoff water to flow with less force and reduced erosion potential and decreases the probability of sediment traveling to the watercourse. A location at a curve in the road also increases the risk to people and vehicle safety due to a reduced line-of-sight.
Minimize disturbance of natural areas	Where possible, select crossing locations that have already been altered or cleared. If constructing a new approach and crossing, ensure that disturbance in the right of way is minimized and approach widths are tapered into the crossing.
Natural obstacles	When possible, place the watercourse structure and road near an impassable barrier, such as a significant vertical drop. Such areas are already impassable to fish, so placement of a structure in this area would not impede fish passage to existing habitat.
Field observation	It is good practice to confirm the final site location on the ground to ensure there are no features missed during the planning process. See *Watercourse Site Assessment and Survey* section below for more information.
Beavers	Choose an area where beaver activity is absent or not likely to occur.

When designing the final location of a watercourse crossing structure, consider all of the above factors and seek the best fit. The watercourse crossing should consider the goals in a watercourse crossing project included in this guidebook's *Goals of a Watercourse Crossing* section and provide safe, efficient traffic flow.

Try to avoid construction within riparian areas and watercourses that support species at risk or species of special concern. Understand that regulatory requirements will vary depending on the level of risk and if the species is provincially or federally listed.

Watercourse site assessment and survey

To confirm an optimal crossing location and create an effective crossing structure design, it is important to understand the local features and processes within the natural watercourse at the potential watercourse crossing site. This can be completed by conducting a detailed site assessment and survey.

Site assessments and surveys are used to gather information on habitat features (e.g., unique spawning gravels) and geomorphology (i.e., physical features) of the watercourse channel. Many components of the assessment portion can be explored with desktop tools, such as maps, aerial photos, Google Earth™, and LIDAR.

Gathering information on fish and fish habitat is also essential to ensure it is incorporated in the watercourse crossing design. Most information about fish and fish habitat can be gathered in available databases (e.g., DFO Critical Habitat Mapping Tool, Fish and Wildlife Internet Mapping Tool[31]) and additional literature.

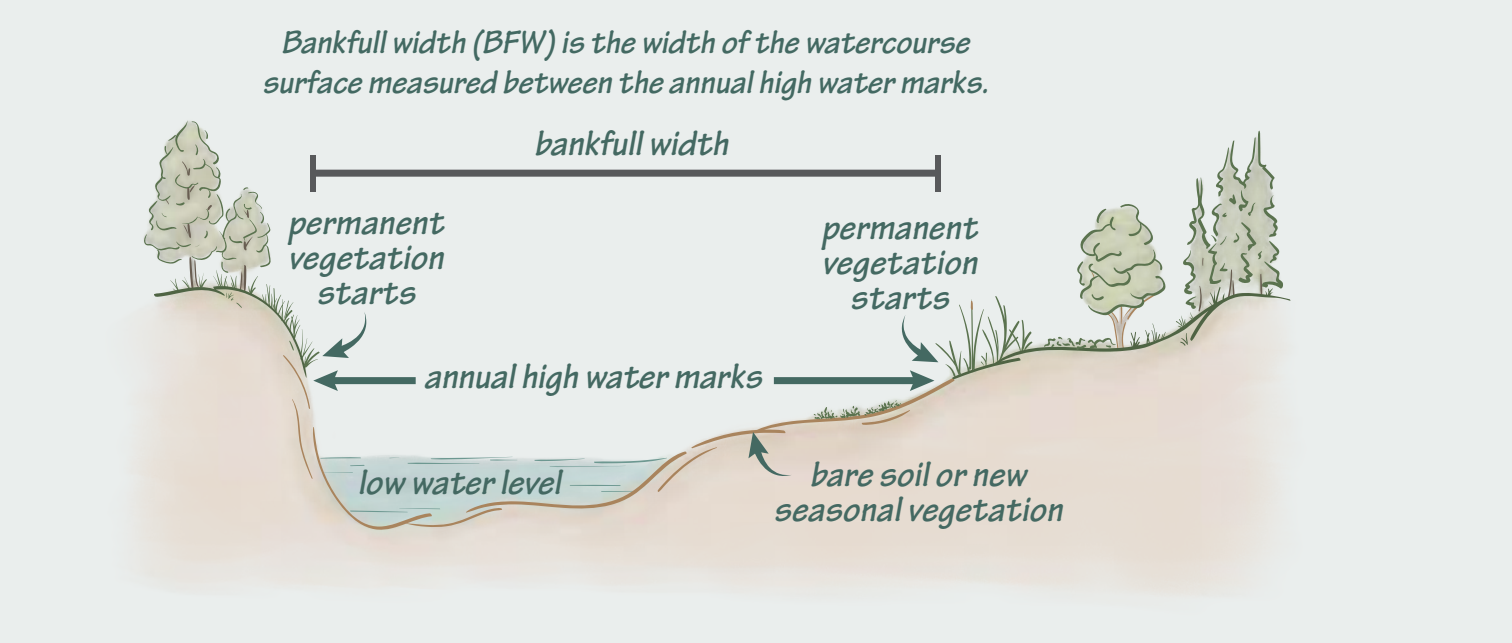
31 Government of Alberta. 2023. How to access the data, FWMIS data is available spatially online. https://www.alberta.ca/access-fwmis-data.aspx

In some cases, information may not have been collected for the site and fish sampling may be necessary to adequately understand characteristics of the site and presence of fish. Remember that absence of data does not equal absence of fish and that fish may be present in smaller streams during different seasons or stages in their life cycles.

The following information should be collected:

- A list of the fish species likely present in the watercourse.
- A list of at-risk aquatic and riparian species that are potentially in the area.
- A brief characterization of the type of fish habitats (e.g., rearing, shelter, spawning) that exist in the section of the watercourse planned for the crossing.
- Any natural or anthropogenic obstructions.

Collecting high-quality field data is key to ensuring that designers have the best available information to create watercourse crossings that accomplish all desired crossing goals (fish passage, erosion minimization, water flow maintenance, climate resiliency, and healthy watercourse habitats). To get quality data, it is important to understand the geomorphological features of the watercourse. The assessment should be conducted over an area larger than that of the planned crossing site to include all factors that may influence local habitat. Importantly, this provides evidence to the regulators that proponents understand characteristics of the site that will influence crossing design in terms of meeting goals.



Generally, a field survey should include the proposed watercourse crossing site, upstream, and downstream areas. A minimum survey length of 20–30 times the bankfull width (BFW) of the watercourse (i.e., the width of the surface of the watercourse between the annual high-water marks; see above image), both upstream and downstream of the proposed crossing, is considered appropriate. The survey distance can also vary based on specific features of a given watercourse segment. For instance, the length of the section to be surveyed should increase if there is a watercourse crossing structure already in the survey area to account for this structure's influence on the channel.

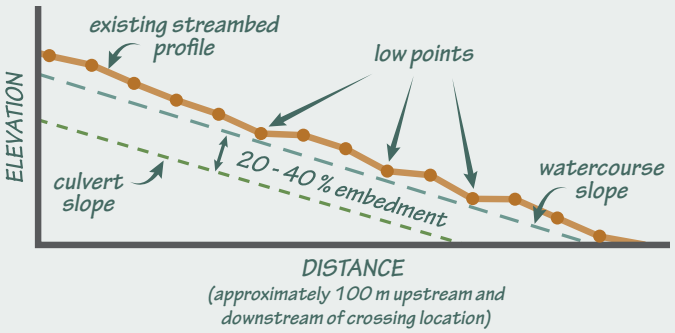
Key information to gather within the watercourse channel survey area includes:

- History or presence of debris flow, fish presence, and fish habitat
- Overhead shade and surrounding riparian characteristics
- Photographs documenting watercourse and channel characteristics
- Other potential site features that may influence flow both up and downstream (e.g., impassable barriers)

- Channel width
- Channel gradient
- Channel characteristics
- Water depth
- Water speed
- Substrate type and size
- Evidence of erosion

For culverts, the surveyed area should include a reference section to help determine natural channel measurements (see illustration). A reference section is a nearby watercourse reach that is not influenced by roads or other land disturbances. The river survey should include all grade control locations such as the upstream start of riffles. Surveying the bottom of pools is less important for the design of a culvert. A reference section is selected using the following criteria:

- The slope is similar to the slope of the area where the planned culvert will be installed.
- The flow should be similar at the planned crossing location.
- The reference section is at least as long as the planned culvert structure.
- The reference section should be as straight as possible.
- The channel shape of the reference section should be comparable with the planned crossing segment.



An elevation profile (also called a longitudinal profile) of the existing watercourse thalweg (the deepest part of the cross-section) is used to inform the design location, depth, and gradient for watercourse crossing structures (e.g., a culvert). The cross-section (or profile) is then used to understand the shape of the natural watercourse.

When planning a field survey, there are several key factors about the field data to consider to ensure accuracy and provide enough information for effective watercourse crossing design:

Approach	Rationale
Amount	Collect at least eight cross-sections of the watercourse within, above, and downstream of the crossing location.
Planned site	For a new structure, one or two reference sections should be surveyed at the planned site.
Reference sections	For culverts, at least two reference sections should be located within the reference area.
Representative	Selected segments should capture the range of variability within the immediate area of the watercourse.
Avoid	Zones with temporary structures or modifications (e.g., rip rap) should be avoided as they may influence the channel and streambed characteristics.

The channel width at bankfull discharge also needs to be measured during the field survey. Bankfull discharge is the maximum amount of discharge that a stream channel can accommodate without overflowing. This requires representative cross-sections be included. At each cross-section, the following information should be gathered:

- Bankfull discharge
- Bankfull depth
- Channel width and depth of the water
- Geometry of the watercourse cross-section, including the low-flow channel

Where there is an existing road crossing, other upstream disturbance, or tributary watercourses, the watercourse width measurements should be taken far enough away from the disturbance so that it does not influence the measurement.

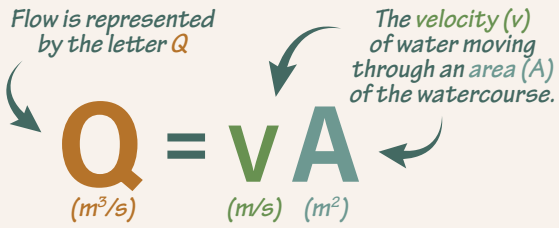
Hydrology and fish passage design

Hydrology and fish passage are key design aspects to consider when working to avoid future road washouts and to ensure environmental compliance for fish passage. The watercourse crossing design basis therefore needs to include:

- **A design flow:** Also known as the conveyance design flow for the crossing structure to allow flow during a selected high flow flood event (e.g., 100-year flood).
- **Fish passage design basis:** If the channel is fish-bearing, the structure should also have a fish passage design basis that ensures the water velocity (speed) and depth are appropriate for fish passage.

Generally, fish can move through natural channels with average slopes < 10%[32].

A design basis identifies the design requirements, such as the design flow, for a proposed watercourse crossing so the installed structure can support site-specific flow and fish movement.



Q100 is an estimate of the extreme flow volumes expected during a 100-year flood scenario.

Design Flow

Design flow accounts for variation in seasonal flow and possible storm or peakflow conditions that may occur at a crossing. Spot flow measurements are normally not a good indication of design flow due to the variability of flow at most locations. A standard best management practice to estimate design flow is to use data from long-term flow monitoring stations that are available across Alberta. Where a monitoring station is not available near the watercourse crossing, a desktop analysis can be used to transform/extrapolate the available regional information. The estimated design flow will depend on the upstream drainage area, surficial geology, land use, and other factors. However, the primary factor in estimating design flow is the measured upstream drainage area, based on available topography.

Once design flow has been estimated, hydraulic analysis tools are used to provide a hydraulic design. The hydraulic design involves calculating water level and velocity for a potential structure of a given size. Multiple iterations are normally needed to match the site hydraulic conditions with an appropriate structure size.

32 Hoffman R, Dunham J. 2007. Fish Movement Ecology in High Gradient Headwater Streams: Its Relevance to Fish Passage Restoration Through Stream Culvert Barriers. U.S. Geological Survey.

Fish Passage Design Basis

The fish passage design basis accounts for species requirements. A fish passage assessment normally involves both hydrology and hydraulic analyses to determine the design water depth and allowable water velocity. Both DFO and Alberta Ministry of Transportation and Economic Corridors (ATEC) provide guidance on fish passage assessments. Fish passage depth and velocity requirements often depend on the target fish species, target life stage, and structure length.

Selecting structure type

The types of watercourse crossings typically used on resource roads include:

- Open-bottom structures (e.g., bridges, arches)
- Embedded closed-bottom structures (e.g., embedded culverts)
- Temporary winter structures (e.g., ice bridges, snow fills)

Not all watercourse crossing structures are appropriate for all sites. Selecting a watercourse crossing structure starts by using the design basis and flow calculations (e.g., frequency and magnitude of peak flows, depth of flow, low-flow characteristics) to conceptually evaluate different structure types. Assessing the need for fish passage is an essential step in determining appropriate structure types. Leveraging information from the site assessment and survey, particularly related to fish habitat characteristics and presence or absence of impassable barriers is key at this stage. The road design is another critical element influencing structure selection (e.g., road approaches, number of traffic lanes, and design life).

There are many other factors to consider when choosing and designing a crossing structure for watercourses:

Factor	Rationale
Legislation and policy	Be aware that provincial and federal legislation and policy could affect the selection of the watercourse crossing structure.
Hydrology	Different structures support different flows and structures must therefore be selected for the unique flow requirements of a site.
Fish habitats	Each fish species has unique biological characteristics and habitat requirements. Designers should seek guidance from a qualified specialist about unique requirements of the fish species present.
Engineering requirements and safety	Consider the range of vehicles and vehicle weights that need to pass over the road and watercourse crossing structure. Be aware that heavier loads increase the risk of road failures.
Materials cost and availability	Ensure watercourse crossing materials are available and affordable for the project within the planned installation period.

Road longevity	The structure type and design requirements of a crossing location will likely vary between permanent and temporary watercourse crossings. For instance, design capacity for a temporary crossing used for one month during low flow or frozen winter conditions will differ from that for a permanent road that must safely accommodate high flow spring runoff events and provide multiple years of service.
Cost of inspection, maintenance, and deactivation	Each watercourse crossing structure has its own unique monitoring, maintenance, and removal requirements. For instance, a clear-span bridge is more costly to install but is easier to remove. Considering the lifecycle costs of a crossing structure is therefore important.
Beavers	Beaver activity can create barriers to fish passage, increase maintenance requirements and, if not maintained, contribute to crossing and road failures. It is therefore important to carefully select a structure that reduces the possibility of beaver activity blockage. For instance, if your site is in beaver habitat, bridges and arches are less likely to be dammed as often as embedded culverts.

Hydraulic design

The hydraulic design converts the design flow to water depth and velocity. This conversion is needed to determine an appropriate size and configuration of watercourse crossing structure to be installed. In other words, choosing a culvert size solely based on the inventory of culverts in the yard is not advised, it is important to choose the structure and size best suited for the site conditions to meet the goals and regulatory requirements of the watercourse crossing.

The 'design' component indicates that there is an engineering liability in the case that a road washes out or there is a failure in the associated infrastructure. This design process and liability are regulated in Alberta by the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Hydraulic designs are normally completed by a hydraulic or hydrotechnical engineer. There are numerous hydraulic modelling tools available to help with the calculations, such as the Alberta Transportation and Economic Corridor FlowProfile tool[33], HY-8 by the US Department of Transportation[34], CulvertMaster by Bentley Systems[35], HEC-RAS by the US Army Corps of Engineers Hydrologic Engineering Center[36], and others.

A bridge's hydraulic design would include the span between the abutments and the height of the opening between the watercourse and the bottom of the bridge girder.

Hydraulic design depends on:

- Design flow
- Slope (or gradient)

33 Alberta Transportation. 2009. AT Flow Profile Tool User Manual.
34 US Department of Transportation. 2022. HY-8 Culvert Hydraulic Analysis Program: https://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/. Accessed May 2023.
35 Bentley Systems. CulvertMaster Software: https://docs.bentley.com/LiveContent/web/Bentley%20SewerCAD%20SS5-v1/en/GUID-963C828E64CB4B20AA4E246DCB64B222.html. Accessed May 2023.
36 US Army Corps of Engineers. HEC-RAS: https://www.hec.usace.army.mil/software/hec-ras/. Accessed May 2023.

- Geometry
- Roughness of the structure
- Inlet and outlet configuration

The hydraulic design determines the recommended size or diameter of the watercourse crossing structure, and the configuration or layout of the watercourse crossing. Additional details from the hydraulic design include: span, slope, length, configuration of the structure inlet and outlet, and erosion protection around the inlet and outlet. The slope of the culvert is very important as it can greatly affect fish passage. Steep culverts will result in higher water velocity, and this can cause problems even if they are just a few percent steeper than the natural watercourse gradient.

Once a hydraulic design is complete, the planner can obtain the appropriate watercourse crossing structure from a vendor. Some general guidelines for hydraulic design include:

- Fish passage is often difficult for culverts with a slope of more than few percent; try to design culverts to have less than a 5% slope, and much less than 5% if fish passage is required. It is important to consider the natural watercourse gradient as well.
- Do not install culverts with reverse grade (i.e. sloping opposite of the natural channel), as this can result in a perched or hanging culvert outlet.
- Culverts should be embedded below grade and filled (or allowed to fill) with natural sediment. This reduces the conveyance capacity and therefore embedded culverts should be over-sized to account for this loss of capacity.
- The culvert alignment should avoid skewed alignments across the road to minimize the culvert length where possible. Long culverts are difficult to maintain and can make fish passage more difficult.
- Design the water level so that it is equal to the top of the culvert inlet. This design criteria helps to avoid road washout if debris accumulates at the culvert inlet.
- Over-size the culvert at cross-drains and other small ephemeral channels to allow for culvert maintenance after sedimentation occurs.
- An end treatment or bevelled culvert entrance can improve the hydraulics at the culvert inlet for larger culverts. An end treatment helps to reduce the water velocity at the culvert inlet.
- Avoid an unsupported culvert at the inlet that is too long for the road crossing. The entire culvert should always be supported by road fill. An unsupported culvert has a high risk of failure due to buoyancy. When the water level outside of the pipe is higher than the water level inside the pipe, buoyancy forces could lift and damage the pipe.
- Beaver guards can reduce conveyance capacity. Regular maintenance is preferred over the use of beaver guards.
- Erosion protection around the inlet and outlet are part of the standard configuration of culverts and bridges. Alberta Transportation and Economic Corridors provides guidance on erosion protection . The rock used for erosion protection or the equivalent configuration (e.g. headwall) is necessary to prevent damage or washout of the culvert.

Environment protection plan and sediment and erosion control

An environmental protection plan (EPP) describes measures to avoid or minimize potential adverse effects to watercourses during the construction and reclamation phases of a project. The EPP identifies the unique environmental risks associated with the project, clarifies measures to mitigate those risks, and translates measures into clear management actions. Here are a few examples of management actions:

- Limit the removal of riparian vegetation to the minimum disturbance footprint required for construction. This will minimize the amount of exposed, unvegetated soil that is a potential source of soil erosion and sedimentation to the watercourse.
- Apply rock-armouring over areas of concentrated flow to minimize erosion and sedimentation.

More specific erosion control options can be found in the Preparing Your Site section of this guidebook.

- All debris resulting from construction must be removed from the worksite following completion of the project to prevent the contamination of water and fish habitats.
- To prevent the spread of aquatic invasive species (e.g., plants, insects, fish), clean and dry any equipment before arrival at the site and following any activity in water. Never move organisms or water from one body of water to another. For more information, see the Alberta Decontamination Protocol for Watercraft and Equipment[37] and the Equipment List for Decontamination[38] for decontamination guidance to curb the spread of aquatic invasive species and fish disease.

Any activity that disturbs soil has the potential to affect fish populations, fish habitat, and fish movement throughout a watercourse.

An essential component of the EPP is to develop an erosion and sediment control plan for any watercourse crossing structure. During, and immediately after, watercourse crossing installation, it is critical to monitor and manage erosion and sedimentation. Designers should refer to a certified erosion control specialist to understand and identify erosion and sedimentation risks and mitigation options. While field operators have a responsibility to manage erosion and sediment control on-site, watercourse crossing designers have a critical role to play in laying out the plan and identifying erosion and sediment control measures to be used.

As a starting point, consider including erosion and sedimentation control BMPs, such as:

- Avoid watercourse crossing where practicable.
- Retention of vegetation and/or vegetation re-establishment is usually the best long-term erosion and sedimentation control measure and should be used as often as possible, on its own or in tandem with other erosion control measures. Encourage natural vegetation to establish around the watercourse crossing structure after installation to support the removal or minimization of sedimentation.
- Bioengineering is an effective, natural, lower-cost option with low maintenance demands and no requirement to remove synthetic materials at project completion.
- Integrating both bioengineering and conventional erosion and sediment control techniques within a single project has proven successful.

One of the most important roles of a designer for managing erosion and preventing sedimentation is to articulate who is responsible at each step in the EPP and erosion and sediment control process. Inspections should also be planned for during and after installation to ensure mitigations are present and functioning — see this guidebook's section on *Post-Installation Responsibilities* for more information on inspections, monitoring, and maintenance.

One or more means can be selected to mitigate the water quality impact at the crossing. Here is a planning checklist of possible solutions to reduce erosion and fine sediment from entering into streams:

37 Alberta Environments and Parks. 2017. Decontamination protocol for watercraft and equipment. https://open.alberta.ca/dataset/c6a491b1-632f-405a-8f1a-1bad4b16127d/resource/94afd608-483e-4637-b822-5b0f57ca3c0c/download/decontaminationprotocol-watercraft-equipment-aug30-2017.pdf

38 Government of Alberta. 2017. Equipment life for decontamination purposes. https://open.alberta.ca/dataset/c6a491b1-632f-405a-8f1a-1bad4b16127d/resource/3711084e-f2b4-4566-a2e8-f1b7dfcf18ac/download/decontaminationequipmentlist-jun2017.pdf

Activity of Concern	Possible Means to Reduce Stream Sedimentation
Road location	▪ Avoid watercourse crossings and locate the road away from the watercourse ▪ Avoid steep, unstable slopes ▪ Avoid watercourse crossings that require road approaches with long gradients flowing towards the stream
Road and/or cutblock design	▪ Avoid deeply dug ditches close to streams ▪ Plan for a proper number of cross drain culverts so that flows are not redirected or concentrated ▪ Bridge deck should be higher than the road grade and sloped gently away from the bridge ▪ Design a narrower road along natural topography break to channel surface water off the road and away from natural drainage ▪ Ensure that trees remaining in riparian zones are firmly rooted and resilient to wind
Construction/ timber harvesting	▪ Avoid disturbing soil as much as possible ▪ Protect soil in disturbed area through armouring, seeding, or spreading logging debris ▪ Avoid compaction by avoiding wet areas or by using brush mats ▪ Ensure good quality road subgrade and capping materials that are similar to the natural substrate of the crossing area ▪ Place rock armouring over areas of concentrated flow ▪ Construct a sediment basin that is capable of managing coarse sediment that can result during new road construction
Management/ maintenance	▪ Ensure good quality road fill and surfacing ▪ Remove grader berms ▪ Prevent or reduce traffic during spring thaw and particularly wet weather ▪ Reduce any unnecessary traffic on road ▪ Reduce any livestock damage within the riparian area
Seasonal or permanent deactivation	▪ Install cross ditches, water bars, or ditch blocks ▪ Pull back and end haul any unstable road fill to a safe location ▪ Pull culverts and armour the crossing

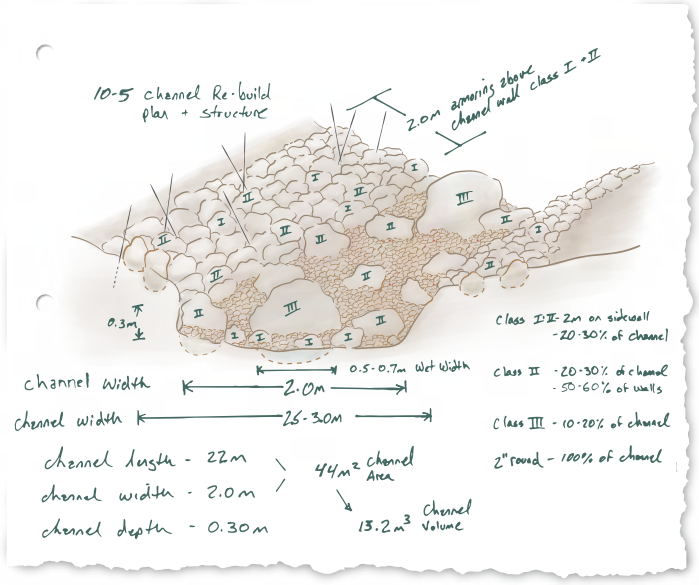
Table source: https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=603880eba0034040810572ca99f7c385

Developing and communicating an engineering design or plan

Successful watercourse crossing structure planning and installation requires a well-engineered design and effective communication. Effective communication of planning ideas, the engineering design, through to the field installation is particularly key. To help achieve this, the desired outcomes and engineering information for a watercourse crossing structure should be documented in a written Engineering Plan that includes engineered drawings.

Engineering Plan

Drawings are an essential way to communicate the Engineering Plan to the construction installation team. An effective plan clearly states the motivation (or "why") behind the engineered design and the outcome to be achieved (e.g., protection of riparian vegetation, fish passage, etc.). Engineered drawings provide specific guidance to the contractor for the construction of the water crossing, including direction for site-specific conditions. and site-level plans. They will also help identify the motivation and desired outcome. Making these connections empowers field operators to create the best crossing project possible.



Other information that should be considered when developing the Engineering Plan for the watercourse crossing includes:

- The environmental information obtained from the site assessment and survey and analyzed during the EPP (see above), which contains relevant environmental design ideas (e.g., fish habitat needs).
- A plan for structure and roughness (an index of flow resistance). Increased channel roughness will have a positive effect on moderating flow volumes.
- A plan to maintain pre-installation conditions (i.e., natural watercourse conditions) to the full extent possible.

For more specific design and engineering considerations appropriate for different crossing structure types, please see the *Watercourse Crossings: Installation, Replacement, and Restoration* section of this guidebook.

It is important to ensure that all permitting requirements are being met. See the Legislation, Regulatory Approvals and Permitting section for more details.

Construction Plan

After the Engineering Plan (i.e., the "what") is complete, the next step is to create a Construction Plan to describe the process for "how" and "when" the crossing will be installed. The Construction Plan is a set of documents that define the requirements for crossing installation and help "operationalize" the crossing installation. The Construction Plan contains information such as a breakdown of all the construction activities, clarity regarding roles and responsibilities, the project budget, and a schedule of activities including procurement of materials and when to apply for permits.

