Best Practices for Small Scale Stream Crossings

Includes:
Draft Report

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Community Based Natural Resource Management (ERSC – 3160H)

ORCA Community Based Research Project – Enhancing Stewardship Capacity

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1.0 Introduction

Conservation Authorities, created in 1946 by an act of provincial legislature, are mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economical needs. They are non-governmental agencies funded mainly through self-generated revenues and municipal levies with some additional funding from provincial and federal grants.

The Otonabee Region Conservation Authority (ORCA), a community-based environmental protection agency, was established in 1959 to serve the areas of: The Township of Cavan Monaghan, the Township of Otonabee South Monaghan, the Township of Asphodel-Norwood, the Township of Smith-Ennismore-Lakefield, the Township of Douro-Dummer, the City of Peterborough and portions of the Municipality of Trent Hills and the City of Kawartha Lakes. The ORCA watershed region covers an area of 1,951 square kilometres and encompasses the drainage basin of the Otonabee, Indian, and Ouse Rivers.

Conservation Authorities roles and services include:

- Water Resource Management Managers – Conservation Authorities are Ontario's community-based environmental experts, who use integrated, ecologically sound environmental practices to manage Ontario's water resources, maintain secure supplies of clean water, protect communities from flooding and contribute to municipal planning processes that protect water.
- Environmental Protection – Conservation Authorities protect local ecosystems and contribute to the quality of life in communities throughout the province.

- Lifelong Learning Recreation – Conservation Authorities provide educational and recreational experiences in a natural environment that enrich the lives of peoples of all ages, by instilling an appreciation and enjoyment of our diverse natural heritage.

2.0 Purpose

The purpose of the ORCA small-scale stream crossing project is to develop modules and collect sources of information that will aid in the communication of technical information and best management practices (BMPs) to rural landowners. There is significant difficulty with gaining compliance among rural landowners and new means of communicating valuable information are needed. It was stated in the consultation that it is not known if all technical aspects of small scale stream design and construction could be summarised and made into reader-friendly modules, but much ground has been gained in this area.

3.0 Scope

Several organizations provide support for rural land owners, but there is concern that the technical elements of stream crossing projects act as barrier to stewardship. This project addresses the issues, clarifying and demystifying some of the technical aspects of stream crossing design and construction.

The research undertaken consists largely of reviews of published literature, internet research, and an interview at Sir Sandford Fleming College. This research was condensed into this document and the following modules:

- Common Consequence of Poor Stream Crossings

- Obtaining Approvals – Information Requirements
- Reference List of Pertinent Sources

This document identifies technical barriers and solutions, current BMPs and small scale stream crossing designs.

4.0 Technical Barriers

Many rural properties, particularly those in the Otonabee Region watershed, are traversed by several watercourses (streams, creeks and rivers). In order to facilitate the movement of machinery and livestock around the property, those watercourses must be crossed. The design and condition of a stream crossing determines whether a stream behaves naturally and whether or not fish and wildlife can migrate along the stream corridor. Stream continuity must be the highest priority of any watershed improvement program. As any non-compliant stream crossing can act as a barrier preventing all upstream migration rendering possible habitat, breeding or recreational