Once the watercourse crossing plan is complete and permits are obtained, an essential step in executing the crossing

plan is to notify key groups about upcoming construction activities. The local public should be notified if a road will be deactivated during construction of the crossing. Notification can be through an announcement in the newspaper, local signage (installed weeks in advance), an email from the project operator, or other appropriate means.

Finally, a construction kick-off meeting should be scheduled and attended by all key designers, aquatic specialists, engineers and operators. The aim is to clearly communicate the goals and desired outcomes of the project, to convey key information from the Engineering Plan, and to confirm operational details from the Construction Plan. All key parties should understand the plans and the site-specific values and risks.

Timing considerations

Scheduling is an important element of effective watercourse crossing installation and management. To develop a schedule that meets the project goals and regulatory requirements, there are key factors to consider that can influence scheduling and impact construction timing:

Factor	Influence on Timing
Regulations	Be aware of and understand the regulations and restrictions that can affect project operations. See the Legislation, Regulatory Approvals and Permitting section for more information.
Permitting	Awareness and planning for permitting timelines are important for maintaining project schedules. For example, the timeline between applying for and receiving a permit can take from less than one month to over a year.
Low flow	It is a best management practice to install watercourse crossing structures during low flow conditions, which is generally summer or fall in Alberta.
Winter and *freeze-thaw* periods	These seasonal periods should be avoided where possible, as they present unique construction challenges. For example, soil work during *freeze-thaw* periods can create layers of snow and soil that turn to mud after a thaw.
All-weather conditions	Be proactive in planning and monitoring for all weather events. For example, if rain is forecasted and construction cannot be avoided, plan for more erosion control measures. Avoid peak rain periods, which can trigger erosion and sedimentation.
Futures thinking/ Lifecycle thinking	Be aware of how long the road and watercourse crossing structure will be in use and take the time to ensure they will meet the overall goals throughout their lifespans. Temporary roads and crossings may only be used for a few years, and decommissioning involves removing all materials brought in. The cost and work required to decommission should be considered early in the planning lifecycle to maximize cost savings and environmental outcomes.

Unique planning considerations for watercourse crossings

There are often unique planning, construction and maintenance challenges that need to be considered when planning a watercourse crossing. These may include:

- **Alluvial fan:** A sediment deposit that naturally forms at a significant change in channel slope from high slope to low slope, where the reduced watercourse power results in the deposition of larger sediment. Alluvial fans result in highly unstable channels where the creek may flow on one side of the alluvial fan and migrate to the opposite side of the fan after a flood event. Because of this instability, construction of watercourse crossings should be avoided along alluvial fans. In locations where an alluvial fan cannot be avoided, the best location to cross the fan is at the upstream apex where the channel location is likely more stable. Other mitigation measures may need to be considered by a qualified professional.
- **Watercourse gradient changes:** Changes in watercourse gradient from steep to flat within a segment of the watercourse result in sediment accumulation. These zones have higher risk of deposition and watercourse migration outside of the established channel during a flood event.
- **Steep watercourses:** Fish are unable to move up steep watercourses. If the watercourse is determined to be fish-bearing, appropriate planning features (e.g., habitat design) need to be incorporated into design decisions (e.g., watercourse crossing type selection).
- **Crossing wetland complexes:** Watercourses occasionally flow through wetland complexes. Watercourse crossings planned in these complex areas need to be sized appropriately and should include extra flow crossing structures (e.g., extra cross drains, porous gravel). See the *Wetland Crossings: Installation, Replacement and Restoration* section in this guidebook for more information on crossing structures and spacing to maximize water flow.
- **Specialists:** Refer to an Authenticated specialist when planning for watercourse crossings or any activities within wetlands (i.e., Qualified Wetland Science Practitioner (QWSP)) and watercourses (i.e., Qualified Aquatic Environmental Specialist (QAES)) to identify risks and appropriate mitigation options.

Poor planning has resulted in the failure of this clearspan bridge over a small wetland stream. Overwinter flows and subsurface groundwater seepage should have been expected at this location. In addition, the span was not long or high enough to accommodate winter streamflow and ice jams.

Planning for a watercourse crossing within a wetland

This section provides watercourse crossing owners and designers with unique planning and design information that needs to be considered for a wetland crossing project. The organic soils and high water tables associated with wetlands can contribute to saturation of a road, increased settlement of roads and flow structures, and water ponding on the road surface. These scenarios can lead to seasonally restricted road use, low-functioning wetland crossing structures, higher maintenance and repair costs, and the inability for a road to support vehicle loads, in addition to potential negative impacts to wetland habitat and fish habitat and populations.

Operators can maximize the likelihood that wetland

crossings and fish habitat can function effectively through:

- Careful planning
- Knowledge of the wetland classes and functions
- Understanding and maintenance of the flow characteristics of each wetland class
- Understanding the needs of local fish species

> ***Wetland assessments must be completed by an Authenticating Wetland Professional in order to be included in the permitting process.***

Wetlands take many forms, which can vary over time and have complex flow regimes. An important aspect of front-end planning is to use wetland and drainage maps and field observations to inform design choices[39]. These tools help field practitioners to recognize wetland presence and wetland types, identify potential road routes, flow scenarios, and crossing locations along the road, and to understand the connectivity between wetlands and the surrounding environment.

A wetland site assessment and survey use observations to identify the wetland type(s) and the unique water flow characteristics. Gathering information on fish and fish habitat is also essential to determine whether fish passage is required at the crossing location and to incorporate unique conservation features in wetland watercourse crossing design. Whether or not fish are present, be aware that downstream water bodies, especially fish-bearing ones, depend on wetlands to keep lake and watercourse habitats healthy and functioning properly.

Key foundations for effective and efficient wetland crossings include a series of steps related to planning and design are presented in the table below. For more prescriptive guidance, see Ducks Unlimited Canada and FPInnovations for eight planning, construction and maintenance steps for building a resource road across a wetland[40].

Foundation	Description
Avoid and minimize	Where possible, plan the road to avoid and minimize building across wetlands, since operations in these ecosystems are more complex and costly compared to developments on upland sites. Consider using frozen access only to minimize wetland ecosystem impacts.
Know your wetlands	Consult an Authenticating Wetland Professional to identify the wetland class and complete an assessment of the unique water flow characteristics to plan for road and environmental performance.
Maintain wetland flow	Ensure the choice of road placement, crossing locations, and crossing structures maintain natural water flow and fish passage from one side of the structure to the other.
Understand peat bearing capacity	Know the factors that contribute to wetland soil (peat) bearing capacity and how to manage them. This can help operators reduce wetland soil failure during construction.

39 Ducks Unlimited Canada. 2023. Alberta Wetland Classification System Field Guide. https://www.ducks.ca/resources/industry/alberta-wetland-classification-guide/

40 Partington, M., Gillies, C., Gingras, B., Smith, C. & Morissette, J. 2016. Resource roads and wetlands: a guide for planning, construction and maintenance.

Predict settlement	The timeframe and amount of peat settlement after road construction can be estimated using peat consolidation graphs. These estimates can be incorporated into planning to ensure water flow and fish passage structures continue to function properly post-settlement.
Ditches	Incorporating ditches alongside the road should be avoided within a wetland as they can intercept flow, lower the water table and lead to peat settlement.
Understand other environmental impacts of wetland development	Alteration and compression of the natural "hump and hollow" microtopography of wetlands can result in changes to biodiversity, surface vegetation and greenhouse gas (i.e., methane) emissions.
Monitoring	Regular inspections (monitoring) are required to assess the performance of crossing structures and identify any required maintenance to ensure crossing structures perform to operational and safety requirements and mitigate impacts to wetlands and fish.

As for watercourses, successful wetland crossing structure planning and installation require a well-engineered design. The Engineering Plan (i.e., report) should include written instructions and engineered drawings that communicate the motivations, outcomes, and specific design of the wetland watercourse crossing to the project team.

Once the Engineering Plan is complete, the next step is to create a Construction Plan to help operationalize the crossing installation. The Construction Plan should include an itemization of all construction activities and materials for procurement, roles and responsibilities, a list of required permits, and a schedule and budget for all tasks.

This section provides guidance on careful planning, including an overview of the planning and design process for a new or replacement watercourse crossing in a wetland. If you are considering building resource roads and watercourse crossings within wetlands, specific information related to wetland crossing BMPs can be found in the Wetland Crossings: Installation, Replacement, and Restoration section of this guidebook.

5. Preparing your site

Once permits are obtained and the planning phase of the watercourse crossing is complete, site preparation can begin. Although exceptions can be granted, site preparation should occur in the appropriate season according to the restricted activity period (RAP) for instream work. The main objective of site preparation is to minimize the impact of watercourse crossing installation or restoration on the natural flow of the watercourse and fish passage. Site preparation activities include three core steps:

Fish isolation and rescue

Dewatering the site

Erosion and sediment control

Site preparation needs to be tailored to the unique constraints or challenges present at each site and the type of crossing installation or restoration taking place. For example, the installation of a clearspan bridge may require significantly less site preparation than a culvert if the bridge is being installed without any instream work.

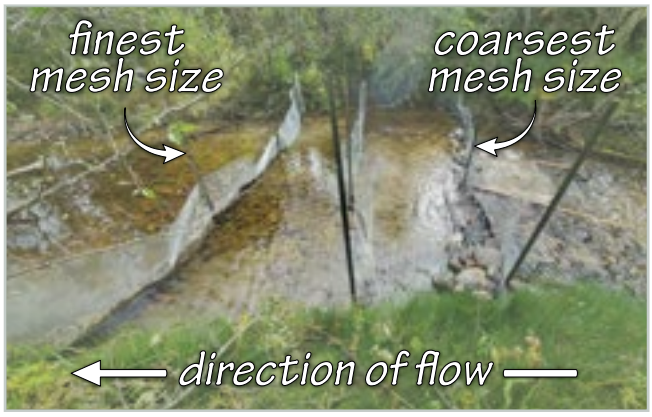
Also, erosion and sediment control should look different for sites with soft sediment, rocky substrates, very steep gradients, or slow meanders. The following sections will clarify the range of options and practices available for each of the three core steps to prepare your site.

Note that erosion and sediment control activities begin during the site preparation stage and continue throughout the life of the crossing — including the post-work monitoring, maintenance, and restoration stages.

Fishery isolation and rescue

Before dewatering the site, all fish present in the isolation area must be safely removed and released upstream or downstream. The isolation area includes all of the watercourse area affected by the installation. Releasing captured fish upstream of the worksite is considered best practice both because fish instinctively swim upstream and the dewatering procedure can sometimes cause interruptions to downstream flow. However, on very small watercourses small upstream stretches may not have the resources to support a large fish release. In this case, a downstream release is appropriate.

Removing fish requires the use of isolation nets (also called seine nets) or fences that are placed across the watercourse channel on both the upstream and downstream sides of the work area. Their core purpose is to keep fish out. To prevent tangled or injured fish, try to place nets or fences in low flow areas where fish can easily approach and swim away before contacting the net. On watercourses where debris accumulation is an issue, combining fences that have decreasing mesh size can be particularly useful. Place a series of two or three fences above the watercourse in order from coarsest (1 inch) to finest (1/8th inch) with the finest placed closest to the worksite. This will help prevent excessive debris from building up on the finest mesh size. Downstream of the watercourse crossing, a single mesh net can be used. The isolation fences or nets must remain in place on both the upstream and downstream sides of the work area during the entire installation.



Once fences are placed, fish rescue can be conducted within the isolation area using nets, traps, electrofishing equipment, or a combination of the three. If traps are being used, they

will need to be set up along with the fish isolation measures 2–3 days before the installation starts. The traps must be checked and emptied every day. If using nets or electrofishing equipment, multiple passes of the isolated watercourse area should be conducted to capture every fish.

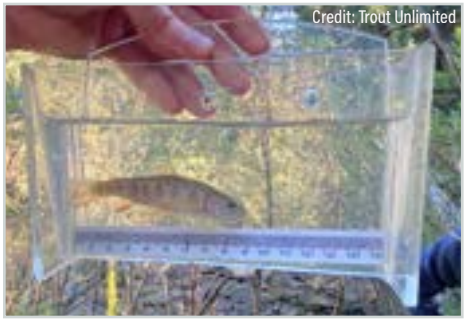
Once site dewatering begins and the work area is being drained of water, watch carefully for any fish that may have been missed. If additional fish are observed, dewatering must be paused while the remaining fish are captured. Any fish that are rescued and relocated are first processed to collect information on population number, size, and species. All fishery isolation and de-fishing activities must be conducted under a FRL (fish research licence) or a RL-PAAS. These licences permit fish to be captured and ensure all fish data are submitted to Alberta Environment and Protected Areas and kept in the provincial Fisheries and Wildlife Management Information System (FWMIS).

Although fish isolation and rescue occur at the beginning of the site preparation procedure, monitoring should continue throughout installation or restoration. Isolation nets or fences should be monitored for the accumulation of debris — which should be promptly removed. Keep all personnel and equipment onsite as unexpected and sudden conditions can require fish rescue to be repeated. Conditions that warrant a repeat fish rescue include:

- If high flows overtop barriers during installation and the dry work zone is flooded.
- If fish isolation nets or fences are dislodged by high flows.
- If fish isolations nets are damaged by debris.
- If additional fish are discovered in areas that were already surveyed and thought to be fish-free.

Ensure that all fish isolation and rescue gear is decontaminated before use to prevent the spread of whirling disease and other pathogens. For more information on whirling disease decontamination protocols visit: alberta.ca/stop-whirling-disease.aspx

Conducting fish rescue with an electrofishing technique



A rescued fish being measured

Site dewatering

Methods and practices

Installation or restoration of any watercourse crossing must be conducted in isolation from the stream flow to maintain water quality. During installation, water must continue to flow around the worksite either by the force of gravity or by using pumps. Three common methods for dewatering a site include:

Cofferdams

Temporary diversion channels

Pump-around systems

The choice of dewatering method should consider the slope of the watercourse, height of stream banks, water flow, existing site conditions, length of time the site will be dewatered, and the type of crossing being installed. Temporary diversion channels or gravity bypasses save time, energy, and are overall a safer method of diverting a watercourse around a construction site.

Dewatering procedure

Regardless of the method chosen, all dewatering procedures should adhere to the following BMPs:

- Work quickly to limit the time the watercourse is without water.
- Time the dewatering procedure to avoid working before or after large rain events.
- Continue to monitor the entire dewatering system throughout the installation phase to check for erosion, fish, sedimentation, and changes in flow. Creeks have a daily flow peak (usually in the early afternoon).
- Daily flow patterns can be highly variable by region and season and regional difference needs to be determined when planning water diversion.
- Any barriers used to block the flow of water need to be inspected at the start and end of each workday. Additional inspections should be completed any time excess water is observed seeping into the work area.
- Monitor for seepage within the work area. Since the area of installation is usually below the water table, water will seep in over time. The water seepage rate into the work area will depend on the topography, soil type, and how well the barriers are built. It is important to have separate water pumps available to remove this water from the work zone. Even streambeds that are seasonally dry can have seepage once excavation begins. A bellhole (single excavator scoop taken out of the streambed) can be used to concentrate seepage water so that it can be easily pumped out of the work area.
- Divert pumped seepage water onto stable, non-erodible vegetated surfaces to limit erosion and allow sediment to be removed (by filtering or settling out).
- Have emergency plans in place for sudden high flows or breach of the isolation measures. This includes having additional equipment (such as pumps) onsite.
- Secondary containment systems should be in place for all pumps, fuels, etc. This ensures that any leaks do not contaminate the watercourse.

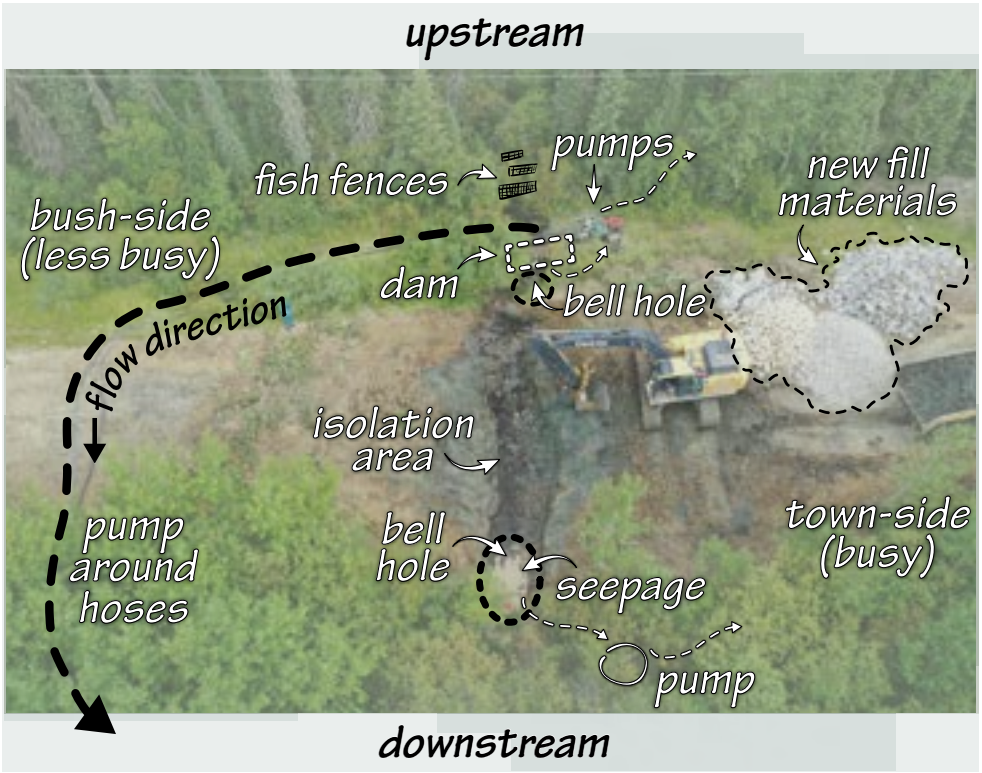
Pump-around systems

A pump-around system involves moving water around the installation site using one or more pumps and hoses. Multiple pump systems may be needed to move large volumes of water. When using a pump-around system, pumps should be in place and ready to move water before the watercourse is dammed. Create a bellhole with an excavator scoop on the upstream side of the crossing directly upstream from where a dam will be placed. This creates an area of deeper water to help prevent the pump from agitating bottom sediments.

Usually, vehicles and equipment that bring personnel and materials to the site will arrive on one side of the crossing (closest to town). Determine which side of the crossing will be the busy side and install the pump on the opposite side, out of the way. Once the pump and hose are in place, the watercourse can be dammed on the upstream side of the installation site. Dams can be created from steel, large sandbags with an impermeable sheet of plastic, or any other material that can effectively block the flow

Machinery should be cleaned prior to arriving onsite to prevent pollution, the spread of invasive plants, and the spread of whirling disease. Note that protocols may vary for different locations.

Reference applicable decontamination protocols for whirling disease at: alberta.ca/stop-whirling-disease.aspx



- *The pump is located downstream of the fish isolation fences, but the pump intake should still be covered in an appropriately sized mesh as a precaution against harming any fish.*
- *Once a site is dewatered, it may take several hours for the water held within the streambed materials to drain out. It can be captured and pumped out using the bell hole on the downstream side of the installation zone.*

of water and withstand the forces of the watercourse. Ensure that all materials entering the watercourse are clean and disinfected. As water begins to back up, the pump around system should be started or brought online. For steep watercourses, a downstream dam may not be necessary. Otherwise, construct an additional dam on the downstream side of the installation to prevent water from flowing backward into the work area.

Key guidelines for using a pump-around system include:

- Ensure the pump system(s) is appropriately sized for the watercourse and can manage the volume of water that naturally passes the installation site. Pump-around systems should be checked regularly to ensure they are keeping up to flows as they fluctuate throughout the day.
- Always have a complete backup pump system onsite to deal with emergency malfunctions. The pump system should be continuously monitored while in use. This includes having someone stay overnight at the site for projects that last more than one day.
- Ensure the dams protecting the worksite are strong enough to withstand the force of water produced by the watercourse and tall enough to not be overtopped.
- In addition to the isolation nets, ensure the hose intake is screened to prevent fish or other organisms from entering the pump or being trapped by suction forces. Screened intakes need to follow Federal Codes of Practice with a minimum mesh size of 2.54 mm placed 30 cm above the streambed. Screens must be sized according to the diversion rate required to pump water around the isolated area. Pumps within isolated areas do not need to be screened since fish have already been removed. For more information visit: dfo-mpo.gc.ca/ pnw-ppe/codes/screen-ecran-eng.html
- Do not allow the force of water exiting the hose to erode sediments. A perforated outlet or diffuser can help

Seepage water being pumped into a vegetated area away from the watercourse.

dissipate energy. Locate the outlet in an area with stable streambed conditions or, if not available, place materials (sandbags/rocks/a plastic tarp/etc.) at the outlet to stabilize the area.

- When removing the dams around the installation site, the downstream dam should be removed first (if used), and the upstream dam should be removed slowly to prevent a large flush of water from dislodging sediments.
- When rewatering the newly completed construction site, continue to pump water around (maintaining water quantity and quality) until the construction site is rewatered. Use the upstream flow moving through the construction site to "clean" the new creek channel. The pump in the downstream bellhole will capture the dirty construction water and pump it onto an adjacent vegetated area. Continue this process until the water runs clear before fully stopping the pump around system.
- Pumps and fuel should be placed in secondary containment and stored away from the watercourse. Fueling should be done away from the watercourse when possible.

An example of a well-constructed dam across a watercourse.

Depending on the topography of the site, a pump may not be required to move the water around the worksite. Particularly for very small watercourses with steep slopes, a gravity-fed pipe may be sufficient. This type of dewatering procedure is called a gravity bypass. Note that a pump will still be needed to remove seepage from the work area.

Temporary diversion channels

Using a temporary diversion channel involves constructing an alternate path for the water to flow. A temporary diversion channel runs parallel to the original watercourse. The new channel must be large enough to accommodate any peak flows that could occur within installation window. Sometimes the existing topography of a site can be used to make this process easier. For example, water can be diverted through existing ditches to the next crossing site downstream as long as it is returned to the originating channel. It is also sometimes feasible to use an existing culvert as a gravity bypass while a new channel is being excavated or if a new crossing is being installed adjacent to the old culvert. The slope of the diversion channel should not be steeper than the natural watercourse.

A temporary diversion channel can be constructed by following these key steps:

- Excavate the new channel parallel to the original but leave a small section unfinished at each end to ensure it remains isolated from the streamflow until the full diversion channel is completed. For very small watercourses, a simple channel made of plastic sheeting may suffice.
- Line the entire new channel with plastic and secure in place using a combination of rocks and stakes. The plastic serves as a barrier between the water and the new channel, preventing erosion and sedimentation. Once the diversion channel is protected with plastic and the fish rescue procedure has been completed, the plugs at both ends may be removed, starting with the downstream side.
- Construct a dam across the original watercourse at the upstream end of the work area. As the dam is being constructed, water should begin to be diverted through the diversion channel.
- Monitor the downstream end of the diversion channel where the water rejoins the original watercourse. Ensure the water is not overly turbid (sediment rich) and is not eroding the outlet area.

Note that isolation nets are only required if the channel is being completely diverted through a temporary channel or a pump-around system. Dewatering methods that leave a portion of the natural watercourse free (cofferdams) can allow fish rescue within the erected barrier.

- Once the upper dam is completed and water has drained from the work area, construct another dam on the downstream side of the work area. This may not be necessary on streams with a steep slope.

Cofferdams

Cofferdams are instream barriers that direct the flow of water to the opposite side of the channel while work is being conducted. Most cofferdams are made from interlocking pieces of steel that are driven into the streambed. They need to be installed and removed twice, once for each side of the watercourse.

Cofferdams are usually used on larger watercourses that cannot be easily diverted or pumped. This means cofferdams are used mostly for bridge installations. Since cofferdams never completely block the flow of water within the natural stream channel, they do not require isolation nets or fences. Fish rescue can be conducted directly in the area that is blocked off by the dams. Key guidelines for using cofferdams include:

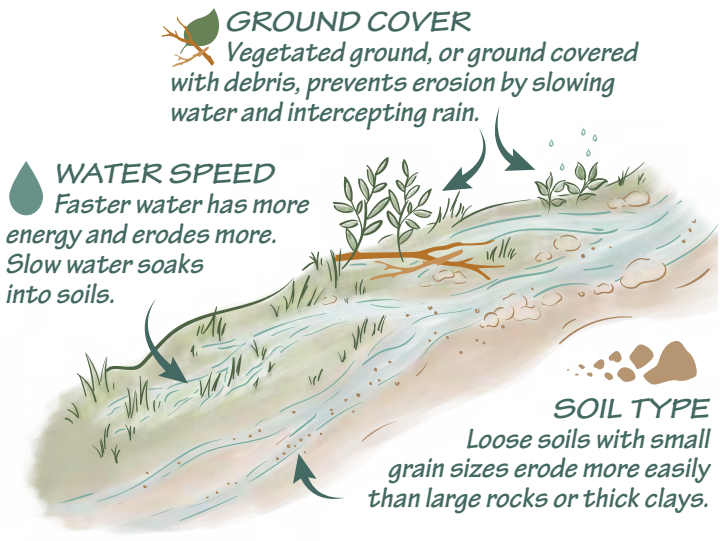
- Construct the dam from materials capable of withstanding the force of the water. Sandbags, concrete blocks, plastic sheeting, rocks, and sheet piling are all commonly used materials. Sheet piling is the strongest cofferdam material and can be safely used in watercourses with very strong forces. Ensure that all materials entering the watercourse are clean and disinfected. This is particularly important if they have been used in other watercourses as they can spread whirling disease, pathogens, and invasive species.
- The dam must be tall enough to prevent water from overtopping.
- Construct the dam in a manner that prevents excess water from seeping into the construction area. Use a pump to withdraw seepage water and release it into a vegetated area.
- Leave as much of the natural watercourse channel open as possible. Good practice is to leave two thirds of the channel width open but this ratio can vary depending on the size and force of the water. Channels that are restricted too much can risk causing erosion issues on the opposite bank.
- Understand the risks of installing dam materials, particularly sheet piling, in watercourses with very soft sediment bottoms. A floating sediment curtain or boom may be necessary to prevent turbid water from moving downstream.

A floating sediment curtain installed around a bridge abutment.

Erosion and sediment control

Erosion and sediment control begin at the planning stage and are incorporated into all other stages of the project including post-work monitoring, maintenance, and reclamation. The methods for controlling erosion and sediment at watercourse crossings will evolve throughout the planning, installation, and monitoring stages. In general, extra focus on the early planning and preparation stages can save time and money over the life of the watercourse crossing.

Effectively controlling erosion considers water



Sedimentation is not allowed under provincial and federal rules. Every effort must be made to minimize erosion and prevent sedimentation. There is a duty to report to the appropriate regulator if sediment is released into a watercourse or waterbody.

speed, soil type, ground cover/texture, or combinations of all three. It is important to use these three properties to identify where erosion protection is needed on disturbed areas around the watercourse and where it is not needed. For example, natural meandering watercourses always erode along the outer bank, where the water speed is highest, and deposit sediments along the inner bank, where water speed is lowest. If the soil of the outer bank is loose and unvegetated, higher rates of erosion occur. These same principles apply to human influenced watercourses and construction sites. Greater erosion measures may be needed on loose sediments, unvegetated surfaces, and locations where water moves faster or changes direction. Any time the installation or restoration alters one of these fundamental properties, the erosion potential should be anticipated and controlled for.

Erosion control is a preventive measure whereas sediment control is a reactive measure. Controlling erosion prevents the sediment from moving, whereas controlling sedimentation involves recapturing the material once it has begun to move — which is more difficult to manage and maintain. Managing erosion should always be prioritized because it is much easier to control erosion than sedimentation.

All erosion and sediment control practices need to be monitored and maintained over time to ensure they are functioning correctly. The effectiveness of different erosion and sedimentation control efforts will depend on the site-specific conditions. Since each site is different and it is important to be ready to adapt to the individual conditions. Be sure to evaluate the effectiveness of the control measures being used and modify if necessary. Consider consulting a professional to design a site-specific erosion and sediment control plan.

Material stockpiles

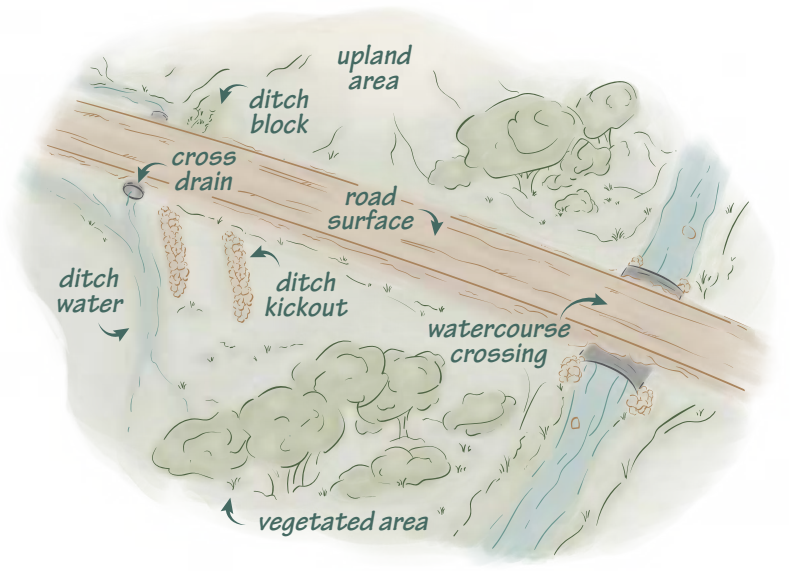
While installation is taking place, material from the streambed may need to be removed to ensure the crossing is placed at the correct depth in relation to the watercourse. This loose material needs to be safely stored next to the stream to prevent it from contributing to sedimentation. Key practices include:

- Store the material a practical distance from the watercourse channel and avoid keeping it too close.
- Store the material in one steep pile (do not spread it out) so it can be easily recollected and the area potentially washed down by rainfall is minimized.
- If possible, the stockpile should always be located on the opposite site of the watercourse from where trucks with new material will arrive. This keeps it out of the way and ensures there is room to bring in new materials.
- Place a straw roll or sediment fence around the pile and between soils and the watercourse, known as a sediment containment barrier.
- If heavy rains are expected, cover the pile with a tarp or any other type of erosion control blanket.
- Use the machinery onsite to contour the ground (temporary ditching) so the soils in the material stockpiles cannot reach the watercourse.

Road and ditch drainage

Water runoff from the road and in ditches can be the single largest contributor of sediment at the crossing site.

Controlling road drainage is an essential step in ensuring a watercourse crossing is protected against erosion and sedimentation. Ditches should never be directly connected to streams for any type of watercourse crossing. Even well protected and stabilized watercourse banks will do little to prevent sedimentation if the sediment-rich ditch water is permitted to flow directly into the watercourse. Sediment that has been displaced from the road through use and by rainfall is easily suspended in ditch water and needs to be filtered out before the water reaches the watercourse crossing. The amount of sediment generated from



a road is dependent on the type and frequency of traffic, road surface area and slope, road condition, and the composition of the road material itself.

Water from ditches should be diverted across a vegetated stretch of land. Vegetation slows water and traps the sediment, cleaning the water as it passes through. In addition, water that is given time to soak into the ground is further cleaned by soils and can help recharge groundwater reserves. The distance of vegetated land required to slow discharged ditch water is dependent on the amount of water, how fast it is flowing, and the size of the sediment particles within it. Fine sediments take longer to drop out of flowing water. Knowing the approximate upstream drainage area can provide a reasonable estimate. For example, for a drainage area of less than 10 m^3, a forested stretch of more than two meters is sufficient to disconnect the ditch water from the stream. In contrast, for a drainage area of 2000 m^3, the water needs a stretch of vegetated land over 30 meters long.

Cross drains are pipes under the road that move water from one ditch to the other. They are needed in areas where a hill on one side of the road does not allow for water to be diverted into the surrounding vegetation. A ditch block/dam and a cross drain under the road will move the ditch water trapped on the high side of the road to the low side. Once on the lower elevation side, ditch kickouts (also called offtakes, berms, water bars, etc.) force the water out of the ditch and off the roadway where it can flow into the vegetated area. They can be constructed of different materials but are often built from rock. A cross ditch can also be used instead of a cross drain to divert ditch water. They serve the same purpose, but a cross ditch has an open top (creating a dip in the road surface) whereas a cross drain flows under the road.

In extreme situations, the site may be too steep and not have adequate space for sediment to be filtered out. In these rare cases, consider building a settling pond (also called a sediment trap). This is a small pond built a minimum of 30 meters from the main watercourse where soil has been excavated to create a pond. The pond needs a minimum depth of 1.2 meters (approximately 4 feet) and a length twice its average width. The greater the drainage area upstream, the larger the pond must be. Ensure the pond outlet is well stabilized against erosion. Settling ponds are a lot of work, and regular monitoring is required to ensure the pond does not fill completely with sediment. When this occurs, it must be dredged to ensure it continues to function.

When graders perform road maintenance, they can sometimes create a false ditch. This is a ridge of material located at the road edge that intercepts water flowing into the true ditch. As a result, the water bypasses the sediment control measures installed in the true ditch and flows directly into the watercourse. Monitoring activities should watch for the creation of false ditches.

A false ditch at the side of a gravel road. Rainwater from the road flows along the edge instead of into the vegetated ditch.

Best management practices for roads and ditches include:

- Construct ditch kickouts (offtakes) to divert water away from the ditch and into a vegetated area.
- Gravel the watercourse crossing approaches. Graveled approaches can reduce sediment generation over

mineral soil roads by approximately 170%.

- Include road grade reversals, swales, and rolling dips in road and ditch design.
- Space cross drains and ditch check dams appropriately to reduce water speeds. They should be spaced according to slope, soil type, and expected precipitation.
- Do not track, pack, or smooth the ditch when the job is complete. Leave the surface rough with mounds, dips, and irregular undulations.
- Place woody debris or other organic materials in the ditch to slow water.

Straw bales can potentially contain the seeds or material from invasive plants. Understand the risks of introducing invasive plants at the site and source straw products accordingly.

Sediment control measures

Straw bales

Straw bales are a temporary sediment control that can be used until more permanent measures are working. They have a lifespan of approximately two months but may need to be replaced earlier depending on conditions. It is important to monitor the condition of the bales, particularly after large runoff events. Any sediment building up behind the barrier should be removed to prevent it from becoming remobilized during large flows. Remove sediment buildup once it reaches half the height of the straw bale barrier. At the end of their use, the bales along with any sediment they have trapped must be removed and the surface on which they were located must be stabilized. When managing larger flows, it may be necessary to stake down the bales to prevent them from moving.

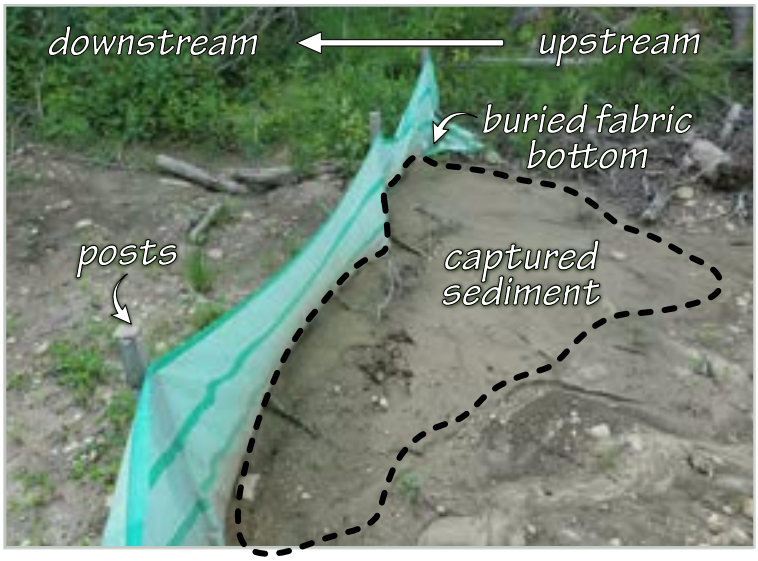
Sediment fences

Sediment fences (also called geotextile fences) are another type of temporary sediment control and can be used for approximately six months before needing replacement. Key practices for using sediment fences include:

- Pay attention to post spacing. Placing posts too far apart can increase the chance of failure. Make sure the fabric is on the uphill side of the post or the buildup of sediment may push the fabric off the post.
- The bottom of the fabric must be buried in a shallow trench (approximately 15 cm deep) on the uphill side of the fence to prevent sediment from escaping underneath. Be sure to compact the overlying soil once the bottom edge is buried.
- Sediment fences cannot be installed within the watercourse itself. For instream fences, specially designed

SEDIMENT FENCES

- *To prevent failure of the barrier and remobilization of the sediment, any sediment caught behind the barrier must be removed once it reaches half the barrier height.*
- *When the fences are removed, be sure to collect all the fence materials and any loose sediment they have retained.*



floating sediment barriers should be used instead.

- Ensure the fabric used for the sediment fence is strong enough to withstand the forces acting on it.
- Do not install sediment fences directly on top of mats or nets intended to promote vegetation growth. Any repair or removal of the fence will also damage the matting, and the emergent vegetation.
- Monitor the fence to check for rips and sedimentation. Any torn or collapsed sections should be replaced immediately.
- Once vegetation has been established the fence must be completely removed and the area stabilized.

Ecological erosion measures

Ecological erosion measures (sometimes referred to as bioengineering) are often preferred over engineered solutions. This is because ecological erosion measures are inexpensive and better preserve the natural conditions that existed before the watercourse crossing was installed. They are permanent, regenerative, and self-sustaining over time — meaning they do not require removal or maintenance. The most important ecological erosion measures include establishing native vegetation and surface roughness.

Harvested willow stakes ready for installation (left) and planted stakes showing growth one year later (right).

Native vegetation

Whenever possible, prevent vegetation already present on the site from being destroyed, then re-establish vegetation as the primary defence against erosion. Replanting exposed soils is the most cost-effective erosion prevention strategy and does not require long-term maintenance. Natural vegetation provides habitat and a source of food for animals, creating an ecologically healthier watercourse crossing. Establishing vegetation can be done by spreading seeds, planting partially grown plants, or through staking. Staking is when limbed stems of willow (sometimes poplar or other shrubs) are harvested and driven deep into a hole in the soil created with a rod or pipe. The stakes can also be treated with rooting hormone or fertilizer to improve growth.

Even when other erosion methods are chosen, planting vegetation should still always be included. It is important to consider the time it takes for vegetation to become established. Using native species is preferred, but for difficult sites that need to be revegetated quickly, choosing non-native species can help improve the chances of success. In the meantime, temporary erosion measures such as sediment fences or straw bales should be used until the vegetation is capable of controlling erosion independently. In some cases, heavy clay, sandy soils, compaction, or overly steep banks can prevent vegetation from becoming established. Under these circumstances, revegetation may not succeed, and other protection methods will be required. Which other protection measures are chosen will depend on the specific site features. When choosing species for revegetation, ensure success by:

- Apply practices identified in the Native Plant Revegetation Guidelines, which focus on revegetating disturbed sites by establishing native plant communities[41].
- Planting a diversity of species. Herbaceous plants with fibrous root systems are better at protecting banks from surface erosion. Woody species with deeper roots are better at increasing soil cohesion and reducing slope failure.

Note: Prioritize retaining natural vegetation on the site as it is the most effective and economical method of preventing erosion.

41 Government of Alberta. 2001. Native plant revegetation guidelines for Alberta. https://open.alberta.ca/publications/native-plant-revegetation-guidelines-for-alberta

- Prioritizing the use of species with large fibrous roots that will stabilize the soils.
- Choosing fast growing and low-maintenance species. Species that naturally resprout from roots or branches are a great choice.
- Avoiding species that are particularly favourable to wildlife or livestock.

Surface roughness

Anything that helps slow the flow of water will help prevent erosion. Surfaces where water is expected to flow can be roughened using natural materials to effectively slow down the water. In addition, increasing surface roughness creates small microsites that can promote plant growth and increases infiltration of water into the soil, further protecting the site against erosion. Different surface roughening techniques include:

- Rough and loose — when replacing fill material around the crossing, avoid the urge to smooth out the material. Leaving texture on the surface will help prevent erosion.
- Woody debris — logs or large branches — serve as an effective and inexpensive resource for surface roughening. Place the material perpendicular to the flow of runoff for the best effect and make sure to securely press it into the surface (key it in) so that it creates an effective barrier.
- Wattles are bundles of willows tied into place with willow staking that function as a type of sediment fence. Wattles slow the flow of rainwater and will resprout over time, vegetating the surface. Place perpendicular to the direction of runoff flow and stake into place.
- Adding mulch can serve as a temporary erosion protection measure and helps natural vegetation become established. Mulch improves infiltration and reduces erosion from rainfall. It is useful as a protection during non-growing seasons. Mulches can be made from a variety of materials including straw, wood chips, plant cuttings, tree bark, or biodegradable mats. If using biodegradable mats or nets, ensure they are staked down properly to prevent water from scouring underneath.
- Hydromulching is another type of mulching where a mixture of wood fibre and fibre-bonding agents is sprayed onto the ground surface. Ensure application rates are appropriate to site objectives as too much will hamper vegetation growth. The benefits of hydromulching include:
    - No need for manual labour
    - Unlike netting, hydromulching cannot be moved out of place
    - Biodegradable — no removal required
    - Unlike traditional mats or nets, hydromulching does not have defined edges where erosion can be concentrated.

Woody debris

Mulch

Wattles

Engineered erosion control measures

Engineered erosion and sediment control methods include permanent structures designed and installed along with the watercourse crossing structure. Some examples include riprap, headwalls, endwalls, wingwalls, and gabion baskets. As suggested in the name, engineered solutions should be designed by a professional. As a result, these types of erosion measures are costly and can be time consuming to install.

Ensure the use of riprap is not contributing to thermal pollution of the water. Rock heats up quickly in direct sunlight and should be shaded by vegetation in watercourses sensitive to increasing temperatures. High watercourse temperatures can decrease levels of dissolved oxygen needed for fish survival.

Riprap

Riprap consists of durable broken rock, cobble, or boulders placed over exposed soil to prevent erosion. Riprap must be used appropriately to prevent scouring of the sediments they are intended to protect. Note that extensive use of riprap may require additional approvals. Ensure that riprap is:

- Clean, durable, non-ore-bearing, and nontoxic rock.
- Has an angular shape. Angular rock interlocks better and is easier to anchor into soils. The increased roughness is also better at slowing water.
- NOT taken from a watercourse nor from within 30 m (100 ft) of a watercourse or wetland.
- Properly sized for the watercourse where it is being used.
- Is not placed on very steep slopes.
- Layered thick enough that the water cannot force its way behind the rocks and erode the sediment.
- Not contributing to thermal pollution of the water.
- Placed with machinery capable of controlling its placement and not be dumped or pushed over the shoulder of the slope. Pushing riprap into place can damage the watercourse banks and cause sedimentation.
- Placed according to the professionally engineered design.
- Placed so that it does not change channel depth or width, as doing so could restrict fish passage.

Vegetating within the riprap (staking between rocks) can further prevent erosion and help keep rock temperatures low.

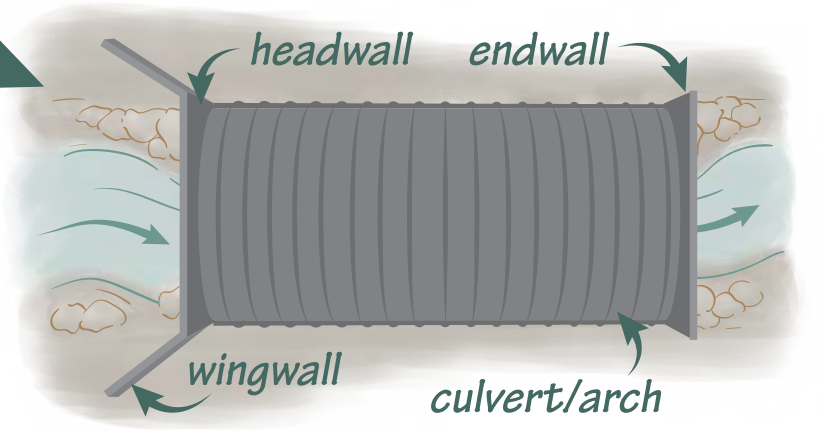
Headwalls and endwalls

Headwalls and endwalls are vertical walls parallel to the roadway and tied into the slopes of the road embankment. Headwalls and endwalls are built in the same manner and simply refer to which end of the culvert they are built on. Headwalls are at the crossing inlet and endwalls are located at the crossing outlet. They are used for erosion protection and since they hold back sediment they can also be used at sites where factors limit the width of the road.

When installing headwalls and endwalls, be sure to:

- Use a solid material to construct the structure such as squared timber, concrete, steel, or gabion baskets.

Engineered headwall of an arch



- Install the headwalls and endwalls below the anticipated depth of scour so they cannot become undermined.
- Tie the headwalls into the slope for stability.

Wingwalls are additional walls that extend upstream and downstream from the outside corners of the headwalls (or endwalls) at an oblique angle to the road embankment. Wingwalls function similarly to headwalls and endwalls. They help retain the fill material on the road, provide additional structural integrity, and help direct the water flow into the crossing. Information applicable to the design of headwalls also applies to the construction of wingwalls.

Other benefits of headwalls and endwalls include:

- Hold back the road embankment to prevent fill material from entering the watercourse.
- Anchor the culvert against potential buoyancy or uplifting.
- Provide structural support to the culvert inlet and outlet.
- Prevent saturation of backfill that can lead to slumping of the material.
- Direct the water through the pipe, reducing turbulence.
- Allow a shorter length of arch or pipe to be installed in deep gullies without the need for huge fills above the structure. The engineered walls support the road fill and the crossing in confined spaces.

Resources

- **Soil Bioengineering Techniques for Riparian Restoration**

  chapter.ser.org/westerncanada/files/2015/01/2002-polster.pdf
- **The Alberta Transportation erosion and sediment control manual**

  open.alberta.ca/publications/alberta-transportation-erosion-and-sediment-control-manual

Key References

- Gillies, C. (2021). Addressing Road Surface Erosion: Protecting Watercourse Crossings. FPInnovations. Pointe-Claire, QC.
- Maloney, D., Carson, B., Chatwin, S., Carver, M., Beaudry, P., & Bleakley, S. (2018). Protocol for evaluating the potential impact of forestry and range use on water quality (Water Quality Effectiveness Evaluation, 2018). Ministry of Forest, Range and Natural Resource Operations and Ministry of the Environment, Victoria, BC.
- New Brunswick Department of Environment and Local Government (2021). Watercourse Alteration Certification Manual, Fredericton, NB.
- Clayton Gillies (2007). Erosion and sediment control practices for forest roads and stream crossings: A practical operations guide. Vol. 9 No. 5. Western Region FPInnovations, Pointe-Claire, QC.
- Barnard, R. J., J. Johnson, P. Brooks, K. M. Bates, B. Heiner, J. P. Klavas, D.C. Ponder, P.D. Smith, and P. D. Powers (2013). Water Crossings Design Guidelines, Washington Department of Fish and Wildlife, Olympia, WA, USA. http://wdfw.wa.gov/hab/ahg/culverts.htm

6. Watercourse crossings
Installation, replacement, and restoration

The following sections summarize key information for different watercourse crossing types. These factsheets provide watercourse crossing designers and installers with BMPs for ensuring watercourse crossings are created in a way that minimizes impacts to the aquatic ecosystem and prioritizes fish passage. All watercourse crossings should be constructed with the following four goals in mind:

1. **Create a safe and sturdy crossing structure that is environmentally sound**
    - Choose a crossing design that allows for the safe passage of vehicles.
    - Use a crossing that is structurally sound for the site.
    - Adhere to best management practices whenever possible.
    - Ensure that there is a plan for the watercourse crossing that has been well communicated to everyone that will be involved with the project.
2. **Prioritize fish passage and habitat**
    - Always try to maintain the original site conditions or re-create them if the site is disturbed.
    - Work outside of the Restricted Activity Period (RAP) which outlines the appropriate fisheries instream work window (see the *Legislation, regulatory approvals and permitting section* for information on RAPs).
    - Dewater the site before completing any instream work (pump water around the crossing during installation or create a gravity bypass).
3. **Prevent erosion and sedimentation**
    - Use dams, sediment traps, sediment fences, straw bales, or other materials to prevent sediment from entering the watercourse while creating the crossing.
    - Promptly revegetate and stabilize the site with native species to prevent post-construction erosion.
    - Do not work during periods of heavy or persistent rainfall or any other conditions that would cause increases in sediment delivery to the watercourse.
    - Control drainage around the crossing so that it does not enter the watercourse without first being properly filtered by the surrounding vegetation.
    - Avoid turnarounds or other soil disturbances within close proximity to the watercourse crossing.
    - Include monitoring in all erosion control plans.
    - Design the road so the crossing is not at the lowest point. This prevents runoff water from flowing towards the crossing and into the watercourse.
4. **Ensure water flow in all conditions**
    - Size watercourse crossing structures to accommodate high flows during flooding events.
    - Monitor crossings to ensure they stay clear of debris and do not become plugged with sediment over time.
    - Match the hydrologic conditions above and below the watercourse crossing structure as closely as possible.
    - Ensure water flows are appropriate for the upstream migration of all fish species present.

Except for temporary watercourse crossings, it is important that crossing structures are designed with longevity in mind. Even initially well-designed and installed crossing structures can prevent future fish passage if allowed to degrade over time. Maintenance programs are a mandatory component of installing watercourse crossings. Ongoing inspection and maintenance of all types of crossing structures is essential to ensure they continue to function properly. An understanding of maintenance requirements should be used to help inform initial structure choice. For instance, watercourses with lots of debris, elevated sediment transport, or high beaver activity could require more maintenance activities depending on which structure type is chosen.

Reminder: These goals should be considered during the planning, installation, and monitoring phases of creating and maintaining a watercourse crossing. See the Planning section of this guidebook to learn how these goals influence structure choice.

Temporary watercourse crossings

Temporary crossings include any structures that allow watercourses to be crossed for a limited period, preferably less than two months. The size of temporary structures can be smaller than what would be required for a permanent structure if they are installed and removed before normal periods of high flow in the fall and spring. The type of temporary structure chosen will depend on the site, expected use, and whether it will be providing winter or summer access. When no longer required, temporary crossings should be removed as soon as possible and sites should be returned to initial conditions. When temporary crossings are removed, it is vital to block road access and install signage to warn people the crossing has been removed. Some temporary watercourse crossing types include fords, log bundles, snow fills, and temporary bridges. Factsheets for each of these techniques are included below. Here we provide a summary of the key advantages and disadvantages for each crossing technique.

▪ *FORDING*

ADVANTAGES

- Does not require installation
- Provides immediate access in emergency situations

DISADVANTAGES

- High risk of watercourse contamination
- Very high sedimentation risk
- Can damage the watercourse bed and banks causing fish death or harmful alteration, disruption, or destruction of fish habitat
- Limited use — if used more than once can cause the channel to become dry in that area
- Not recommended from an environmental perspective

▪ *LOG FILLS AND SNOW FILLS*

ADVANTAGES

- Can leave very little trace if installed correctly
- Can be constructed of locally sourced materials

DISADVANTAGES

- Can only be used in the winter
- Sensitive to environmental conditions

▪ *TEMPORARY BRIDGES*

ADVANTAGES

- Very low environmental impact
- Some types can be salvaged and reused
- Easy to restore site after use

DISADVANTAGES

- Can damage the watercourse bed and banks if not designed, installed, or maintained correctly

▪ *ICE BRIDGES*

ADVANTAGES

- Creates minimal disturbance when constructed according to recommendations
- Can accommodate larger watercourses, lakes, and wetlands

DISADVANTAGES

- Can only be used in the winter
- Sensitive to environmental conditions

▪ *TEMPORARY CULVERTS*

ADVANTAGES

- Some types can be salvaged and reused

DISADVANTAGES

- Can cause harmful alteration, disruption, or destruction (HADD) of fish habitat if not maintained
- Often do not provide fish passage in both high and low flows

FACTSHEET: FORDING

- \+ Do not require installation
- – Limited use
- – Very high sedimentation risk
- – High risk of watercourse damage and contamination
- – Not recommended from an environmental perspective

Fording is not considered a routine type of watercourse crossing and should only be used under exceptional circumstances. This is because when a ford is used, traffic comes into direct contact with the streambed and water. Whenever possible, a temporary bridge should be used instead of a ford. Note that fording is generally restricted to non-fish-bearing watercourses — a critical review is required if used in a fish-bearing stream. Fording can only be done on shallow watercourses and should be approved by a qualified practitioner before use.

The act of fording a watercourse (crossing with no watercourse structure installed) should not be confused with the installation of a permanent ford structure. For more information on ford installation structures refer to the Ford factsheet on page 80.

Left: A rocky and shallow section of a watercourse without steep banks that was chosen as a site to ford. Right: Portable modular bridge sections used to ford during a bridge construction project.

Examples of when a ford crossing could be considered include:

- *Forest fire suppression or other emergency situations.*
- *Sites that only require one-time access (over and back).*
- *Moving machinery into place during a crossing installation or while repairing an existing permanent crossing structure that cannot be safely used.*

Key Considerations

KEYS TO SUCCESS

- Only use a ford after considering other more environmentally appropriate options.
- Choose the ford location carefully. Fish spawning areas and other sensitive sites should be avoided.
- Consider laying down materials that prevent direct contact with the streambed or banks. This can include rig mats or a bridge deck.
- Restore the site as close as possible to its original condition once fording is no longer needed.

WHAT TO AVOID

- Do not drag anything behind the vehicle or equipment that could destroy the streambed.
- Fording is not appropriate for hauling or accommodating regular traffic.
- Do not use vehicles that are leaking fuel, hydraulic fluids, lubricating oil, or cargo.
- Do not ford watercourses that have highly erodible substrates.

FACTSHEET:

LOG FILLS / SNOW FILLS

- \+ Can leave very little trace if installed correctly
- \+ Can be constructed of locally sourced materials
- – Winter crossing only
- – Sensitive to environmental conditions

A log fill that used extra logs that mark the edges of the road.

A log and snow fill with a very soft driving surface that is spilling material towards the watercourse.

If streamflow is anticipated during periodic winter thaws, consider building a modified log or snow fill. The modification involves placing a pipe culvert or heavy steel pipe within the watercourse channel to allow for water movement beneath the crossing. Heavy steel pipe is recommended because it is easier to salvage and has a lower chance of being crushed during use or removal.

Sizing considerations

These crossings are best suited for small watercourses. Position the crossing on a straight and narrow stretch. Avoid creating a crossing at wide, meandering, or braided sections of the watercourse. The size of the crossing is limited by the availability of clean snow. Ensure there is enough snow to properly fill the span of the crossing while taking snow compaction into consideration. It is not recommended to push snow into the watercourse unless there is lots available as it is very easy to incorporate sediment. At sites where there is not enough snow available, snow-making equipment and machines are an option to create more material. However, in winter when flows are low, water withdrawals from the watercourse itself are risky because they can disturb overwintering habitat. Approvals need to be granted before water can be removed and if approvals are not granted, water would need to be trucked in.

Installation best practices

- Begin construction after the watercourse has frozen to the bottom, has ceased to flow, or has ice thick enough to prevent any free water from being dammed once weight is applied.
- Lift the bundled logs or culvert into place. Dragging can damage vegetation and contribute to erosion and sedimentation.
- Log fills must have a geotextile or other type of separation layer placed between the watercourse channel and the logs.
- Place an additional protective layer (e.g., geotextile) that extends over the log bundle or culvert and

onto the watercourse bank.

- Use an excavator to place snow in the watercourse channel. Crawler tractors may be used, but extra care is required to ensure unwanted dirt and debris is not pushed in.
- If the watercourse remains completely dry or frozen to the bottom for the entire time the crossing is in place, fish passage is not a concern. At sites where water is expected to flow intermittently, fish passage needs to be taken into consideration by using modified fill that includes a pipe. Although modified fill is permitted, a temporary bridge or arch are better options in watercourses expected to have fish passage throughout the winter.
- Ensure logs or snow are wide enough to prevent soil from being deposited into the watercourse. Logs should be delimbed and need to extend at least 1.5 meters out from the active road surface at each end.
- Add a layer of snow between the channel and the log fill to allow for easier identification of the crossing layers when removing.

Key considerations

KEYS TO SUCCESS

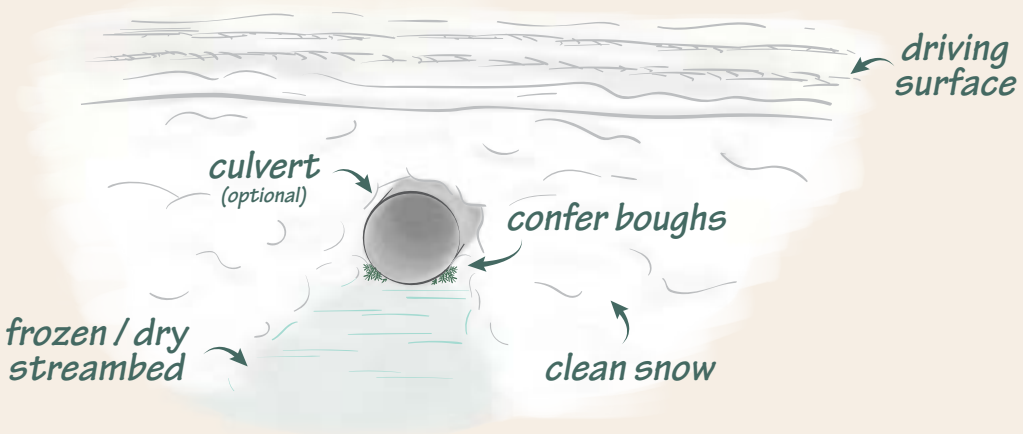
- Use only clean snow to prevent deposition of sediment into the watercourse once it melts.
- For easy removal, prevent logs from becoming embedded by lashing them together. Alternatively add a layer of clean snow or confer boughs underneath them so the operator can identify the bottom of the crossing structure and avoid disturbing the streambed.
- For log fills, enough logs must be available to properly fill the watercourse channel.
- Use enough snow to prevent exposure of the underlying structure. Remember that vehicle compaction can reduce snow thickness by 70%.

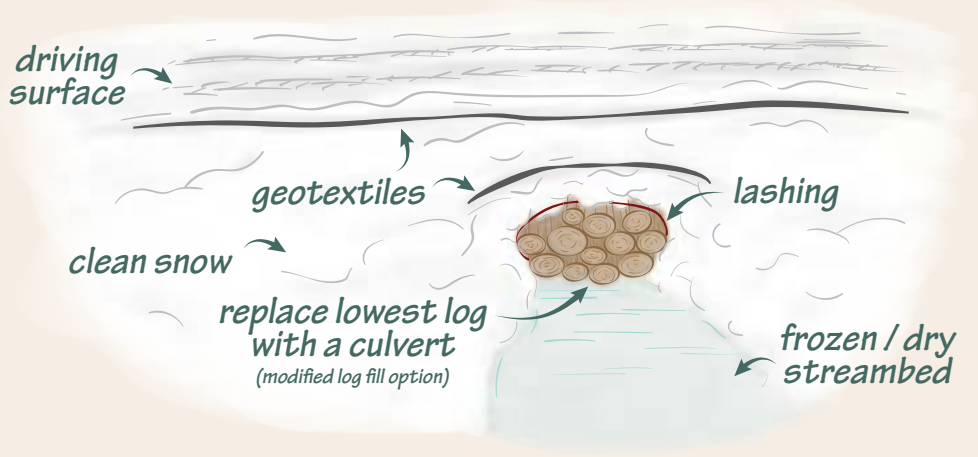
WHAT TO AVOID

- Do not cap the snow with soil as this will lead to sedimentation during spring melt.
- Avoid leaving waste onsite. Unless the material is biodegradable, use a geotextile that will not degrade over the season. Choose geotextile with a high enough tensile strength to be removed in one piece without tearing.
- Monitor the state of the crossing during any warm weather events and prevent vehicles from using the crossing if damage may occur (e.g., deep ruts in the snow that would need repair).

SNOW FILL

An additional layer of clean snow or confer boughs under the culvert separates it from the frozen watercourse bed. The boughs may need to be removed by hand to prevent disturbance to the underlying sediment.





LOG FILL

If needed, additional logs can be placed across the watercourse to help bridge the load.

Logs should be separated from the streambed using an additional geotextile or snow layer.

Site reclamation (Erosion, sediment control, and riparian)

Where regulations specify, the snow and pipe/logs need to be removed before spring thaw to avoid adversely impacting the watercourse. It is important to remove the crossing before peak snowmelt flows to prevent the watercourse from being diverted and forming a new channel. When deactivating the crossing, try not to disturb the bed or banks while removing materials. Locally sourced logs may be left on-site. All removed materials (snow and logs) left on-site should be placed above the high-water mark to ensure they do not cause future sedimentation and erosion. Be sure to completely remove all non-biodegradable materials.

A snow fill that was not removed before the spring thaw.

Inspection, monitoring, & maintenance

Once the structure is installed, it is the responsibility of the owner to ensure the crossing is appropriately monitored throughout its life. If installed correctly, this type of crossing can leave very little trace in the spring. Return to the site during the summer season to ensure natural vegetation has regrown where the crossing was placed.

The crossing may need to be removed within the winter season if temporary warm weather occurs. If this happens, remove any snow fill that could cause damage to the watercourse if it melts, and reconstruct the crossing once colder weather returns.

Key References

- B.C. Ministry of Forests, Lands and Natural Resource Operations, B.C. Ministry of Environment, and Fisheries and Oceans Canada. 2012. Fish-stream crossing guidebook. Rev. ed. For. Prac. Invest. Br., Victoria, BC.
- FPInnovations. 2014. Temporary winter stream crossings: A practical guide for forest workers. Victoria, BC and Pointe-Claire, QC.

FACTSHEET:

ICE BRIDGES

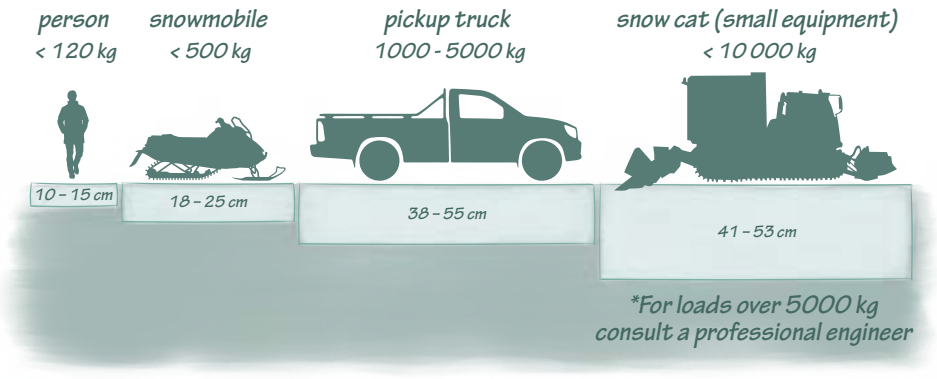
- \+ Creates minimal disturbance when constructed properly
- \+ Can accommodate larger watercourses, lakes, and wetlands
- – Winter crossing only
- – Sensitive to environmental conditions

Ice bridge installation over a creek. No evidence of the crossing was visible the following summer.

An ice bridge that was not reclaimed before the melt season deposits sediment into the watercourse.

Sizing considerations

Ice bridges are an alternative winter crossing method that can be used on watercourses that are too large for the construction of a snow fill. Watercourses appropriate for an ice bridge have water flowing all winter and do not freeze to the bottom. They must be deep enough to prevent the ice bridge from coming into contact with the streambed and should not restrict the movement of water below the ice. A constructed ice bridge should only be wide enough to accommodate the passage of a single vehicle at a time.



The ice thickness required will depend on the size of the vehicles using the crossing and the strength of the ice. Clear blue ice that forms naturally on the surface of a watercourse has the highest strength. White ice that is created either naturally or through manual flooding usually has more air bubbles and is not as strong. River ice is less predictable than lake ice due to fluctuating water levels and currents below the ice that create variability in ice thickness. A combination of these factors should be taken into consideration when determining the correct ice thickness.

Be mindful that both speed and duration should be considered when determining if the ice is thick enough for use. The stress to the ice increases the longer the load remains in place or the faster it travels across. Ice that can be safely driven across at low speeds may fail if a vehicle is parked on it for more than two hours or if a vehicle crosses it quickly.

Installation best practices

- Establish an ice safety plan and communicate it to everyone working on the crossing.

- Determine how much water will be required to construct the crossing. If construction water is used from the watercourse itself, follow your TDL (temporary diversion licences for short-term use of water) or any water use conditions outlined in the watercourse crossing approval. Drawing too much water from a watercourse at one time can have detrimental effects on the ecosystem and fish habitat.
- Appropriately screen pipe intakes when pumping water to prevent injury to fish.
- Protect the watercourse banks by using thick layers of clean ice and snow when constructing the approaches.
- Construct the crossing perpendicular to the watercourse.
- Consider using appropriate rig matting on the driving surface to maintain the crossing integrity. Note that certain colours or materials of rig matting can heat up in direct sunlight and contribute to ice melting in warm conditions. Any materials must be removed well in advance of ice break-up.
- Put up signs to warn users of speed and weight restrictions of the ice bridge.
- Ensure compliance with the *Canadian Navigable Waters Act* for your project.

Key considerations

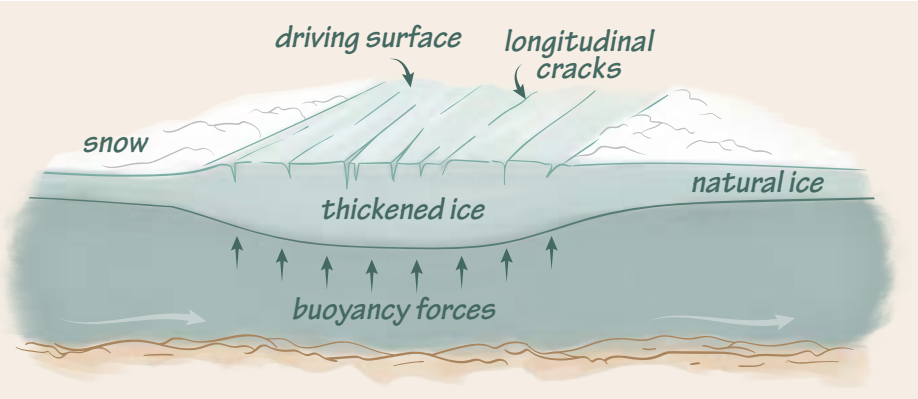
KEYS TO SUCCESS

- Only use clean water to construct the ice bridge. Avoid using municipal water sources for construction as these are typically chlorinated and not suitable for direct return to watercourses.
- Be mindful when trimming riparian vegetation for approaches. Only remove what is necessary and make use of existing trails whenever possible.
- Anyone working on the crossing should first complete an ice safety training program.
- Ensure bridge users know the full weight of their vehicle, understand the risks of using an ice bridge and are properly equipped to deal with emergency situations.

WHAT TO AVOID

- Do not add any gravel, rock, or loose woody materials to the crossing during construction or for additional traction during use.
- Do not allow the crossing to impede the natural flow of water at any time.
- Do not work on, or use, an ice bridge alone. If checking the thickness of ice, wear a flotation suit, stay 10 meters away from teammates, and ensure everyone has received ice rescue training.
- Never pull over to stop or drive on the edges of an ice bridge.
- Do not impede natural water flow below the ice bridge during installation and use.

Longitudinal cracks form on the driving surface because the thickened ice is trying to float in equilibrium with the natural ice cover. They can be repaired throughout the season and do not indicate a structural failure as long as they are less than 50% of the ice thickness and do not intersect each other.



Site reclamation (Erosion, sediment control, and riparian)

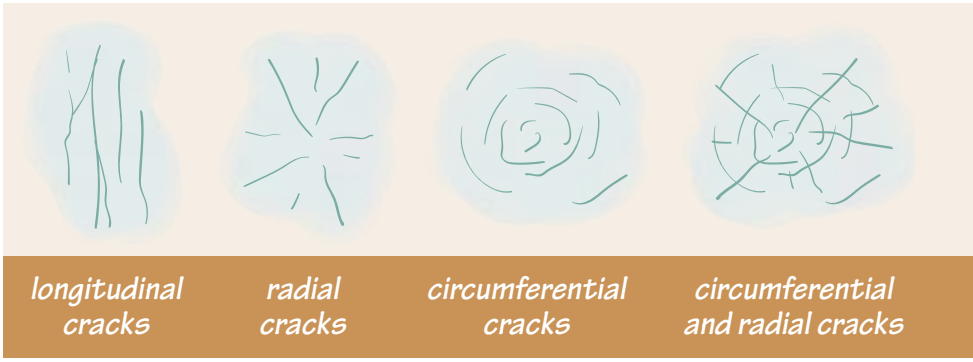
- The period of melt and breakup in spring is the period of greatest potential risk to fish passage. In the spring, consider adding several V notches in the center of the ice bridge to accelerate break-up and to ensure the crossing melts from the center outwards. This practice helps prevent issues with ice jamming, erosion, flooding, and fish passage as the crossing melts.
- Any compacted snow that was used in the crossing should be removed before high spring flow.
- If any disturbance occurs on the watercourse banks, they must be restored to their original condition. Be sure to restore riparian vegetation where the crossing approaches were situated.
- Ensure that erosion control measures are in place until vegetation is established. Depending on the local climate, revegetation may take longer than expected. Use biodegradable erosion measures whenever possible, particularly for remote sites with limited summer access.

Prioritize safety: Across Canada, approximately 50 people die each year on freshwater ice.

Inspection, monitoring, & maintenance

The thickness of the ice bridge needs to be carefully monitored throughout the life of the crossing. Regular snow removal will likely be required to keep the crossing clear. The ice needs to be carefully monitored for thickness and cracking. The road should be closed anytime poor ice conditions are detected, during periods of reduced visibility (storms), and early in the spring before the crossing begins to degrade.

Abrupt changes in temperature (± 20° Celsius in 24 hours) can affect the stability of the ice and cause cracking. Conditions need to be completely re-evaluated whenever air temperatures are above zero degrees for more than 48 hours. Monitor changes in temperature upstream of the crossing as well. Periods of warm temperatures upstream can cause ice jamming and carry surface flood ice to the crossing site.



longitudinal cracks | *radial cracks* | *circumferential cracks* | *circumferential and radial cracks*

Many different processes can cause cracks to form in ice but not all cracks indicate a change in structural integrity. Longitudinal cracks are straight cracks that often run parallel to the driving surface. They are caused by uplifting of the thicker driving ice and can be repaired. Longitudinal cracks that are deeper than 50% of the total ice thickness need to be repaired before the crossing is used. Radial cracks (lines extending out from a particular point like spokes of a wheel) or circumferential cracks (circular cracks forming around a particular point) indicate ice overloading and are a sign of imminent or immediate ice failure. When these two crack types occur together, the ice will fail where they intersect.

Key References

- Fisheries and Oceans Canada. 2007. Northwest Territories Operational Statement: Ice Bridges and Snow Fills. Version 3.0. Yellowknife and Inuvik, NT.
- Fisheries and Oceans Canada. 2022. Projects Near Water. Online resource. https://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html
- Government of Alberta and Work Safe Alberta. 2009. Field Guide to Working Safely on Ice Covers. Alberta Labour, Edmonton, AB.

Watercourse crossings

Watercourse crossings play a key role in providing mid-to long-term access on resource roads. They are critical features that warrant careful planning and consideration to ensure their effectiveness. The two most common types of long-term watercourse crossings are bridges and culverts. Key considerations include:

- Due to their longer-term use, these crossings should be built to accommodate a one in 100-year flooding event (Q100) whenever possible.
- Crossings must be sized properly so that they do not create barriers to fish passage, do not introduce sediment to the watercourse, or cause erosion of the watercourse channel.
- Choosing fish-friendly options can accelerate approval processes since less review is required.
- Not all watercourse crossing types are suitable for all locations. Installing a suitable and well-constructed crossing can offset installation costs by saving time and money for future maintenance and replacement.

Bridges

Bridges have the lowest impact on aquatic habitats of all crossing types. Bridges and other open-bottom structures are the preferred types of watercourse crossings to ensure fish passage since they preserve the natural streambed. Bridge structures can initially be more expensive to install but have fewer constraints than other watercourse crossing types and are therefore applicable to a wider variety of sites. For example, bridges can accommodate steeper and larger watercourses. Also, under certain circumstances, clearspan bridges can be installed without any instream work, bypassing dewatering and fish rescue requirements. Although many different types of bridges exist, the following factsheets provide generalized best practices for clearspan and multi-span bridges.

Culverts

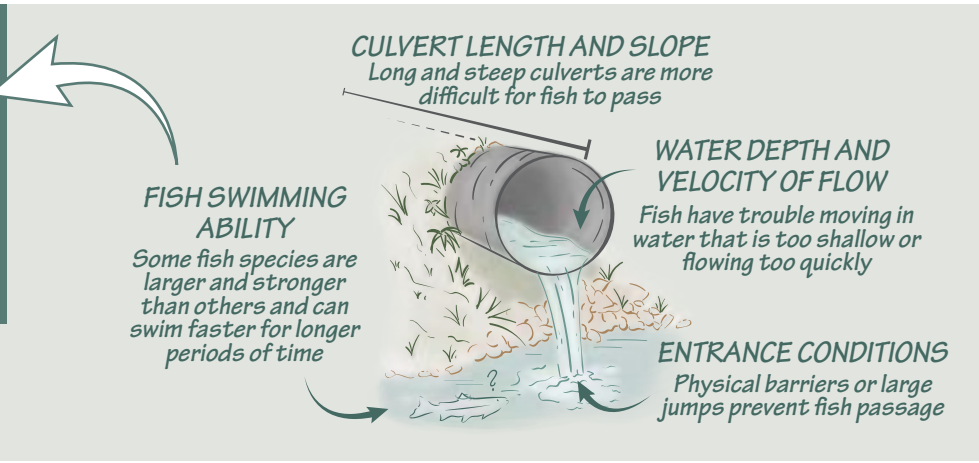
Reminder: A new culvert cannot be installed within 30 meters (100 ft) of a wetland without consulting wetland-specific regulations. Reference factsheets on wetland-specific watercourse crossings in the Wetland watercourse crossings: Installation, replacement and restoration section.

Many different types of culverts exist that can be constructed from metal, plastic, concrete, or wood. Regardless of type, the most important consideration for a culvert installation is size. All culverts must be sized appropriately to be passable by fish, prevent sedimentation, and accommodate high-water flows. The diameter of the culvert must be large enough to accommodate the natural watercourse width and needs to be able to accommodate high flow events without damaging property through back-flooding. This risk increases with larger watercourses or larger watersheds. Culvert installation plans should undergo a hydraulic analysis to determine how the watercourse crossing will affect the flow of water. A hydrologic analysis involves many factors including watercourse slope, water speed, channel cross-sectional area, flood frequency, and ice formation. Proper culvert length is also important since culverts that are too long or too short can cause scouring and fish passage issues. Culvert length must be calculated during the design phase based on the road width, road depth, and culvert angle.

Culverts that are not installed correctly can have severe negative impacts to fish passage. Culvert types that are more prone to fish passage issues tend to require additional approval measures and have more stringent installation guidelines. Open bottom culverts (arches) have less potential to affect fish passage because they retain the natural streambed and are therefore a preferred culvert type from an environmental perspective. They are also less likely to be dammed by beavers than closed bottom culverts. Regulations in Alberta have changed in an effort to reconnect fish habitat across the province. It is now a requirement to embed all closed bottom pipes (fill approximately 25% with material that mimics the natural streambed).

Fish passage is dependent on both the type of fish and the watercourse conditions. A fish needs to be able to swim faster than the flow of water to pass through a culvert. Fish passage is limited by the entrance conditions of the culvert, the water

Different species of fish have different swimming abilities. For more information on the swim speeds of different fish species, visit: fishprotectiontools.ca



depth and speed, the culvert length and slope, channel roughness, and the fish's swimming ability. Channel roughness refers to how smooth the bottom of the channel or culvert is. Smooth culverts are difficult for fish to swim through whereas the irregular bottom created by embedding culverts provides places for fish to rest and recover.

Many culverts in Alberta are now being replaced with open bottom versions since they have a lower potential impact on fish passage. Arches are the most common type of open bottom culvert and come in many different designs and styles. Fish pass under arches easily since they preserve the natural streambed. Arches are also less likely to be dammed by beavers than closed bottom culverts, which can reduce long-term maintenance costs.

Factsheets for a variety of bridges, open bottom culverts, and closed bottom culverts are included in the following sections. Here we provide a summary of the key advantages and disadvantages for each crossing technique. Note that factsheets are only provided for the most common and most applicable crossing types.

Bridges (lowest potential impact to fish)

▪ *CLEARSPAN BRIDGES*

ADVANTAGES

- Can be installed at any time of year
- Easy passage of fish and other aquatic organisms
- Can be installed on steep watercourses
- Do not alter the natural streambed
- Can be prefabricated
- Cannot be obstructed by beavers

DISADVANTAGES

- Can slow traffic and are higher probability points of traffic collision
- Can have high maintenance requirements
- Must be engineered

▪ *NATIVE TIMBER BRIDGES*

ADVANTAGES

- Do not restrict fish passage
- Can be easily customized on site if the right materials are available

DISADVANTAGES

- Require access to large logs
- Include need for active monitoring to guard against wood rot
- Require knowledge of log cribs
- Temporary structures

▪ *MULTI-SPAN BRIDGES*

ADVANTAGES	DISADVANTAGES
• Easy passage of fish and other aquatic organisms • Can be installed on steep watercourses • Do not alter the natural streambed • Can be installed on very large watercourses	• Streambed sediment around instream piers can be prone to erosion • More complex design and engineering requirements • Can slow traffic and are higher probability points of traffic collision • Can have high maintenance requirements

Open bottom culverts (low potential impact to fish)

▪ *ARCHES*

ADVANTAGES	DISADVANTAGES
• Maintain the natural streambed and watercourse gradient • Easy passage of fish and other aquatic organisms • Better able to withstand floods compared to closed bottom culverts • Less susceptible to corrosion • Can also be used as a temporary crossing • Rarely freeze in the winter • Easier to reclaim sites compared to culverts • Can span a full road width	• Certain footing types can be susceptible to scouring and erosion if improperly installed • More complex design, construction, and maintenance • Require an engineered design • Take longer to construct than a closed bottom culvert • Headwalls can be costly and complex

Closed bottom culverts (high potential impact to fish)

▪ *EMBEDDED CULVERTS*

ADVANTAGES	DISADVANTAGES
• Can have many shapes including circular, box, or pipe arch • Embedding helps prevent erosion from occurring under the structure • Less expensive to install than open bottom culverts or bridges	• Can impede fish passage but are generally less prone to issues than other types of closed bottom culverts • Easily blocked by debris or beaver activity • Culverts need to be upsized to accommodate material that is placed within the culvert • Must be engineered to ensure velocity does not impede fish passage or cause erosion at the outlet

▪ *BOX CULVERTS*

ADVANTAGES

- Wider design can help prevent restriction of the natural channel width
- Require less cover material than other types so can be useful where height is limited
- Can be made of wood

DISADVANTAGES

- Wide flat bottom may reduce water depth for fish passage in certain streams
- Must be engineered to ensure velocity does not impede fish passage

▪ *PIPE ARCH CULVERTS*

ADVANTAGES

- Helps retain natural substrate in the culvert
- Useful in areas where the height of cover is limited

DISADVANTAGES

- The wide, slightly convex bottom may result in reduced water depth that could limit fish passage in some streams
- Must be engineered to ensure velocity does not impede fish passage

▪ *MULTIPLE CULVERTS*

ADVANTAGES

- Can pass high water flows in areas susceptible to flooding
- Can be used where the road elevation is limiting

DISADVANTAGES

- Are susceptible to ice or debris blockage
- Can easily obstruct fish migration
- Require more work for proper installation and stabilization
- Limited to a maximum of two culverts at a single crossing
- Must be engineered to ensure velocity does not impede fish passage
- Requires significant engineering on the headwall end of the structure

▪ *NON-EMBEDDED CIRCULAR CULVERTS (highest potential impact to fish)*

ADVANTAGES

- Can be useful for very small watercourses

DISADVANTAGES

- Reduces the cross-sectional area of the channel, potentially increasing water velocity and must be engineered to avoid impeding fish passage
- Prone to erosion below the inlet and scouring of the streambed at the outlet
- May require baffles to accommodate fish passage
- Are susceptible to ice or debris blockage
- All new installations (except for very small sizes) must be embedded

FACTSHEET: CLEARSPAN BRIDGES

- Least impact on fish passage and habitat
- Less prone to beaver problems
- Easiest to restore at end of life
- Can be built on any watercourse gradient
- Fewer regulatory requirements

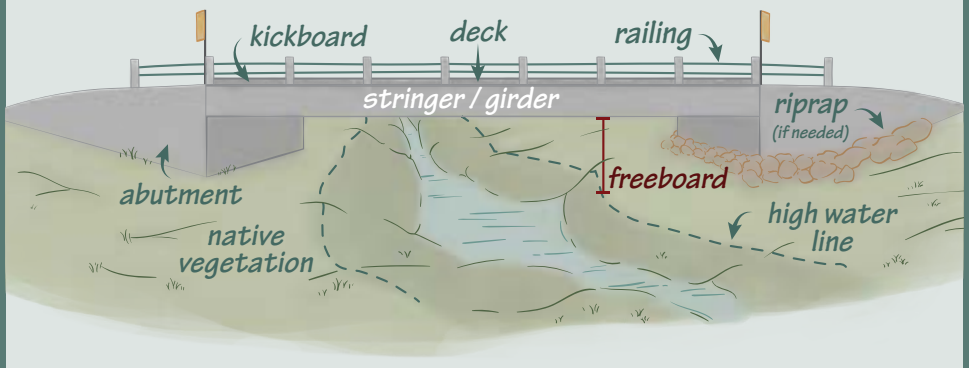
A bridge with guards that prevent road material from falling into the stream. Banks are stabilized with native vegetation.

A bridge was temporarily placed on top of another to increase the load rating and then forgotten about. The freeboard is only approximately 30cm.

Sizing considerations

Bridges are highly versatile structures and can vary in size and materials used. Key drivers of bridge size and type are topography, size of the stream, and frequency of the traffic expected to use the bridge. Proper bridge sizing includes determining structure height and length that are appropriate for the site. The height and opening of the bridge should meet design flows plus an extra clearance space (freeboard) to account for debris or navigation. Proper bridge length is incredibly important. Bridges need to be long enough that they do not constrict the watercourse channel. Spans should extend beyond the stream banks and the abutment walls. Overall, ensure that applicable legislation is understood and followed and that the bridge is not undersized for the site.

The following best practices are applicable to smaller clearspan bridges (without piers). Reference the following factsheet for multi-span bridges.



Clearspan Bridges:

- Also called single-span bridges
- Completely span the watercourse without instream piers
- Have all components above the high-water line
- Do not alter the streambed

Installation best practices

- Clearspan bridges are often built by placing the structure over the watercourse. Installation can occur at any time—including winter—when instream work is not required. Whenever possible, construct clearspan bridges without entering or altering the streamflow. If instream work is unavoidable, construction timing should follow the RAP and any regulations.
- Where possible, keep machinery out of the watercourse channel and away from riparian areas. Minimize fording by using other practices such as temporary work bridges.
- Bridges can be set on steel piles, concrete abutments, or properly stabilized native soil. To avoid damage and retain vegetation, any abutments and wing walls need to be placed outside the high-water mark and not on the banks of the watercourse.
- Minimize soil disturbance near the watercourse to reduce sedimentation and erosion. Existing riparian and upslope vegetation should be preserved as much as possible.

Choosing a proper location is essential to the long-term success of the bridge. Bridges should not be constructed at unstable locations such as meander bends, braided watercourses, or alluvial fans because they are more likely to erode and can alter the natural watercourse over time. Bridge locations should favor flat approaches, stable soils, and straight channels.

- Erosion protection should be based on Alberta Transportation and Economic Corridors standards and authenticated by a qualified engineer. Only use riprap where specified in the design and minimize its use elsewhere. Wherever possible, establish native vegetation.

Key considerations

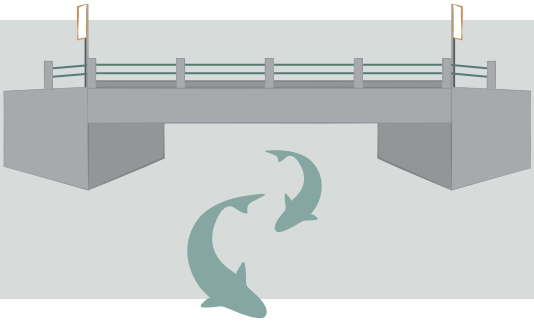
KEYS TO SUCCESS

- The bridge approach and deck should be higher than the road grade so any water on the road flows away from the bridge. This redirects any floodwater damage to the road instead of the bridge and helps keep sediment-rich road water away from stream.
- Ensure the bridge is long enough for the crossing site with all components placed beyond the high-water mark.
- Bridge surfaces and decks must be enclosed to prevent road gravel from entering the stream. Common methods include closed decks with no holes, wrapping stringers or the bottom railing with a geotextile filter fabric, installing gravel guards, and designing the roads so that they direct water away from the stream.

WHAT TO AVOID

- Water flowing in road ditches should not flow directly into the watercourse. It should be directed away from the road well in advance of the watercourse crossing and diverted into an area with stable vegetation.
- Do not use leaking machinery or fuel equipment within 100 m of the watercourse.
- Do not neglect the final details of the job once the watercourse structure is in place. Erosion control and vegetation re-establishment are key to a successful crossing project.
- Limit the use of riprap whenever possible and establish native vegetation as a primary defence against erosion.

Bridges are the best watercourse crossings to choose for restoring fish passage habitat. When clearspan bridges are installed and decommissioned without any instream work, they have very little impact on fish or natural watercourse conditions.



Site reclamation (Erosion, sediment control, and riparian)

Have a plan for the unexpected. Contingency plans for sediment and erosion control must be in place for unanticipated events. This includes increases in flow due to high precipitation inputs, increases in overland runoff, or work-area saturation. Projects implemented during frozen periods must account for how the spring melt period will affect the site.

Site-specific erosion mitigation measures must be implemented at all stages of bridge construction but are neglected most often once installation is complete. After installation, re-establishing vegetation is a top priority. All erosion and sediment control measures need to remain functional and on-site until revegetation is adequately controlling erosion and runoff. Additional valuable practices include:

- Placing salvaged woody material across disturbed areas to increase roughness, slow runoff, reduce erosion, and prevent access.
- Spreading organics across the site to promote regeneration from seed banks. Supplement with seeding or transplanting.
- Protect exposed soils and reclaimed sites from rain erosion.
- Encourage the use of biodegradable sediment control options so they do not need to be removed.

Long-term erosion issue: The bridge components are not outside of the high-water mark. Erosion has removed all the bank material up to the bridge abutment on one side of the crossing.

If a bridge must be removed, the same best management practices used during installation apply for the deconstruction. Following removal, the area must be restored to its natural state.

To avoid long-term structural issues, have bridge projects designed by an Alberta certified engineer.

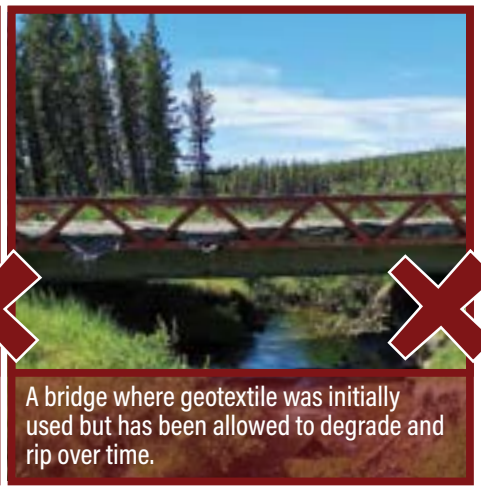
Inspection, monitoring, & maintenance

Over time, excess road material can be dragged onto the bridge. If monitoring reveals an issue with road material buildup, several methods can be used to prevent this material from entering the watercourse:

- Install kickboards (also called gravel guards, curtains, aprons, curbs, splash guards, or bumpers) along the edge of the bridge rails.
- Investigate how the road is being graded and ensure the road approaches are being graded away from the bridge.

Bridge components should be repaired or replaced as soon as weakness or decay is noticed through inspection. If any routine bridge maintenance activities, such as painting, sandblasting, bridge decking, or upgrading scour protection needs to be conducted. Be sure to consider how these activities could affect fish and fish habitat and if approvals might be needed. Conduct maintenance activities outside of the riparian area whenever possible.

A bridge without any measures to keep gravel contained. Material is falling directly into the watercourse.



A bridge where geotextile was initially used but has been allowed to degrade and rip over time.

A bridge constructed with sides that are completely closed, preventing road material from entering the watercourse.

Key References

- Fisheries and Oceans Canada. 2007. Northwest Territories Operational Statement: Clear-span Bridges. Version 3.0. Yellowknife and Inuvik, NT.

FACTSHEET: MULTISPAN BRIDGES

- \+ Low impact on fish passage and habitat once installed
- \+ Less prone to beaver problems
- \+ Can be built on any watercourse gradient
- – More complex design and engineering requirements

PHOTO: SUNDRE FOREST PRODUCTS

Despite the flood, the bridge is large enough and has wideset piers that are allowing water and debris to pass.

PHOTO: SUNDRE FOREST PRODUCTS

Instream piers and low freeboard have resulted in a buildup of debris during a large flood event.

Installation best practices

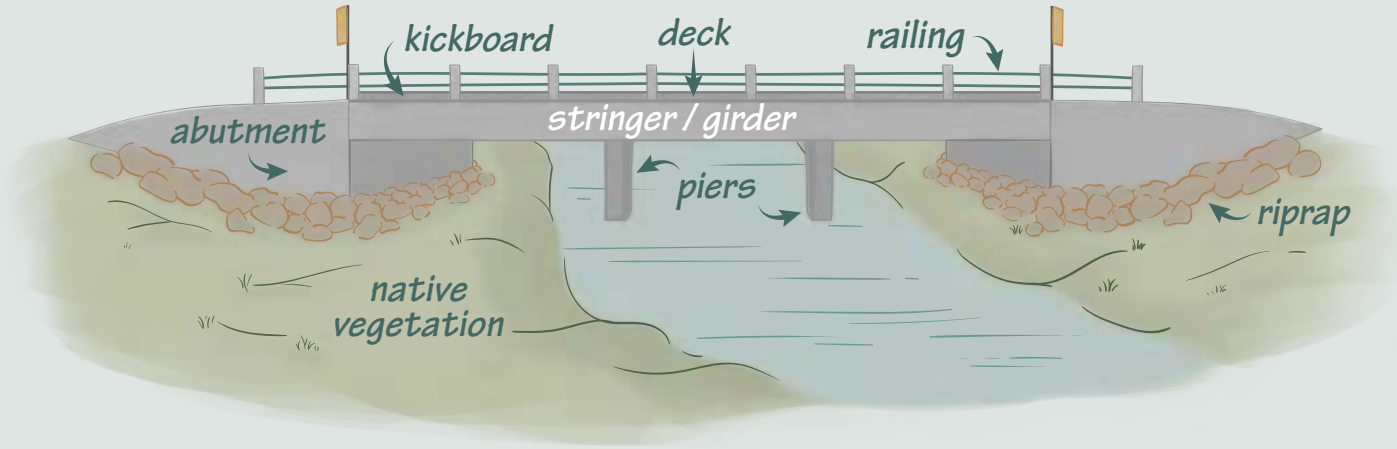
The primary difference between single and multi-span bridge types is the addition of instream piers. Installing piers requires diverting the watercourse and therefore has a greater impact on the streambed and fish. Due to the cost and engineering requirements of multispan bridges, they are rarely chosen for smaller watercourses and are therefore not discussed in detail here. A summary of key installation best practices specific to multi-span bridges include:

- Follow the restricted activity periods (RAPs) for the watercourse you are working in as well as any additional permitting regulations. Note that constructing a watercourse crossing during high flow periods (May–July) can pose significant risks if the worksite isolation measures are washed away.
- Work quickly to limit the time the watercourse is diverted. While constructing the bridge, use a cofferdam to divert streamflow to the opposite side of the channel. At least two thirds of the channel should always remain unobstructed. Ensure adequate equipment and backup supplies are on site for the cofferdam or pump around.
- Excavated material must be stored in a stable area sufficiently above the high-water mark of the watercourse to prevent this material (sediment or debris) from re-entering the watercourse. Any fill material placed below the normal high-water mark of the watercourse must be erosion resistant, usually through revegetation.
- Choosing a bridge location that does not require channel modifications is preferred. If the channel needs to be modified, it must be authorized under the *Water Act*. It is vital to construct or maintain a natural channel under the bridge. Width, depth, and channel roughness should reflect natural conditions. Avoid making the channel under the bridge wider than the natural watercourse. This is often done to help prevent debris hang-ups, but a wide channel also decreases water depth that can be a barrier to fish passage in periods of low flows.

! *Many of the installation, replacement, and restoration best practices that apply for clearspan bridges are also applicable to multispan bridges.*

- Watercourse crossings primarily use precast concrete. This is because uncured concrete or grout can kill fish by altering water pH and by releasing salts and metals during the curing process.
- If it is necessary to use cast-in-place concrete or grout, isolate it from any water that could enter the stream for a minimum of 48 hours. Also, if riprap is being used, carefully consider the type of rock. Certain rock can generate acids and heavy metals over time.
- Ensure that piers are installed deep enough into the streambed that they cannot be undermined by erosion.

MULTISPAN BRIDGE

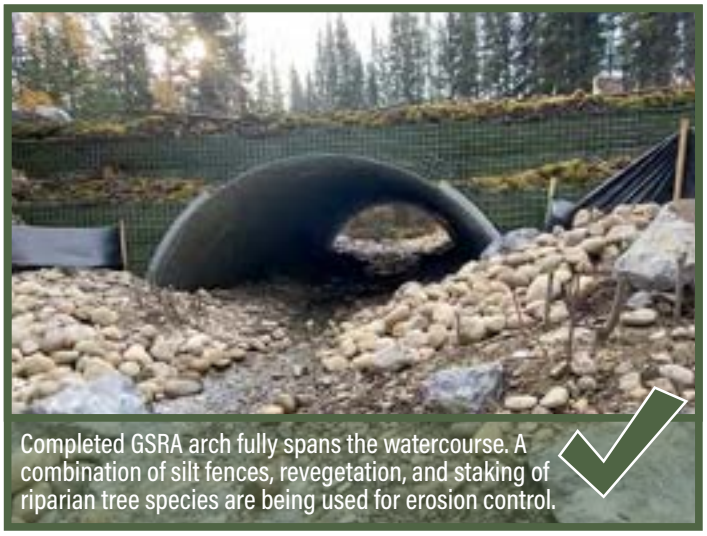


Key References

- Alberta Transportation. 2020. Standard Specifications for Bridge Construction. Edition 17.

FACTSHEET:
ARCHES

- \+ Do not restrict fish passage
- \+ Less long-term maintenance costs than bridges
- \+ Easier site restoration than culverts
- – Some types can be susceptible to scouring under footings
- – Require an engineered design



Completed GSRA arch fully spans the watercourse. A combination of silt fences, revegetation, and staking of riparian tree species are being used for erosion control.

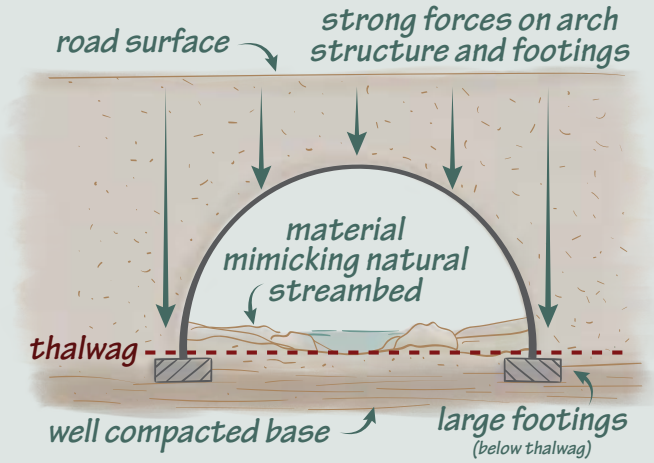
Poorly compacted fill material and failure to properly direct water has led to erosion of the fill material used to cover this arch.

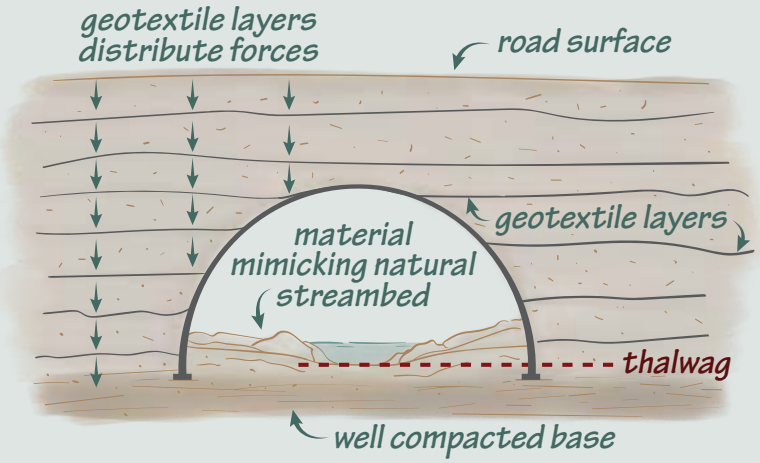
As with all open bottom culverts, arches require a stable bed to prevent sinking. Arches are usually made from steel, high-density plastic, or precast concrete and sit on a footing. The two main types of arches are footed arches and reinforced soil arches (also called GSRAs). GSRAs are designed to reduce the concentration of weight at the base of the arch so that less force is applied to the footing. They disperse the load by using layers of geotextiles within the fill material and wire end-walls. Unlike footed arches, GSRAs usually perform well on less heavily engineered footings such as a well-compacted soil base. Reinforced soil arches are usually more cost-effective and less prone to scouring.

FOOTED ARCHES VS *REINFORCED SOIL ARCHES*

- *Large concentration of weight on arch*
- *Heavily engineered footers are required to prevent sinking or scouring*
- *Footers can be difficult to construct properly*

- *Concentration of weight is dispersed on geotextiles*
- *A simpler footer design (like a well-compacted soil base) is sufficient to prevent sinking or scouring*
- *Compaction levels must meet a defined standard*





Sizing considerations

Both the width and length are important considerations when determining appropriate arch size. A wide enough arch is important to prevent constriction of the watercourse channel, which can increase water flow. Particularly for arches with certain footing designs, a substantial increase in water flow can scour the bed and undermine the structure. In addition, the maximum water velocity through the arch (design flow) should not exceed what is navigable for the species present. There is no minimum or maximum arch size, but smaller arches are more expensive to install in comparison to other crossing types. Sufficient arch length is important to prevent soils from the road surface from entering the stream. Using shorter arches increases steepness of the banks leading up to the road surface, increasing the potential for erosion. In circumstances where length is limited by site features, headwalls and endwalls may be required to help hold back material.

Installation best practices

- Operate equipment from above the top of the watercourse bank to reduce sedimentation.
- Adhere to the Restricted Activity Period (RAP) for fish and, if possible, time the installation to avoid high flow condition and sensitive periods for fish (spawning or migration).
- Ensure fill material is well compacted around the arch. Consider using geotextiles or other measures on the outside of the arch to prevent fine sediments from eroding along the arch wall.
- Ensure footing designs are continuous. For example, if using a concrete footer, ensure the concrete spans the entire length of the arch wall instead of using intermittently placed blocks. This ensures there are no weak points along the base of the structure where water could erode underneath. Footings should be placed on compacted gravel or a similar base of uniform support and must be buried below the thalwag.
    - Bolting the arch to concrete pads embedded below or at streambed level.
    - Attaching the arch to continuous corrugated pad footings placed on non-erodible, compacted aggregate.
- Mimic the natural characteristics of the streambed within and at the ends of the structure. The material used should allow for fish passage, including areas to rest and hide if necessary.

Key considerations

KEYS TO SUCCESS

- Ensure footings are suitable and installed properly to prevent erosion from occurring under the structure. Place footings on level and flat fills that will not erode (or on bedrock) and bury them below the thalweg.
- For reinforced designs, compaction quality control must be maintained during construction to ensure desired strength.
- If replacing an existing culvert with an open bottom culvert, the streambed must be restored to its natural grade first.
- The new channel streambed should include a variety of particle sizes that mimic the natural watercourse conditions.

WHAT TO AVOID

- If using prefabricated structures, do not drag components into place. To minimize erosion and sedimentation, install using machinery that can safely lift the components.
- Large angular material needs to be added inside the arch to create channel roughness and help fish pass but should also not constrict or widen the natural watercourse to the point where it alters the flow of water.
- Avoid introducing extra sediment to the watercourse by using correctly sized and clean fill that will not be easily moved by the force of the water.

- Armor the inlet end of the arch opening to prevent erosion. The inlet should be initially recessed so that when rock is added, it maintains a consistent gradient with the natural channel and does not impede fish passage.

- If an existing structure is being replaced, mimic the **natural** watercourse conditions and not the conditions created by the existing structure.
- Using an oversized arch can help prevent erosion but must simulate the natural channel width. Over-widening a channel can impede fish passage by reducing water depth.

Site reclamation (Erosion, sediment control, and riparian)

Ensure that any side ditches and road water are not draining directly into the watercourse. Once installation of the structure is complete, do not immediately remove sediment controls until vegetation has begun to establish on the site. Use bioengineering methods, such as transplanted vegetation, to stabilize the area around the arch. Planting native species will ensure recovery happens more quickly. When the structure is being installed, organic matter should be collected and saved so it can be spread across the finished structure. The upper layers of organic material contain seeds and other plant matter that can be used to effectively revegetate the crossing in a natural and cost-effective manner. For more information of bioengineered erosion control methods see the section *Preparing Your Site*.

If an arch needs to be removed from a site, the same erosion and fish protection measures for installation apply to its removal. Return the streambed to its natural state and ensure that no fill materials are left within the high-water mark of the watercourse. Ensure that all non-biodegradable materials have been completely removed from the site and revegetate any exposed soils.

Inspection, monitoring, & maintenance

Regular inspections are vital to long-term success of the structure. It is important to send someone into the field to check on the watercourse crossing immediately before seasonal high-water flows and after major storm events. These regular inspections should continue for a minimum of one year following installation. After this time, less frequent checks can occur. Installations should be checked to ensure they are functioning according to design and to identify any erosion or scouring. Monitoring should also check for ice jacking that can raise footings over time. Permanent marker stakes should be installed at each end of the arch to prevent damage from road maintenance equipment.

Note that arch longevity and maintenance requirements will be dependent on the initial suitability of the site. Avoid installing arches in areas that are prone to ice flows or areas with many groundwater seeps. In winter, groundwater seeps can cause ice buildup that can damage the structure over time.

Installation of an arch showing steel footers that run the full length of the arch walls. The footers are supported by a well-compacted base.

Key References

- New Brunswick Department of Environment and Local Government. 2021. Watercourse Alteration Certification Manual, Fredericton, NB.
- Allan Bradley, Francis Bober, Clayton Gillies. 2021. Small Stream Crossings: A Review and Comparison of Available Technologies.

FACTSHEET: NATIVE TIMBER BRIDGES

- \+ Do not restrict fish passage
- – Require access to large logs on site
- – Require regular monitoring to detect wood rot
- – Require equipment operators with knowledge of log cribs

Mid-construction: a geotextile layer and soil cap will be added to finish the crossing.

No geotextile was wrapped around the upper brow logs and sediment is falling directly into the watercourse.

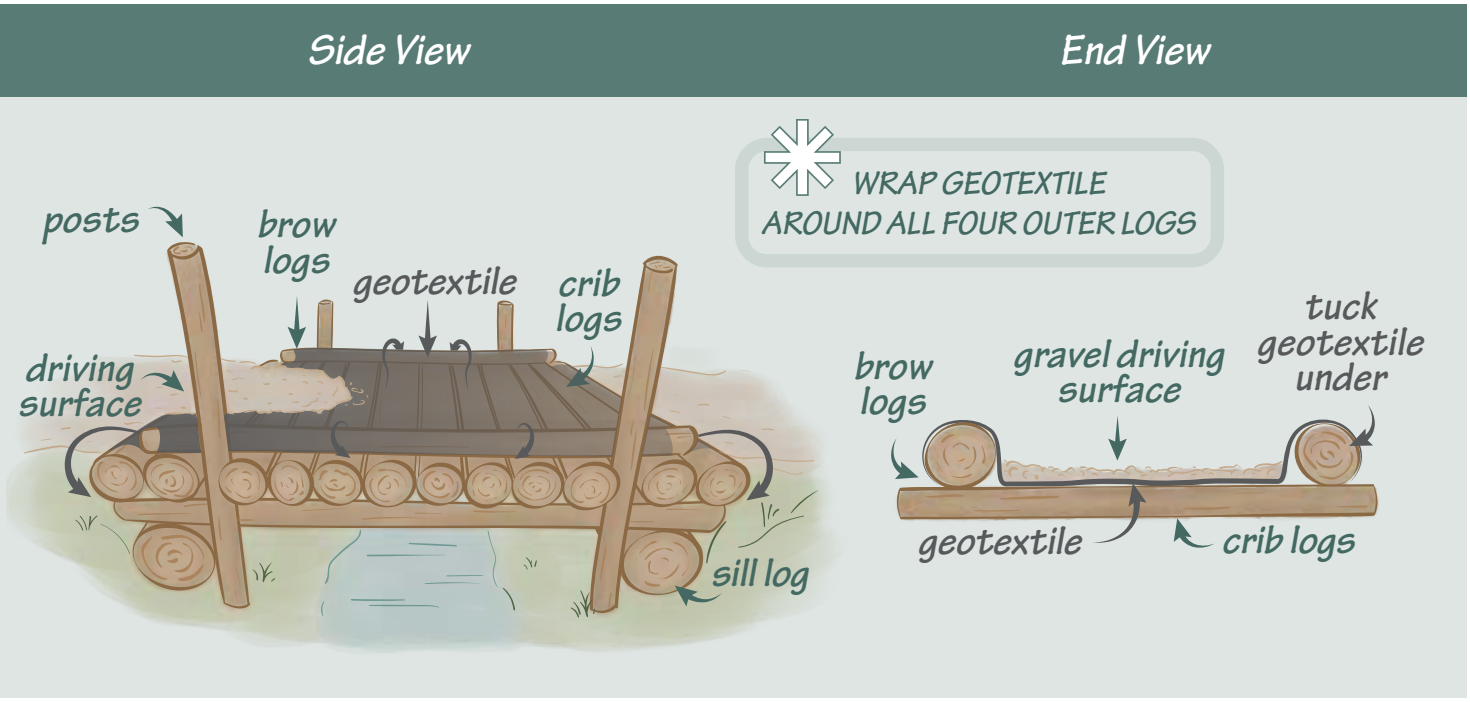
Sizing considerations

The size of a native timber bridge is dependent on the size of the logs available. Larger and longer logs will be able to create a larger structure. Provided the right material is readily available, the crossing can be easily customized to fit the individual site. Obtaining large sill logs or creating log cribbing may be required to match the required flow capacity and to maintain the correct watercourse profile.

Installation best practices

- Native timber bridges are often used as temporary crossing structures and should not be used for more then three years unless they have been designed to last longer and are resistant to decay.
- Since the structure is created onsite from readily available materials, a competent and knowledgeable equipment operator is necessary.
- Design the crossing with the desired load rating in mind. The log diameter needed for the stringers will depend on the size of vehicles expected to use the crossing, the depth of road fill, species of tree used, and how far the logs span.

Many of the best management practices for clearspan bridges also apply to native timber bridges.



Key considerations

KEYS TO SUCCESS

- Place sill logs so they preserve the natural watercourse width. All logs and corners posts should be outside of the high water marks.
- Choose similar sized stringer logs.
- If road material is being placed on the crossing surface it is vital to prevent it from entering the watercourse. Add brow logs to the edges of the crossing and use a geotextile fabric to fully cover the stringer/decking logs.
- At sites with soft substrates, timber footings may need to be used to prevent the sill logs from sinking. Timber footings are shorter logs (1–6 meters) placed at right angles under the sill logs. Ensure the timber footings are placed below the lowest point of the watercourse (thalweg) to prevent erosion from undermining them.
- Use logs slightly larger than what is necessary to account for any unnoticed flaws and natural variation in wood strength.

WHAT TO AVOID

- Ensure sill logs are not within the scour zone of the watercourse.
- Avoid adding too much road surface material to the top of the crossing surface. Thick fills make repairs difficult and increase the risk of sedimentation.
- Hardwood tree species rot quickly and should not be used unless creating a temporary crossing. If available, choose tree species that are resistant to rot.
- Avoid using overly twisted or crooked logs.
- Ensure surface material does not exceed the height of the brow logs.

Site reclamation (Erosion, sediment control, and riparian)

native timber bridges have variable lifespans that depend on the materials used and the environmental conditions. They should be created with repair or removal in mind. When removed, all fill material and logs should be placed above the highwater mark. Sometimes the logs—particularly timber footings—can become embedded into the bank over time. It is important to consider how their removal will affect bank stability and to plan accordingly. In some situations, removing an overly embedded log can create more damage and erosion than leaving it in place.

Inspection, monitoring, & maintenance

- Seed any exposed soils as soon as the crossing is installed and monitor to ensure they are properly revegetated.
- Monitor the structure regularly to ensure the logs are not rotting and that road material is not being deposited into the watercourse.
- Promptly replace any logs that show signs of decay.

This crossing was not built correctly. Corner posts have been installed within the high-water mark which has reduced the channel area for streamflow to pass through.

Key References

- Allan Bradley, Francis Bober, Clayton Gillies. 2021. Small Stream Crossings: A Review and Comparison of Available Technologies.
- Government of British Columbia. 2023. FOR Engineering Manual. Online resource. https://www2.gov.bc.ca/gov/content/industry/natural-resource-use/resource-roads/engineering-publications-permits/engineering-manual/road-survey-design/culvert-design/log-culvert-design. BC Ministry of Forests, Lands and Natural Resource Operations, Victoria, BC.

FACTSHEET: EMBEDDED CULVERTS

- \+ Not as prone to erosion beneath the structure
- \+ Can mimic natural stream conditions and water flow
- – Can be prone to fish passage issues
- – More easily blocked by debris or beavers

Mechanical compaction of material both around and within the culvert. Culvert has been upsized to accommodate the material inside.

An improperly embedded culvert that does represent the natural stream substrate. Only ~ 10% is embedded and there is an absence of larger stream bed material.

Embedded culverts are superior to formerly conventional, non-embedded culverts because they re-create the natural streambed. Embedded culverts are typically circular but can also use a pipe arch or boxed culvert shape. A pipe arch culvert shape can be beneficial as their increased width reduces restriction of the natural watercourse width and its lower height helps reduce the amount of road fill required to bury the crossing. Embedded culverts are becoming the new standard for culvert installation as they greatly reduce the risk of impeding fish passage when installed correctly.

The key objective of embedded culverts is to permit fish passage by mimicking natural conditions. To accomplish this, the natural velocity of the watercourse needs to be maintained (neither increased nor decreased as it passes through the structure). Maintaining a natural velocity permits natural sediment flow through the culvert. The key considerations for maintaining a natural velocity, sediment flow, and fish passage include:

- The velocity in the culvert matches the surrounding watercourse through a calculation of slope, size, and roughness.
- Sediment flow through the culvert matches the surrounding watercourse by maintaining a consistent roughness (distribution of material within the culvert).

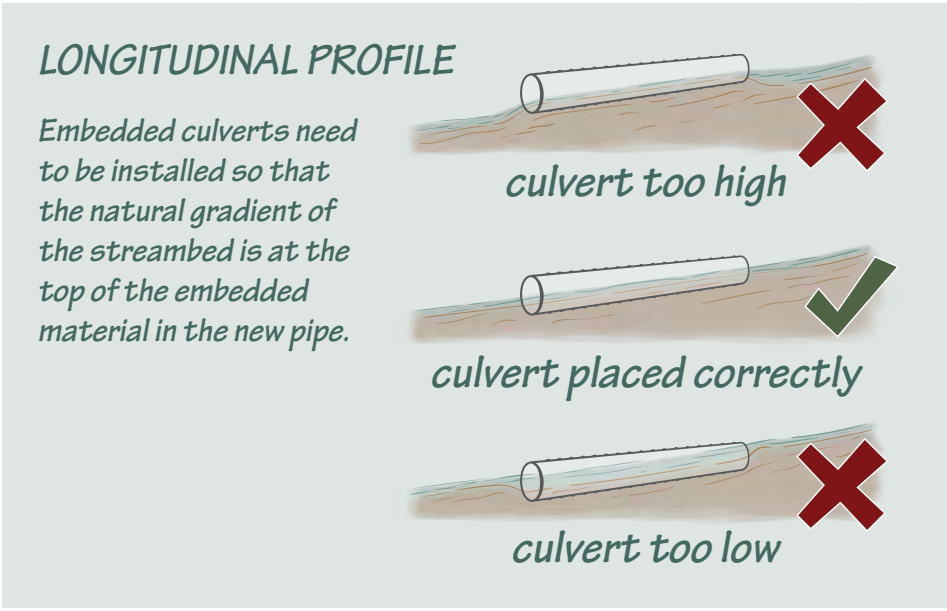
Be aware that provincial and federal legislation and policy could affect the selection of the watercourse crossing structure type depending on the location of your project.

Sizing considerations

Diameter: Select a culvert that is large enough to accommodate the full width of the watercourse channel and can manage high flow events. Sizing must consider that the culvert will be partially filled with sediment. Sediments should fill between 15% and 30% of the culvert diameter.It is recommended to embed all but very small culvert installations. Placing material inside any culvert smaller than 1500 mm can be difficult. Upsizing the culvert is the simplest solution but otherwise material can be easier to add if shorter sections of culvert are filled sequentially and assembled in place. Others have had success pulling a tray of fill material through the pipe using an ATV winch.

Length: The culvert needs to be long enough that the inlet and the outlet do not become blocked over time by the encroachment of fill materials from the road. At sites where the length is limited by valley shape, a shorter crossing can be used along with a steel headwall. Headwalls will hold back the road fill or ditch grade material and prevent encroachment. Factors used to determine the appropriate culvert length include:

- Fill depth
- Angle of the culvert in relation to the road
- Culvert gradient
- Road width

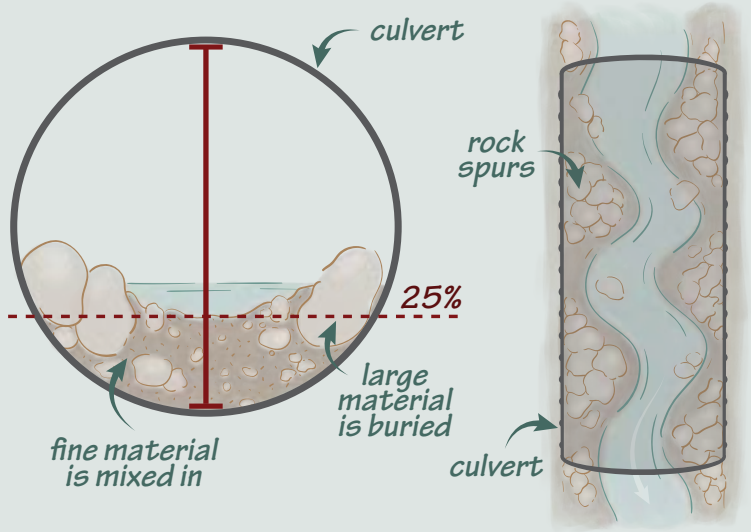


Steep sloped channels

For culverts installed at slopes greater than 3%, larger material should be mixed into the substrate within the culvert to help anchor it in place. The large materials should be placed so they are partially buried in the streambed and interlocked. Proper placement will create areas where fish can rest, help hold substrate inside the culvert, and simulate the natural watercourse conditions. The larger natural material can also be used to create an in-stream riffle (also called a constructed riffle/grade control riffle/Newberry riffle/designed cross vane) approximately 1.5–2 channel widths downstream of the culvert outlet to prevent the formation of a plunge pool.

Installation best practices

- Install the culvert at the same slope as the natural streambed. Steep gradients should be avoided as this can result in accelerated water velocities within the crossing.
- Avoid letting side slope and backfill material enter the culvert or flow channel.
- Substrate within the culvert should match the surrounding watercourse and cover the full length of the culvert.
- Minimize the disturbance footprint and revegetate areas to provide erosion protection. Riprap can be used at the inlet and outlet to protect the installation and maintain long-term integrity.
- Do not store materials or equipment on the riparian vegetation during installation.
- The vertical placement of the culvert in relation to the longitudinal profile of the watercourse is important. Designers should assess the natural stream profile (100 m upstream and 100 m downstream of the crossing) and match the crossing to this profile.
- The depth of water in the pipe above the substrate should be similar to water depth upstream and downstream of the culvert
- Properly compact backfill material to ensure the structure can support the required live and static loads over time without deforming. Geotextiles or other measures can be used to help prevent erosion of the fill material that can occur along the pipe length.
- Adhere to the restricted activity periods when possible. Avoid installing during spawning and other critical periods in the fish life cycle.
- Add additional larger material to anchor the substrate, prevent scour, and to assist fish passage. Note the material size chosen will affect water velocity through the culvert.



Features:

- *Larger material is buried within the fill material*
- *A variety of fill sizes including fine material*
- *Culvert is filled between 15% and 30%*
- *High channel roughness coefficient throughout the crossing*
- *Large material placed in clumps to provide cover, slow water, and mimic natural features*

Key considerations

KEYS TO SUCCESS

- Accurately replicate the streambed within the culvert. If replacing an existing structure, model the natural streambed and not the artificial conditions created by the existing structure.
- Mechanically compact backfill adjacent to and within the culvert.
- Use a range of substrate sizes to ensure the streambed is sealed. Finer substrate materials can be washed into the larger material after it is placed to seal the artificial streambed. When washing in material, be sure to set up sedimentation protection measures to recapture sediment at the outlet of the pipe before it enters the watercourse.
- A clay cap should be used to create a seal underneath and around the structure.
- Create a V-notch in riprap materials to ensure fish passage in low flow conditions.
- For culverts with >1% slope, ensure large rock or other structures are in place to hold sediment within the culvert over time and avoid washouts.

WHAT TO AVOID

- Do not install an embedded culvert in the bend of a watercourse as this can create bank erosion and debris issues.
- Do not use this strategy at sites with very thin streambed layers. The streambed layers need to be thick enough above bedrock to embed the culvert.
- Do not "embed" a culvert that has already been installed by adding material to it. Embedded culverts need to be sized up and installed deeper to function properly.
- Do not fill the culvert with only large material. This creates a condition where water flows through the fill material instead of over, decreasing the depth of water in the culvert and limiting fish passage.
- Avoid erosion at higher watercourse gradients by using larger material sizes.
- Ensure there are no barriers to fish passage at the inlet or outlet of the culvert.
- Ensure culvert is sized properly so that natural water velocities and bed materials are maintained.

Site reclamation (Erosion, sediment control, and riparian)

Ensure that any side ditches and road water are not draining directly into the watercourse. Revegetate exposed soils as soon as possible after disturbance to prevent erosion. If an embedded culvert needs to be removed, all erosion and sedimentation measures required during installation are applicable to the removal.

Inspection, monitoring, & maintenance

Monitor the installation periodically to ensure it is functioning following construction. Conduct inspections before seasonal high-water flows and following any major storm event. When monitoring, ensure there is no built-up sediment upstream. Embedded culverts are resistant to scouring at the outlet but should still be monitored for any changes. Check the substrate within the culvert. If it has moved, add additional large material placed in an interlocking manner so that pieces downstream prevent the movement of pieces upstream. Check for plugging of the culvert from upstream debris and remove if necessary. Permanent marker stakes should be installed at each end of the embedded culvert to prevent damage from road maintenance equipment.

Erosion and sediment control measures are critical when installing culverts. Refer to the Environmental Protection Plan and Sediment and Erosion Control section of the guidebook.

An embedded culvert outlet that has been appropriately armored with large rocks to prevent erosion.

A culvert (not embedded) that was not adequately protected at the outlet. High flows have extensively eroded the crossing, causing severe issues.

Key References

- Allan Bradley, Francis Bober, Clayton Gillies. 2021. Small Stream Crossings: A Review and Comparison of Available Technologies.
- Fisheries and Oceans Canada. 2016. Guidelines for Watercourse Crossings in Quebec. Ottawa, ON.

FACT SHEET:

FORDS

- Critical review is required if used in fish-bearing streams
- High risk of watercourse contamination
- Not appropriate for many situations
- Only suitable for sites where limited use is expected

A properly constructed ford crossing using a rock substrate. Water still flows over the crossing, allowing fish passage.

A ford installation that was removed but not reclaimed properly. It has now become a source of sediment to the watercourse.

Installing a permanent ford structure is not the same as the act of fording (crossing with no watercourse structure installed) and should not be confused. For more information on fording see page 53.

Sizing considerations

Fords are uncommonly used crossings that are only applicable for shallow watercourses where very low traffic levels are expected. A ford should only be used at sites with very shallow water and should always be approved by an appropriate practitioner before use. In addition, the maximum width of a ford should not exceed 1.5 times the width of the equipment crossing it. Fords cannot be installed on watercourses wider than five meters (between ordinary high-water marks).

Installation best practices

- Choose the ford location carefully. A good location has low bank slopes on the approaches and a rocky or firm watercourse bottom with no risk of rutting. Do not install a ford at sensitive sites such as fish spawning areas. (Note that fords are generally not appropriate for use in fish-bearing watercourses).
- Install the ford in isolation of the watercourse. Use proper dewatering and fish rescue practices. Otherwise, install the crossing during winter once the watercourse has frozen completely and fish are not present.
- Properly install a driving surface made from rocky fill materials.

Fords are appropriate for sites that have extremely limited use. In very remote areas, installing crossing structures like culverts can pose more risk due to poor accessibility for maintenance. For example, a remote well pad that requires access only 1–2 times per year could be a suitable circumstance for installing a ford.

Key considerations

KEYS TO SUCCESS

- A properly designed ford should protect both the streambed and streambanks from erosion.
- Select sites with stable and non-erodible banks for installation.
- Ensure equipment is clean and decontaminated before installation or use.
- Install signs that explain the ford crossing and include instructions on how to use it properly.

WHAT TO AVOID

- Do not drag anything behind the vehicle or equipment that could destroy the surface of the ford.
- Ensure that vehicles are not leaking fuel, hydraulic fluids, lubricating oil, or cargo before they use the ford.
- Do not impede fish passage. Only install driving surfaces that can be navigated by fish at low flows.
- Ensure the ford will not redirect water onto the road during high flows.

Site reclamation (Erosion, sediment control, and riparian)

Restore the site as close as possible to its original condition. Decommission the approaches in a way that prevents access for vehicular traffic and minimizes erosion and sedimentation. Any material used on the approaches, banks, or streambeds that could cause future environmental problems needs to be removed from the site and disposed of safely. Ensure any removal of material is done promptly and in a manner that does not release sediment into the stream. Seed with native species and stake with native riparian plants.

Inspection, monitoring, & maintenance

Revisit the site to ensure natural vegetation is reclaiming the areas where the approaches were situated. Replant if vegetation is not occurring. This is a critical step for minimizing sedimentation and erosion and promoting long-term site recovery.

How do fords impact fish?

- *Can damage spawning areas*
- *Fish can be crushed as the ford is being used*
- *Changes to the streambed and stream banks can create low flow risk*
- *Can be sources of sediment if not well designed*

Installation of a ford surface shown while the watercourse is still frozen. Banks have been staked to promote spring revegetation. An erosion net protects the bank during construction.

Key References

- B.C. Ministry of Forests, Lands, and Natural Resource Operations, B.C. Ministry of Environment, and Fisheries and Oceans Canada. 2012. Fish-stream crossing guidebook. Victoria, BC.

Other techniques

Multiple culverts

To accommodate fish passage, it is always preferable to install a single culvert or a bridge rather than multiple culverts. When multiple culverts are installed, the watercourse crossing site is prone to obstruction by debris, sedimentation, and scouring, making it more difficult to ensure fish passage. It is not advisable to embed double culverts (adding material within the culvert to simulate the streambed) unless the watercourse naturally divides into two. Multiple culverts are compatible with baffles but will require thorough and complex design calculations. Multiple culvert designs should never include more than two culverts. They must be placed a minimum of 1 meter (3 feet) or half the culvert diameter apart, whichever is larger. This spacing ensures a mechanical compactor can fit between the culverts to properly pack down the fill.

The first culvert must be placed in the thalweg of the channel with both ends embedded below the thalweg of the nearest upstream or downstream riffles. The second culvert must be placed at least 150 mm (6 inches) higher than the nearest natural watercourse riffles. These measures ensure all the water flows through a single culvert during low flow conditions since dividing the flow between the culverts can result in water depths too low for fish passage.

Improper installation of multiple culverts:

- *Too many culverts used*
- *Culverts were placed too close for proper compaction between them*
- *Scouring has resulted in severe fish passage issues*

Other closed bottom culverts

Different types of closed bottom culverts exist, including the simple circular culvert which is the most used watercourse crossing structure. Simple circular culverts are not recommended for watercourses with fish as they are prone to fish passage issues. If a closed bottom culvert is the only economically feasible option, it is vital to ensure fish passage is not obstructed. Adding baffles or embedding the culvert are two ways to help improve fish passage in closed bottom culverts. Note that it becomes more difficult to ensure proper fish passage in closed culverts as the slope of the watercourse increases. Closed-bottom culverts are only installed without fish passage provisions (i.e., baffles) when the watercourse slope is <0.5%.

A baffle in a culvert. The center notch helps ensure fish passage is not impeded.

Baffles

Baffles can be used in a large variety of structures and are found in circular, pipe-arch, box, and open culverts. Baffled culvert design must consider fish species and size, the surrounding hydrology, and slope and longitudinal profile of the watercourse. Adding baffles reduces the flow area of the culvert and needs to be considered when calculating the culvert size. The purpose of baffles is to increase the roughness of the channel which helps promote fish passage. It is now considered best practice to use natural rocky material to achieve the roughness

(embedding the culvert). Natural material is preferred over baffles because it requires less engineering, better preserves natural fish habitat, and allows for natural watercourse processes to continue.

Key References

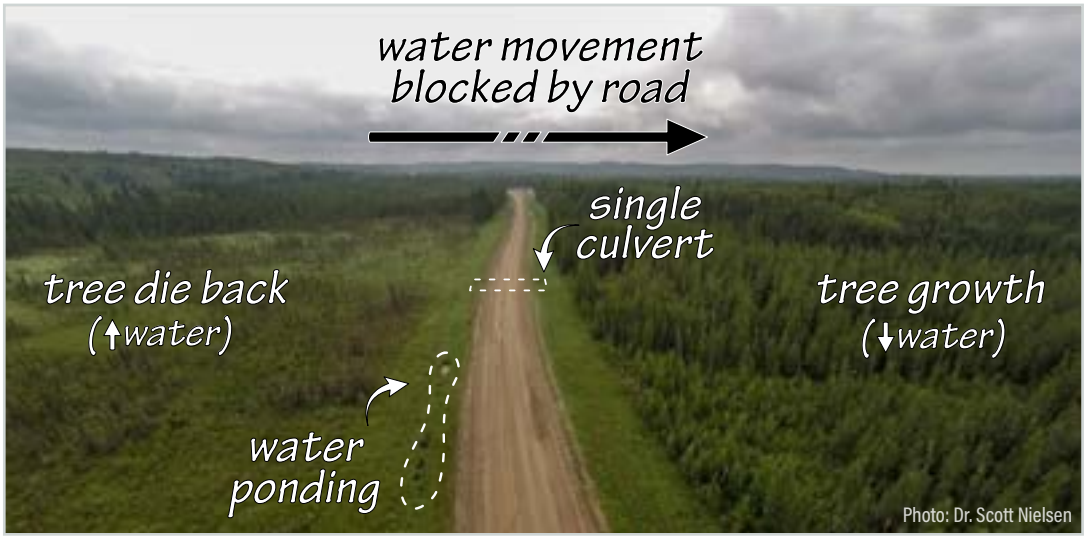
- Government of Alberta. 2019. Alberta Government Code of Practice for Watercourse Crossings. Water Act and the Water (Ministerial) Regulation. Edmonton, AB.
- Allan Bradley, Francis Bober, Clayton Gillies. 2021. Small Stream Crossings: A Review and Comparison of Available Technologies.
- Fisheries and Oceans Canada. 2016. Guidelines for Watercourse Crossings in Quebec. Ottawa, ON.
- New Brunswick Natural Resources Forest Management Branch. 2004. Guidelines for Roads and Watercourse Crossings. Fredericton, NB.

7. Wetland watercourse crossings

Installation, replacement, and restoration best practices

Resource roads and watercourse crossings within wetlands present unique planning, installation, and maintenance challenges. The organic soils and high soil moisture content that naturally occur in wetlands can contribute to saturated roads, rapid roadbed settlement, and road surface water ponding. These conditions can lead to seasonally restricted road use, low-functioning wetland crossing structures, and high maintenance and repair costs, and can ultimately result in roads that are unable to support vehicle loads. These negative transport outcomes are in addition to the potential damage to wetland water flow, fish habitat, and aquatic wildlife populations.

A common example of the environmental impacts of roads on wetlands occurs when water accumulates on one side of a road while a wetland dries up on the other side as a direct result of reduced water flow from the road damming the wetland. Applying BMPs can greatly reduce environmental impacts and ensure proper performance of resource roads and wetland crossings.



A road constructed through a wetland has created a barrier to water movement. Water ponding and tree die back is occurring on one side (left) of the road and accelerated tree growth is occurring on the drier side (right).

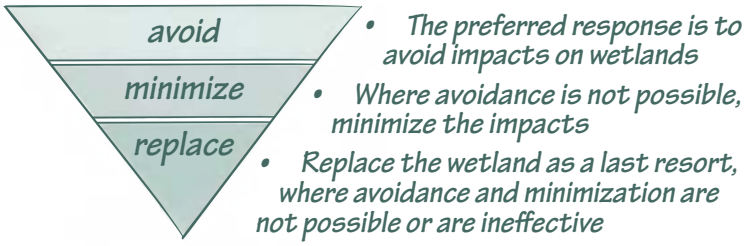
To assist with planning your wetland crossing, please see the Planning for a Watercourse Crossing within a Wetland section of this guidebook. For more prescriptive guidance, see Ducks Unlimited Canada and FPInnovations for eight planning, construction and maintenance steps for building a resource road across a wetland[42].

Knowing your wetlands: Classification and identification

Wetlands in Alberta are diverse, and wetland characteristics vary within and across the natural subregions. It is important to be aware of the wetland types common to the area where you work, how to tell them apart, and the unique hydrological characteristics of each wetland type. Also, be aware that plans to build roads through a wetland

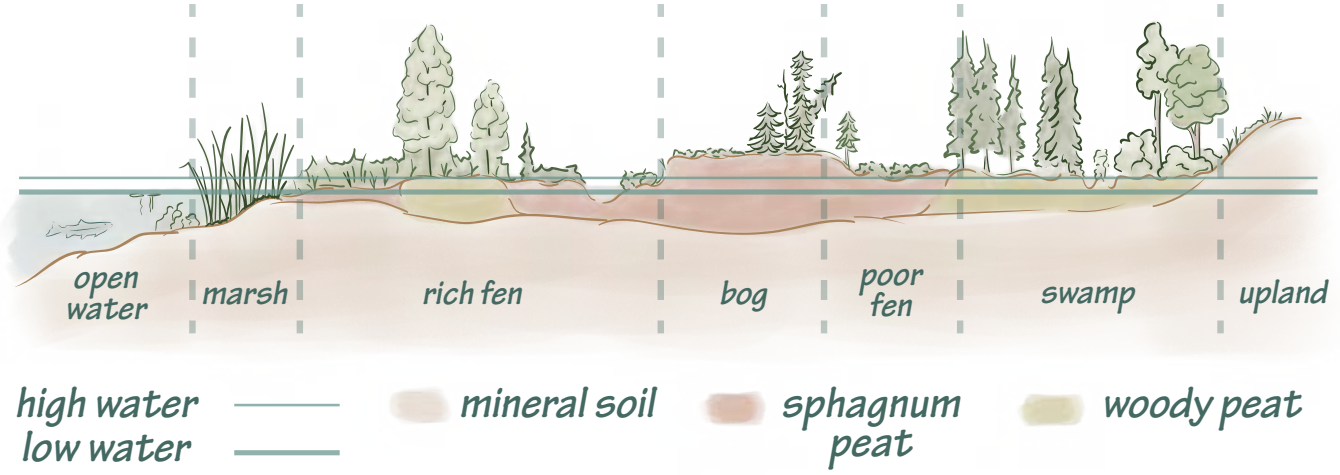
42 Partington M, Gillies C, Gingras B, Smith C, Morisette J. 2016. resource roads and wetlands: A Guide for Planning, Construction and Maintenance.

are likely subject to the Alberta Wetland Policy[43], which supports the conservation, restoration, protection, and management of Alberta's wetlands. Seek understanding to determine if your proposed project is subject to the permitting and regulatory requirements associated with this policy.



Knowing the wetland type you are working in for your crossing and the unique water flow and peat-bearing capacity characteristics of that wetland are key to the long-term effectiveness of a wetland crossing and to minimizing impacts on wetland health. An Authenticating Wetland Professional should be consulted to help in assessing the wetland type and informing appropriate steps.

There are various types of wetlands across Alberta. Assessing wetland types is a complex task and requires an Authenticating Wetland Professional qualified to aid in classification and assessment of implications for the crossing design.



Maintain wetland water flow and fish habitat

Operators can maximize the likelihood that wetland crossings and aquatic habitat will function as anticipated through careful planning, knowledge of the wetland classes, understanding the flow characteristics of each wetland type, and the needs of local fish species. Hiring an Authenticating Wetland Professional is a key component of this.

Wetlands take many forms that can vary over time. They can be interconnected over large areas or isolated from the surrounding environment. Water table levels and flow patterns within a wetland can fluctuate and change throughout the year. Additionally, not all wetlands appear wet year-round and can sometimes be misidentified.

When planning for a crossing structure in a wetland, obtain guidance from an Authenticating Wetland Professional to perform a wetland assessment, and determine if fish and fish habitat are present in the wetland. This specialist can also identify other installation planning risks and appropriate mitigation options.

Key References

- To learn more about wetland identification, classification and hydrology see Ducks Unlimited Canada (2021)[3].
- For more detailed information on planning and construction of resource roads and crossing structures on wetlands see Okso et al. (2018)[4] and Partington et al. (2016)1.

43 Government of Alberta. 2013. The Wetland Policy. Alberta. https://open.alberta.ca/dataset/5250f98b-2e1e-43e7-947f-62c14747e3b3/resource/43677a60-3503-4509-acfd-6918e8b8ec0a/download/6249018-2013-alberta-wetland-policy-2013-09.pdf

Wetland watercourse crossings

Responsible management of wetland water resources is linked to the choices of road placement, watercourse crossing location, and crossing structure. Constructing ditches alongside the road should be avoided as they can intercept flow, lower the water table, and lead to effects such as peat settlement. Wetland crossing structures that are able to maintain fish passage and natural water flow from one side of the road to the other should be considered. Key advantages and disadvantages of common wetland crossing structures include:

▪ *WETLAND CULVERTS*

ADVANTAGES

- One of the most effective wetland crossings for maintaining water flow when installed correctly
- Provide opportunities for fish passage

DISADVANTAGES

- Use manufactured materials that require removal and disposal at the end of the project
- Can freeze over in the winter and flood roads in the spring until they thaw

▪ *WETLAND LOG BUNDLES*

ADVANTAGES

- Use locally available products
- Less attractive to beavers
- Low maintenance requirements

DISADVANTAGES

- Logs do not have uniform properties like manufactured products
- Do not allow fish passage unless used with a pipe or culvert

▪ *WETLAND ROCK DRAINS*

ADVANTAGES

- Not affected by blockages from beavers or icing
- Effective in flow channels or road sections where high flow requirements are anticipated

DISADVANTAGES

- No fish passage unless used with a pipe or culvert
- Suitable rock sizes may be hard to source

FACTSHEET: WETLAND CULVERTS

+ One of the most effective crossing structures for maintaining water flow and fish passage
− Use manufactured materials that require removal and disposal at the end of the project
− Can freeze over in the winter and flood roads in the spring

Although difficult to see due to vegetation regrowth, this culvert was appropriately installed for the wetland setting.

Photo: GOA

Two old wetland culverts that have not been maintained and need replacement.

Sizing considerations

To maximize the effectiveness of wetland culverts, careful consideration of culvert sizing and spacing is required. The key factors that inform culvert spacing on a wetland road are:

- Wetland type
- Wetland flow characteristics
- Road permanence

Some wetlands have significant water flow, and need multiple culverts to ensure the water can flow effectively. Culverts spaced at regular or irregular intervals along roadways can reduce impacts on the wetland. Reliance on a single culvert over large stretches of road can create a barrier to water movement and leaves no contingency for water flow if the culvert is plugged. This may concentrate drainage and flow, causing channelization of the wetland.

	stagnant ↓ *WIDELY SPACED*	*slow lateral flow* ↓ *MID – SPACED*	*seasonally fluctuating* ↓ *CLOSELY SPACED*
maximum culvert spacing (permanent road)	*200 m*	*150 m*	*100 m*
maximum culvert spacing (temporary road)	*250 m*	*200 m*	*150 m*
culvert diameter	*250 – 500 mm*	*500 – 800 mm*	*> 800 mm*

Topography will inform culvert placement. At a minimum, culverts should be placed at elevation low points and where LiDAR, maps, and field observations identify obvious flow channels. However, experience has shown that relying on low points alone may not be enough to ensure proper water flow. Consider wetland hydraulic connectivity and precipitation models to determine the placement and frequency of culverts on a road. FPInnnovations and Ducks Unlimited Canada provide advice on proper culvert spacing and sizing based on road permanence and wetland type (see table).

Installation best practices

- **More is better:** Placement of culverts, or culvert sets, at higher density routinely improves road integrity and reduces environmental impacts by improving water flow from one side of the road to the other, especially for permanent roads.
- **Planning for wetland complexity**: The direction of wetland flow is not always predictable and wetland flow direction can change within a wetland over short distances. One option is to decrease culvert spacing. This will increase construction costs but reduce long-term maintenance costs associated with the road base becoming saturated and degraded.
- **Culvert foundation planning:** More stable culvert foundations and improved culvert operation can be achieved by adjusting the construction sequence to enable peat consolidation before the culverts are placed. This is particularly important when building floating roads over deep peat wetlands. Creative solutions such as using piles to support culverts, or culvert pyramids have also been used in some areas of Alberta's boreal region.
- **Culvert material selection:** Solid steel pipes increase culvert consistency, installation efficiency, and reliability relative to plastic and corrugated steel pipe culverts.

Peat naturally consolidates over time due to the weight of the road, providing unique challenges for culvert performance in wetlands, including the loss of any potential fish passage structure benefits. Peat consolidation graphs are a tool that can be used to estimate the amount and rate of settlement relative to road type and use. When possible, installing culverts AFTER this settlement occurs can significantly improve the long-term culvert function, as long as water flow is not severely interrupted during the settlement period.

Key considerations

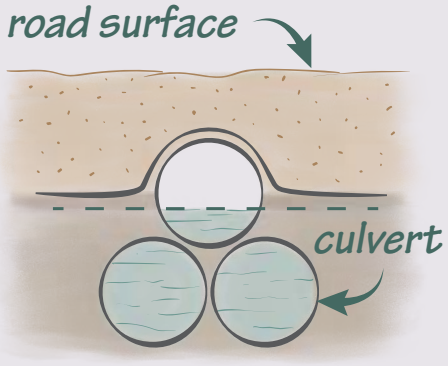
KEYS TO SUCCESS

- Be sure to consider both the surface and subsurface water flow when designing a wetland crossing structure.
- Conduct desktop planning exercises, using tools such as wetland maps, with a multidisciplinary team of planners, operators, and a Qualified Wetland Science Practitioner (QWSP) to identify and address wetland flow requirements and inform culvert sizing and spacing.
- Maximize water flow by designing road crossings beyond the defined flow channels and including more opportunities for water movement beneath a road.
- Leverage combinations of strategies where wetland health and fish passage are priorities.

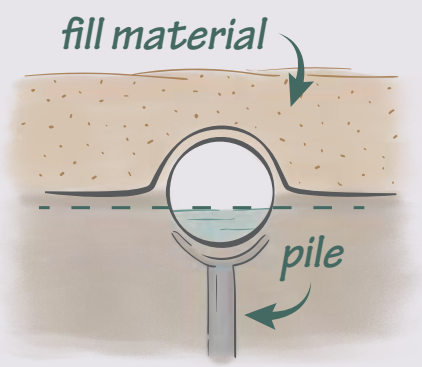
WHAT TO AVOID

- Avoid installing too few culverts. Reliance on a single culvert for a large stretch (>300 m) of road over a wetland can result in ponded water along the road, wetland channelization, and localized road settlement.
- Ensure that bowing or failures of the crossing structure does not occur during road settlement. Culvert deformation can occur with plastic and corrugated steel pipes. Solid steel pipes have more strength to resist bowing but can be more difficult to find in larger diameters (above 762 mm).
- Culverts that settle below design elevations. Consider installing after the peat has settled (after road seasoning).

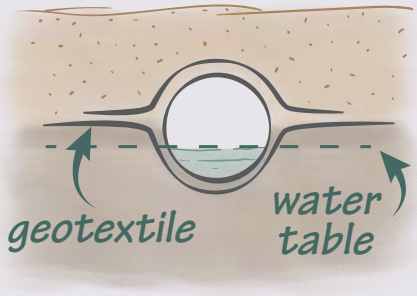
CULVERT PYRAMIDS



CULVERT ON PILE



CULVERT INSTALLED AFTER ROAD SEASONING



adapted from Osko et al. (2018)

Site reclamation (Erosion, sediment control, and riparian)

During and immediately after culvert installation or removal, it is important to manage erosion and prevent sediments from entering the wetland. Ensure materials are removed promptly and in a manner that minimizes sediment production. Encourage natural revegetation establishment around the culvert structure after installation or removal to minimize erosion and prevent sedimentation.

During road and crossing structure decommissioning, practitioners should be aware of, and plan for, wetland decompression and rebounding where it could affect downstream water flows. A revegetation strategy may include natural regeneration from the soil seed bank or seed rain (i.e., spread of seeds from nearby plants), planted seedlings, willow cuttings, the moss layer transfer method, or a combination of these strategies.

Inspection, monitoring, & maintenance

Monitoring should include routine inspection of culvert performance, especially in spring and after major precipitation events. Inspections should include observations of any difference in water elevation on either side of the crossing, uneven water ponding, and ecosystem drying adjacent to the road. Inspections should also look for blocked and sunken culverts and develop appropriate mitigation or repair strategies if identified.

If there is a need for routine culvert maintenance, be sure to consider how activities could affect fish, fish habitat, and wetland health.

Key References:

- Osko T, Gilies C, Pyper M. 2018. COSIA in-situ oil sands shared practices for working in and around wetlands. Edmonton (AB): Canadian Oil Sands Innovation Alliance.
- Partington M, Gillies C, Gingras B, Smith C, Morisette J. 2016. Resource roads and wetlands: A guide for planning, construction and maintenance. Point-Claire, QC: FPInnovations (Special Publication SP-530E).

FACTSHEET: LOG BUNDLES

- \+ Makes use of log products that are locally available
- \+ Less attractive to beavers
- \+ Low maintenance
- – Logs do not have uniform and standardized properties
- – No fish passage unless used with a pipe or culvert

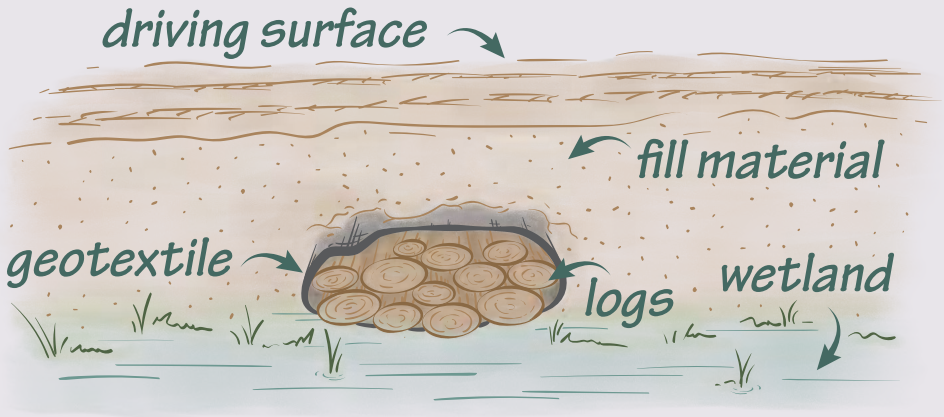
Multiple layers of logs covered with geotextile allow subsurface water to continue to flow in the wetland.

An unsuitable crossing type that is preventing subsurface flow and causing channelization.

Sizing considerations

Log bundles allow surface and subsurface water passage and are considered an alternative to culverts. Log bundle spacing along a road is similar to that for culverts. Structures should be spaced according to road permanence and wetland types. Bundles should be spaced closer together for permanent roads and for wetland types that have more complex flow conditions.

LOG BUNDLE



- *Involves placing a set of long logs below the road surface*
- *Spaces between the logs provide a conduit for water flow*
- *The linear nature of logs and the spaces between the logs can address weight bearing and hydrologic functions*
- *Similar, but not as extensive, as corduroy*

Installation best practices

- Use natural products obtained from close to the project site to reduce the environmental footprint and reduce operational costs.
- Log bundles can be used in combination with other conduits, like culverts, to support fish movement.
- Be sure to leave the log ends open so that water can pass through the structure.

	stagnant ↓ WIDELY SPACED	slow lateral flow ↓ MID – SPACED	seasonally fluctuating ↓ CLOSELY SPACED
maximum spacing (permanent road)	200 m	150 m	100 m
maximum spacing (temporary road)	250 m	200 m	150 m

- Include a separation layer (such as geotextile fabric) to ensure fill material does not occupy the spaces between logs. This ensures water can flow through the structure. A geotextile separation layer can be placed on top of the log structures and is often also installed completely around the logs.

Key considerations

KEYS TO SUCCESS

- A geotextile layer separating the logs and the road base maintains voids between logs, promotes flow through the log bundles, and prevents sediment from being introduced to the waterway.
- In fish-bearing wetlands, log bundles should be accompanied by an adequately sized culvert or pipe to allow fish passage.
- Use log bundles to address flow concerns on existing roads.
- Log bundles should be used as part of a system to manage flow rather than independently.
- Logs should be partially embedded into the wetland soil (peat) to support groundwater movement through the soil.

WHAT TO AVOID

- Erosion and sedimentation at the time of construction.
- Geotextile blocking water from entering at the log ends.
- For permanent roads, avoid using a biodegradable geotextile.

Site reclamation (Erosion, sediment control, and riparian)

Restore the site to be as similar as possible to its original condition to minimize changes in downstream flow regimes and to restore natural fish habitats. In Alberta, many fish live in wetlands and depend on upstream flows to keep their habitat healthy. Thus, it is important to ensure that material removals are done promptly and in a way that minimizes sediment production. Immediate revegetation is an effective strategy for reducing erosion and preventing sedimentation. Adopt a revegetation strategy that is appropriate for site conditions and restoration goals.

Inspection, monitoring, & maintenance

Log bundles have the added benefit of being relatively low maintenance crossing structures. They usually do not attract beavers whose activity can dam conventional and larger openings. Also, submerged logs have little exposure to oxygen which significantly reduces their decay. Regular inspection — at least annually and particularly in the spring — is recommended to ensure that the road is passable to vehicles and that structures are maintaining water flow. Inspect for uneven road settlement, ponded water, erosion, and sedimentation or other blockages at the log ends that could inhibit water flow.

Key References:

- Ducks Unlimited Canada, FPInnovations, Louisiana-Pacific Canada Ltd., Weyerhaeuser Canada, and Spruce Products Ltd. 2014. Operational guide, forest road wetland crossings, learning from field trials in the boreal plains ecozone or Manitoba and Saskatchewan, Canada. V 1.0. Edmonton (AB): National Boreal Program.
- Ducks Unlimited Canada. 2010. Reinventing corduroy roads. https://boreal.ducks.ca/reinventing-corduroy-roads/
- Osko T, Gilies C, Pyper M. 2018. COSIA in-situ oil sands shared practices for working in and around wetlands. Edmonton (AB): Canadian Oil Sands Innovation Alliance.
- Partington M, Gillies C, Gingras B, Smith C, Morisette J. 2016. Resource roads and wetlands: A guide for planning, construction and maintenance. Point-Claire, QC: FPInnovations (Special Publication SP-530E).

FACTSHEET: ROCK DRAINS

- \+ Enables water flow that is characteristic of the specific wetland
- \+ Not affected by blockages from beavers or icing
- \+ Effective for flow channels or for road sections where high flow requirements are anticipated
- – No fish movement unless used with a pipe or culvert

A rock drain built with a culvert. Erosion protection surrounds the crossing until vegetation can grow.

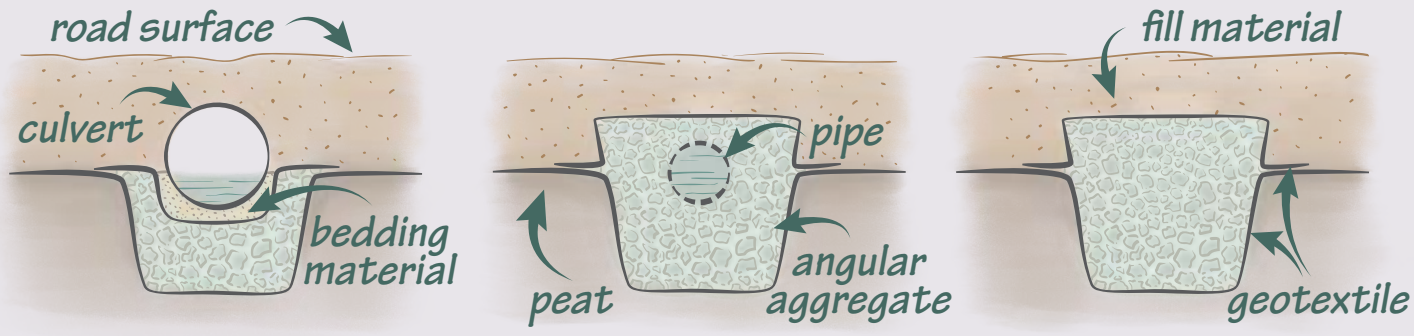
Photo: GOA

A wetland passage created with just soil and no rock to allow for drainage from one side to the other.

Sizing considerations

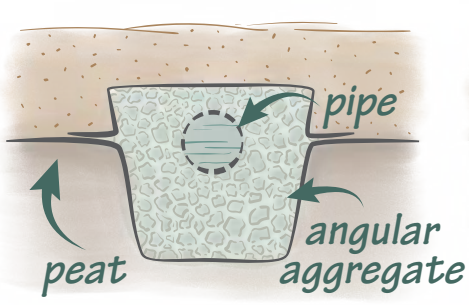
Rock drains are considered a newer practice that have achieved high success in maintaining surface and subsurface flow through wetlands. The factors to consider when designing and planning rock drains are the wetland type, wetland flow capability, road permanence, and soil bearing capacity. Rock drains are versatile and can be installed in most wetland types and flow regimes. The primary sizing consideration involves achieving the correct flow capacity. They can be installed in any of the following ways to promote wetland flow:

- *As a base below culverts*
- *In combination with a 100–150 mm diameter perforated pipe*
- *Wholly comprised as large aggregate*



High Flow Wetlands

For wetlands with high flow requirements, performance can be enhanced with the addition of perforated pipes that can be installed directly through the rock drain. A 150 mm diameter pipe or a smaller diameter perforated pipe with a permeable "sock" type covering is generally sufficient to resist clogging by fine sediment particles. To maximize flow potential and reduce clogging or filling by fine sediments within the rock drain, use Class 1 rock that is 50 mm to 400 mm in size.



Installation best practices

- Perforated pipes installed through the rock drain can provide additional openings for water flow.
- In fish-bearing wetlands, rock drains can be accompanied by a culvert or pipe to allow fish passage. Depending on the water level, a fish culvert may need to be installed above, and in addition to, the rock drain.

"Drain rock" is a type of crushed and screened stone with angular shapes that comes in different particle sizes. This permeable material (also called "gabion rock" when placed in metal cages) is widely used in landscaping and construction projects for drainage and stabilizing shorelines against erosion. Class 1 drain rock ranges from 50 mm to 400 mm and has few fine materials.

GABION CAGES

Key considerations

KEYS TO SUCCESS

- An appropriate rock size is important for maintaining natural flow conditions. Class 1 size is often recommended.
- When necessary, pair the rock drains with culverts to allow for fish passage.

WHAT TO AVOID

- Minimize local roadway settling by ensuring rock drains are spaced close together and in series.
- Avoid using rock that does has low drainage performance. Smaller rock sizes (80 to 125 mm) can impede natural flow conditions in some wetlands.

Site reclamation (Erosion, sediment control, and riparian)

During and immediately after installation, manage erosion and prevent sediments from entering the wetland due to the construction activities. The most effective way to minimize erosion, and prevent sedimentation is to encourage natural vegetation establishment around the rock drain structure.

Restore the site to be as similar as possible to its original condition. Road and crossing structure decommissioning should consider:

- Decompression and rebounding of the wetland soil after road removal.
- Removal of non-biodegradable materials from the wetland area in a way that minimizes sediment production.
- Timing to minimize impacts to wetland and fish populations.

Inspection, monitoring, & maintenance

Monitoring should include routine inspections of rock drain performance, especially in the spring and after major precipitation events. Inspect for localized settlement issues and water ponding on, or adjacent to, the road on only one side. Water flow through the rock drain may be high immediately following construction but is expected to decrease over time to a rate that is typical for wetlands.

If monitoring detects poor water movement, consider adding more rock drain structures or other crossings nearby. If routine maintenance or repairs are required, consider how activities could affect fish, fish habitat, and wetland health and conduct maintenance outside of the wetland and shoreline riparian area if possible.

Key References:

- Osko T, Gilies C, Pyper M. 2018. COSIA in-situ oil sands shared practices for working in and around wetlands. Edmonton (AB): Canadian Oil Sands Innovation Alliance.

8. Crossing removal and restoration

Crossing removals and restoration focus primarily on the resource road end-of-life. Removals and restoration present an opportunity to re-establish the natural watercourse and remove all road infrastructure. This section of the guidebook is focused on key steps to remove a crossing and restore the site, with particular emphasis on how to ensure the physical, biological, and chemical (i.e., water quality) components can support a healthy aquatic environment and provide habitat for fish. Qualified professionals (such as biologists) should be consulted when planning a crossing removal to ensure key outcomes are achieved.

Before ***During*** ***After***

Credit: Michael Short

For crossing replacement, some of the principles discussed here will apply, and readers are also encouraged to review the Watercourse Crossings: Installation, Replacement and Restoration factsheets for more specific guidance on installation BMPs for crossing structure replacement.

Generally, watercourse crossing sites are restored when a temporary road is no longer required. Temporary watercourse crossing structures are removed and the disturbed areas are restored to be as similar to pre-existing natural watercourse and fish habitat conditions as practicable.

What is the difference?

- **Remediation:** The action of reversing environmental damage. For example, if a watercourse crossing is no longer fulfilling the role it was designed for, the watercourse crossing must be improved or a new type of structure installed. This could be due to the crossing no longer allowing fish passage, requiring immediate action.
- **Removal:** The action of uninstalling a watercourse crossing structure and disposing of the materials off-site.
- **Restoration:** The process of recovering an ecosystem that has been degraded, damaged, or destroyed[44].

44 Society for Ecological Restoration. 2021. What is Ecological Restoration? Washington, DC: Society for Ecological Restoration. https://www.ser-rrc.org/what-is-ecological-restoration/

Removal and restoration projects generally fall into one of two categories, instream restoration or out of stream restoration:

Category	Description
Instream restoration	At least part of the crossing structure is located within the watercourse. Typical examples include culverts, pipes, log fills, and multi-span bridges. The crossings need to be removed and areas need to be actively restored to recover natural ecosystem functions (e.g., fish habitat).
Out of stream restoration	Crossings that span over and across the watercourse (e.g., clear-span bridges and arches) and are generally easier and more efficient to remove and restore, relative to instream crossing structures.

Effective watercourse crossing removal and restoration requires a plan to ensure that natural habitat conditions are re-established for fish and other aquatic species. Effective field implementation will ensure successful delivery of the plan. This section first focuses on planning considerations and then highlights key steps to be aware of during field removal and restoration activities. Collaborating with a qualified professional (e.g., biologist or QAES) will help ensure the final restoration meets the needs and requirements of fish and other species.

Planning to achieve successful crossing removals and restoration

In this guide, watercourse restoration is focused on the return of a watercourse ecosystem's structure and function to a state that is more reflective of its pre-disturbance form. This return to pre-disturbance characteristics helps to restore native fish habitat and populations. To achieve this, watercourse restoration activities must plan for the physical, biological and chemical elements that pertain to watercourse ecosystems and aquatic communities. Understanding how native fish respond to their environment across all parts of their lifecycle is vital to constructing and implementing a successful restoration project from a fish conservation perspective.

Physical factors to consider

Physical watercourse elements include the dimensions and gradient of the streambed, water flow regime, types of cover, and streambed material. These physical features play important and variable roles for fish and other aquatic organisms.

Using the adjacent natural watercourse as a reference, it is important to re-establish natural watercourse channel widths, depths, and slopes. Vegetation is another key physical element that should not be overlooked as it provides shade and bank stability. Instream features, such as logs, provide shade and resting and hiding shelter, although any plans for instream features should be approved by an individual with an appropriate professional designation. Restoration of instream channels and substrate, including hiding and resting cover for fish, needs to consider both high and low water flows.

Biological factors to consider

Biological elements to consider in a restoration plan include both terrestrial and aquatic environments. Newly constructed watercourse segments are relatively sterile compared to natural systems; therefore restoration activities

An upstream or downstream section of a stream can be used as reference to inform the physical, biological, and chemical aspects of a watercourse and riparian areas for design and planning purposes.

should focus on re-establishing pre-disturbance environments. As an example, natural vegetation provides stability to watercourse banks and creates hiding cover with undercut banks. Trees in the riparian area are sources of wood recruitment which is a natural process that can increase groundwater downwelling, trap instream sediments, allow for formation of pools and hiding cover, and attract terrestrial insects for fish to eat.

Re-creating a representative biological environment starts with establishing vegetation that stabilizes newly placed watercourse bank slopes. Aim to include mostly native, non-invasive plant species in the vegetation plan. If using a seeding method, only apply approved seed mixes. Refer to the Alberta Native Plant Revegetation Guidelines[45] and *Alberta Weed Act* for more information[46].

The streambed itself is home to aquatic organisms and fish communities that live in or on the streambed gravel. Sediments suspended in the watercourse (i.e., total suspended solids) can be lethal to fish and settling sediment can bury fish eggs and aquatic insect habitat. It is therefore critical to plan for restoration activities to minimize erosion and prevent sedimentation.

Finally, restoration plans should consider the needs of all native fish species found within the watercourse, especially those that may be at risk (e.g., Arctic Grayling, West Slope Cutthroat Trout, Athabasca Rainbow Trout, and Bull Trout). Be aware that each fish species has unique habitat requirements and these need to be included into the restoration plans. These needs can be identified by a qualified professional, such as a biologist.

Chemical factors to consider

A restoration plan could also include a design for key chemical elements and outcomes that fall within the natural ranges for watercourses in the restoration area.

The chemical element to plan for is dissolved oxygen, and the chemical environment to plan for is water temperature. Temperature increases in shallow water and in areas without any vegetative or physical cover. It is important for cold water-loving fish that restoration plans recreate natural watercourse channel geometries, vegetation, rocks, and coarse woody materials to provide a variety of water temperature environments.

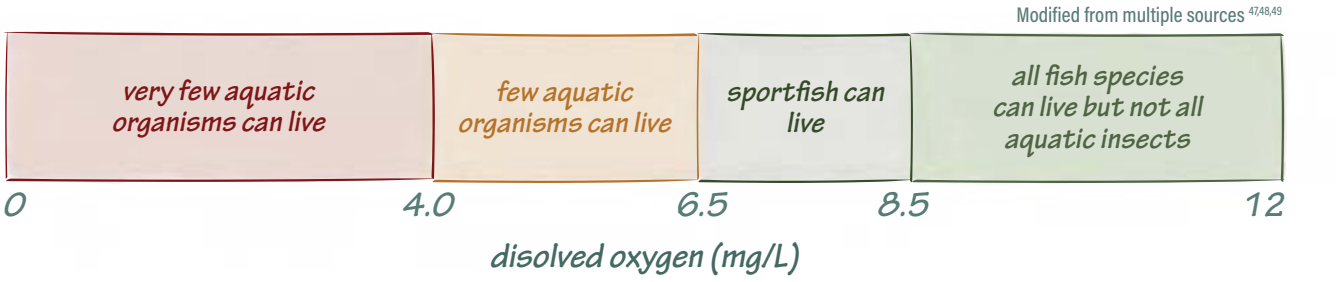
Fish and other aquatic organisms also require oxygen to survive. Oxygen from the atmosphere dissolves in the watercourse and is used by fish and other aquatic organisms, like insects, to breathe. Dissolved oxygen levels depend on whether the water is flowing, whether there are rocks or other obstacles for water to flow over, the number of plants growing in the water, and the water temperature. For example, oxygen enters the water from aquatic plants, when water pours over rocks within a watercourse, and when the water temperature is cooler. Thus, there is more dissolved oxygen for fish and insects in cold, flowing waters with many obstacles and some aquatic plants.

This natural habitat for trout contains many desirable characteristics, including woody debris for hiding cover and natural vegetation on the watercourse banks. These features contribute to a healthy watercourse environment.

45 Alberta agriculture, food and rural development. 2001. Native plant revegetation guidelines for Alberta. https://open.alberta.ca/publications/native-plant-revegetation-guidelines-for-alberta

46 Government of Alberta. Weed control act. https://kings-printer.alberta.ca/1266.cfm?page=W05P1.cfm&leg_type=Acts&isbncln=9780779838455

Each fish and aquatic insect species has different dissolved oxygen requirements. Understand the dissolved oxygen requirements for native fish and their food sources and plan accordingly.



Developing restoration and construction plans

A key step to guide effective site restoration is to create a clear and effective Restoration Plan. An effective plan clearly articulates the motivation of "why" behind the proposed actions, identifies outcomes to be achieved (e.g., materials removed, habitat and passage for specified fish types, etc.) and, where appropriate, engineered drawings.

Once approved, the Restoration Plan can become the Construction Plan that clarifies roles and outcomes for the field operations team. Where a Restoration Plan describes "what" the goal will be, a Construction Plan describes the process for "how" and "when" the crossing will be removed to achieve the planned goal. A Construction Plan is a set of documents that define the requirements for crossing removal and help operationalize the crossing site restoration. It should contain information such as a breakdown of all the construction activities, procurement of materials, roles and responsibilities, schedule, and budget.

Winter crossings (i.e., ice bridges and snow fills) are unique from other instream watercourse crossings. They are always temporary structures constructed for one winter season only. Any ice or snow on the crossing surface that has been soiled by vehicle activity must be removed and dumped well away from the stream and riparian areas.

Effectively implementing a crossing restoration

After Restoration and Construction Plans have been created, and all appropriate permitting and approvals have been obtained, activities for instream removal of a watercourse crossing and site restoration can begin.

Some of the common aspects of a watercourse crossing removal include:

- Fish isolation and rescue
- Site dewatering
- Watercourse crossing structure excavation
- Transportation of deleterious materials off-site
- Backfilling of the area

47 Alberta Lake Management Society. 2014. pH and Alberta Lakes. https://alms.ca/wp-content/uploads/2014/02/pHLakes_AWQA.pdf
48 Government of Northwest Territories. No Date. Dissolved oxygen. https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf
49 Alberta Environmental Protection. 1997. Alberta water quality guideline for the protection of freshwater aquatic life. https://open.alberta.ca/dataset/82793404-d376-4b9e-a399-94da6e279b0a/resource/f223f816-1268-4f4e-9698-78824bb8a5fe/download/7254.pdf

- Watercourse bank recontouring
- Watercourse bed grading
- Streambed material restoration (rock and coarse woody debris)
- Native species revegetation

BMPs for many of these activities are outlined in the *Preparing your Site* section of this guidebook.

Before

During

After

There are unique considerations for instream versus out-of-stream watercourse crossing removal and site restoration. Out-of-stream watercourse crossings do not have piers, pillars, or pipes located within the watercourse, so there is no need for excavation within the water body. Consequently, there is often less need for reconstruction of the watercourse channel and banks.

It is a BMP to hire a qualified professional to help plan and execute watercourse crossing removals and site restoration, regardless of whether the work happens instream or out-of-stream.

Key considerations for watercourse crossing removal and site restoration success

There are a number of keys to success and considerations for what to avoid when removing watercourse crossings and restoring the site:

KEYS TO SUCCESS

- **Use suitable materials:** Matching materials to the natural watercourse characteristics is key to recreating representative or natural-like conditions. For instance, try to match the particle sizes observed during upstream and downstream assessments and don't use large rip rap in small watercourses.
- **Gravel and stone materials selection:** Whatever materials used in the watercourse restoration should be clean and contain very little fine sediment particles.

WHAT TO AVOID

- **Uninformed procurement:** Cost-focused procurement approaches should also consider the experience-level and quality of restoration outcomes when selecting a contractor for watercourse restoration work. Use experienced professionals.
- **Be aware of seasonality of flow:** Avoid conducting removal and restoration activities during high flow periods.

- **Restore streambed slope and elevation:** Be aware it is common for existing watercourse crossings to have increased sediment, sand, and gravel deposits immediately upstream of the crossing and fewer deposits downstream. To restore the original streambed elevation and slope, it is therefore important to go downstream, beyond the scour pool, and upstream of any accumulated deposits, to determine the original gradient and elevations.
- **Regularly monitor water quality:** During the removal of the crossing structure and restoration of the area, water quality monitoring is key. Construction activities should be paused and regulators notified if water quality parameters exceed regulatory guidelines.
- **Post-restoration monitoring:** After restoration is complete, inspect the area for, and address, any deficiencies in the completed construction plan (e.g., underperforming revegetation, erosion issues, insufficient use of rip rap, etc.). This can be done shortly after the work is completed and the following year after spring flows (e.g., look for any substrate movement or erosion issues). For detailed information on the development of a monitoring plan see the Post-Installation Responsibilities section.
- **Clear and regular communication:** Communication between designers, planners, and the operations team conducting the removal and restoration activities is critical in helping achieve project goals.

- **Restricted activity periods (RAP):** Be aware there are times of the year when instream work must be avoided to prevent impacts to fish during sensitive life stages, such as migration, spawning, egg incubation, emergence, etc. For more information consult a professional and refer to the published documentation from regulators, including the GOA (2016)[50].
- **Unfavourable weather:** Where practicable, avoid construction during extreme weather events. Be proactive by preparing for predicted weather events during the planned construction period. For example, if rain is in the forecast and construction cannot be avoided, plan for more erosion control measures.

A literature review conducted by the AWC3 on watercourse crossing removals and restoration found very little public information and no guidance documents. In response, this section was developed from the knowledge, experience, and case studies obtained from expert watercourse crossing removal and site restoration practitioners through interviews.

50 Government of Alberta. 2016. Restricted activity period. https://open.alberta.ca/dataset/7bd633f7-5048-4824-8667-2313a37961f5/resource/61905fab-f21f-4503-ba96-33223138c50a/download/eapfr-restrictedactivityperiod-apr2016.pdf

9. Post-installation responsibilities

A watercourse crossing owner is responsible for the site when the watercourse crossing structure is installed, after the streambed and banks are restored, and when a crossing is removed. Post-installation responsibilities ensure the watercourse crossing structure continues to perform up to the specifications of the original design. An effective watercourse crossing will remain structurally sound, maintain fish passage and water flow as well as minimize erosion and prevent sedimentation. Post-installation responsibilities include inspections, monitoring, reporting, remediation and maintenance.

This section provides detail on what is required to fulfill these responsibilities. This information applies to all watercourse crossing owners.

A plan that includes routine inspections, a monitoring program, strategic remediation, and ongoing maintenance offers an opportunity for crossing owners to minimize lifecycle costs and maximize the life, safety, and environmental performance of a watercourse crossing. This is regardless of their participation in any local or provincial programs such as the Watercourse Crossing Program.

Go back to the site after installation to ensure that the watercourse crossing and any erosion control measures are functioning as designed.

All watercourse crossing owners in the province must:

- **Inspect:** Have monitoring programs for all their watercourse crossings.
- **Report:** Provide inspection data to the regulator.
- **Remediate:** Prepare a remediation plan for all watercourse crossings that are not in compliance. Any issues observed on temporary forestry crossings are expected to be remediated immediately upon discovery and reported to the regulator.

Linkages with the WCP and the Watercourse Crossing Management Directive

The Government of Alberta has a Watercourse Crossing Program (WCP) to help address the decline in native fish populations by managing threats to fish created by trails and poorly constructed or maintained watercourse crossings[51]. All *Public Lands Act* disposition holders in Alberta must follow the WCP, which includes fulfilling all applicable federal and provincial regulatory requirements for watercourse crossings (e.g., COP WCC, *Water Act*, etc.).

One key focus of the WCP is to create a robust, provincial inventory of watercourse crossing data and to prioritize remediation plans. This inventory is created with data collected through inspection reports submitted to the regulators. The Watercourse Crossing Management Directive provides support to ensure that watercourse crossing owners are completing regular inspections of all watercourse crossings on a predetermined schedule and that crossing remediation

51 Government of Alberta. 2023. Watercourse crossing program website: https://www.alberta.ca/watercourse-crossing-program.aspx. Accessed April 2023.

plans are being created that prioritize restoring fish habitat based on ecological risk and watershed-scale priorities.

Participation in the Watercourse Crossing Management Directive is voluntary. Those that choose to participate have access to support and information to meet all relevant regulatory requirements and have more choice in how to create and schedule remediation plans. Crossing owners who choose to not participate in the directive will have their crossings inspected by the regulator and, if appropriate, be subject to enforcement action(s).

For more information on the Watercourse Crossing Program (WCP) and Watercourse Crossing Management Directive, including the benefits for a participating watercourse crossing owner see the ***Legislation, Regulatory Approvals and Permitting*** section of this guidebook or the Government of Alberta WCP website.

Monitoring programs and inspection frequency and scheduling

Creation and implementation of a monitoring program that schedules routine inspections can provide early warning signs of crossing structure and watercourse degradation and allow for timely remediation.

An optimal watercourse crossing monitoring plan is designed to ensure that higher-risk watercourse crossings are inspected more frequently. The aim of inspections is to determine if the engineered plan or design was followed and to determine if the watercourse crossing is maintaining water flow and quality, fish passage, and fish habitat. Monitoring programs should also determine if the crossing being inspected is still in compliance with applicable regulations and any conditions that may have been placed on the approval by the regulator. Where deficiencies are noted, appropriate actions should be taken as soon as possible.

The watercourse crossing structure must be routinely inspected throughout its lifetime. The monitoring plan that determines the inspection frequency and schedule is created by the watercourse crossing owner. The frequency of inspections should be informed by risk factors, such as:

- The probability that the watercourse crossing structure may fail to perform its intended purpose given the environment and use.
- The severity of negative consequences for critical habitat or species at risk if the crossing fails.

Watercourse crossing structures should be inspected more frequently if:

- There is potential for erosion and high sedimentation risk.
- The watercourse crossing could create a barrier for fish passage.
- The watercourse crossing structure is prone to accumulating debris (e.g., culverts, beaver-prone areas).
- There are species at risk in the watercourse crossing area.
- The watershed supports critical habitat (i.e., necessary for the survival or recovery of species identified under the Species at Risk Act, such as fish spawning grounds, food supply, and migration).
- The watercourse is in a watershed that contains at-risk fish species or higher order watercourses (i.e., those confirmed to have fish or identified as priorities by provincial or federal regulators).

The level of risk can vary among structure types. For example, bridges or arches have a lower risk of blocking fish passage in comparison to culverts but can still have significant erosion and sediment risks. Culverts without an engineered design have an elevated risk of failure (and therefore should be inspected most frequently).

Time also plays a role in the level of risk. The potential for erosion and sedimentation decreases as vegetation establishes over time following new watercourse crossing installation (lowering risk). However, over time, debris can accumulate within a structure and beavers can occupy an area where they were not previously found (increasing risk).

Suggested inspection scheduling guidelines for watercourse crossings:

- **As-built inspection:** Check and document that the watercourse crossing structure meets the design specifications before being placed in service.
- **Initial inspection:** Observe the new crossing after the first season of use to assess if the crossing is functioning according to plan, has experienced any unplanned settlement, and to evaluate revegetation progress.
- **Major weather events:** Check all watercourse crossings after major storms and flooding events that have the potential to stress the design. These weather events are the leading cause of watercourse crossing failure.
- **Active crossings:** After the initial inspection consider inspecting low-risk crossings every five years, medium risk crossings every three years, and high-risk crossing sites every year.
- **Removed crossings:** The site of a watercourse crossing removal should be inspected regularly until vegetation has established enough to stabilize soils and erosion is no longer a concern.

Forestry companies that own temporary watercourse crossings are required to inspect and monitor using criteria in the *Alberta Timber Harvest Planning and Operating Ground Rules*[52] and monitoring plans identified in approved Forest Management Agreements.

A picture is worth a thousand words. Photos need to be provided to support the inspection conclusions in the Watercourse Crossing App. Taking quality photos during the inspection process can also help determine the severity of any concerns and help establish a path forward for remediation (and can be provided to experts hired to help understand any problems).

Watercourse crossing inspection data collection

Watercourse crossing inspections should include both the crossing structure and the area that impacts the crossing, and gather the following information:

- Any design or structural performance issues that may present safety risks to traffic and people (e.g., collapsed or sunken crossing structures, damaged or missing guardrails and road signage, rotting wood materials, etc.).
- Any signs of erosion or sedimentation (e.g., unvegetated soils, ditches, or roads contributing sediment to the watercourse).
- An assessment of vegetation establishment on disturbed areas.
- Obstacles to fish passage (e.g., beaver dam, debris blockages, culvert settlement, etc.).

Based on these observations, potential remediation actions can be identified[53].

For a list and description of tools available to support data gathering and reporting on inspections see the next section on *Watercourse Crossing Inspection Reporting*.

52 Government of Alberta. 2022. Alberta timber harvest planning and operating ground rules. https://open.alberta.ca/publications/alberta-timber-harvest-planning-and-operating-ground-rules-2022

53 McCleary R, Spytz C, Schindler H, Anderson R, Climie M. 2007. Stream crossing inspections manual, version 3. CR Bamsey, ed. Edgerton (AB): Clear Lake Ltd. https://friresearch.ca/data/null/FSCP_FWP_2007_12_Manual_StreamCrossingInspectionsManual.pdf

Watercourse crossing inspection reporting

A report containing data from watercourse crossing inspections must be submitted by November 30 each year. There are different tools and approaches to document watercourse crossing inspections. These include: the Survey123 App, the Watercourse Crossing Inspection Form, or a field inspection form created by the owner.

The Survey123 App allows owners to meet their regulatory requirement to inspect and report on their watercourse crossings.

Annual reports must be submitted to the Government of Alberta either through the upcoming App or email (aep.wccrossing@gov.ab.ca for non-energy regulated companies or AER.WCC@aer.ca for energy regulated companies).

The Survey123 based App is available to all Albertans who want to help with fish and watercourse conservation in the province. Using a smartphone or tablet and Survey 123 app monitoring can be done easily in a standardized way.

Other reporting requirements for crossing owners to be aware of include:

- An owner must compile and retain records over the lifecycle of a watercourse crossing, including all photos and video recordings.
- If there is a contravention of the Alberta Timber Harvest Planning and Operating Ground Rules (OGRs), the owner must report the incident, and potential environmental implications, within 48 hours. Emergencies are required to be reported within 24 hours. Incidents must be documented and reported to the appropriate ministry and forest area office.
- For temporary forestry roads, reporting on proposed, constructed, active, and reclaimed roads is a regulatory requirement. Timelines for activities are determined by the Timber Harvest Planning and OGRs.

Remediation planning and actions

Over time, watercourse crossings can fail or deteriorate for a variety of reasons and therefore require remediation to return to good working order. It is the responsibility of a crossing owner to maintain functioning crossings and to take proactive measures to repair or replace crossings that have had concerns identified in the inspection process.

Crossing owners should be aware that, while managing fragmentation in all provincial watersheds is important, some watersheds have unique characteristics (e.g., species at risk) that make their conservation a higher priority. These higher risk crossings should be prioritized for repair or replacement. Reported data, gathered largely through reporting apps, contributes to a provincial database of watercourse crossings that is used to inform prioritization and management of remediation efforts by crossing owners. Remediation work within watersheds is assessed and prioritized based on the risk to fish population, overall remediation benefit to the watershed, and coordination of remediation works among multiple crossing owners. When owners use this database and guidance from the Management Directive together to strategize remediation planning, they are contributing to the provincial strategy to improve fish habitat and maximize fish population recovery. Companies should review the data from routine crossing inspection forms to identify where remediation planning efforts should be focused.

Watercourse crossing owners need to create an annual remediation plan and demonstrate that prioritization of remediation or replacement of watercourse crossings has been based on the following criteria:

- The Provincial Watershed Prioritization list
- The risk of impacting species at risk or critical habitat
- Effects on overall fish populations
- Broad benefits to the watershed

- Coordination with other watercourse crossing owners

To be in compliance with the Watercourse Crossing Management Directive, owners participating in the program must submit a remediation plan for all watercourse crossings that are not in compliance by March 31 each year[54]. The remediation plan should include:

- Watershed name
- Watercourse crossing locations
- Watershed priority rank
- Remediation objectives
- Proposed remediation activities
- Schedule for each watercourse crossing repair or replacement.

Once the plan is approved, implementation of the remediation plan can commence. See the *Crossing Removals and Restoration* section for step-by-step instructions and illustrations on how to effectively implement a watercourse crossing removal and replacement of an underperforming watercourse crossing.

Maintenance of watercourse crossings

It is important to maintain watercourse crossings even if they are technically still in compliance. This is most effective if it is scheduled through a routine maintenance plan that includes visiting as many watercourse crossing sites as possible. Visits should identify potential problems with safety, blockages or erosion and sedimentation before they become a problem. This can involve quick observation and action and is additional to the formal inspection and monitoring process. It can be as simple as securing a field crew to remove debris from crossings each year and performing routine maintenance while on site. This simple approach can prevent non-compliance issues, minimize the need for remediation and reduce future costs.

54 Environment and Parks, Government of Alberta. 2020. Watercourse Crossing Management Directive.

Appendix A: Letters of Endorsement

Alberta Forestry and Parks

Forestry Division,
Forest Stewardship and Trade Branch
J.G. O' Donoghue Building
Suite 303, 7000-113 Street
Edmonton, AB T6H 5T6
Canada

January 23, 2024

Board of Directors
Alberta Watercourse Crossing Collaborative
11316 - 119 St NW
Edmonton, AB T5G 2X4

Dear Board of Directors:

I would like to extend my congratulations to the Alberta Watercourse Crossing Collaborative on the completion of the 2023 Alberta Watercourse Crossing Guidebook.

Forestry Division recognizes the Guidebook as an excellent educational resource focused on current best management practices for watercourse crossing design, construction, maintenance, restoration, and remediation in Alberta. Its content reflects many hours of work and contributions by experts in this field.

While the Guidebook does not replace provincial legislative obligations and direction, it is recognized as a tool that can provide an effective mean of achieving outcomes for watercourse crossing owners and a positive contribution to aquatic ecosystem connectivity, restoration of riparian habitat and ultimately a positive outcome for fish habitat and fish populations.

Sincerely,

Ken Greenway, PhD, RPF
Executive Director

cc: Kevin Quintilio
Executive Director, Lands Delivery & Coordination North

Alberta Forestry and Parks

J.G. O' Donoghue Building
Suite 303, 7000-113 Street
Edmonton, AB T6H 5T6
Canada
Telephone 780-427-6807
www.alberta.ca

January 18, 2024

Board of Directors
Alberta Watercourse Crossing Collaborative
11316 - 119 St NW
Edmonton, AB T5G 2X4

Dear Board of Directors:

I would like to extend my congratulations to the Alberta Watercourse Crossing Collaborative on the completion of the 2023 Alberta Watercourse Crossing Guidebook.

Lands Delivery and Coordination recognizes this guidebook as an excellent educational resource focused on current best management practices for watercourse crossing design, construction, maintenance, restoration, and remediation in the province of Alberta. The guidebook content reflects many hours of work and contributions by experts in this field and is applicable to provincial watercourse crossing priorities, programs, legislation, and regulations.

While the guidebook does not replace provincial legislative obligations, it is recognized as a tool that can provide an effective mean of achieving outcomes for watercourse crossing owners and a positive contribution to aquatic ecosystem connectivity, the restoration of riparian habitat and ultimately a positive outcome for fish habitat and fish populations.

Sincerely,

Kevin Quintilio
Executive Director, Lands Delivery & Coord North

cc: Ken Greenway
Executive Director, Forest Stewardship and Trade

Alberta Energy Regulator

Martin Foy
Chief Operations Officer
martin.foy@aer.ca
tel 403-297-6131
cell 587-581-3549
www.aer.ca

January 19, 2024

Alberta Watercourse Crossing Collaborative (AWC3)
11316 119 St NW
Edmonton, Alberta T5G 2X4

Dear AWC3 Board of Directors:

Subject: Statement of Support by the Alberta Energy Regulator for the Alberta Watercourse Crossing Guidebook

The Alberta Energy Regulator recognizes the Alberta Watercourse Crossing Guidebook developed by the AWC3 as an excellent educational resource focused on current best management practices for watercourse crossing design, construction, maintenance, restoration, and remediation in the province of Alberta.

The content in this guidebook reflects many hours of work and contributions by experts in this field and is applicable and aligned to provincial watercourse crossing priorities, programs, legislation, and regulations. This guidebook is not intended to replace or circumvent existing provincial or federal legislation; however, it is in the AER's view that this resource will provide an effective means to achieving regulatory outcomes for watercourse crossing owners and be a positive contribution to maintaining and enhancing fish populations, restoration of habitats and improving aquatic ecosystem connectivity across the province of Alberta.

Yours truly,

Martin Foy
Chief Operations Officer, Operations

Fisheries and Oceans Canada
Pêches et Océans Canada

Ontario & Prairie Region
Aquatic Ecosystems

Région de l'Ontario et des Prairies
Écosystèmes Aquatiques

March 1, 2024

Alberta Watercourse Crossing Collaborative (AWC3)
11316 119 St NW
Edmonton, Alberta
T5G 2X4

Subject: Statement of Support from Fisheries and Oceans Canada – Ontario and Prairie Region for the Alberta Watercourse Crossing Guidebook

Dear AWC3 Board of Directors:

Fisheries and Oceans Canada (DFO) – Ontario and Prairie Region (O&P) recognizes the Alberta Watercourse Crossing Guidebook developed by the AWC3 as an excellent educational resource focused on current best management practices for watercourse crossing design, construction, maintenance, restoration, and remediation in the province of Alberta.

This guidebook was funded in part by DFO – O&P and the content reflects many hours of work and contributions by experts in this field.

While the guidebook does not replace legislative obligations and regulatory requirements, it is recognized as a helpful tool for watercourse crossing owners, designers and field practitioners towards achieving positive outcomes for fish and fish habitat, including aquatic species at risk across the province of Alberta.

Regards,

Curtis, Martyn

Digitally signed by Curtis, Martyn
DN: C=CA, O=GC, OU=DFO-MPO, CN="Curtis, Martyn
"
Reason: I am the author of this document
Location:
Date: 2024.03.12 09:52:56-05'00'
Foxit PDF Editor Version: 13.0.1

Martyn Curtis
A/Regional Director, Aquatic Ecosystems
Fisheries and Oceans Canada, Ontario and Prairie Region

ISBN 978-1-7383447-1-0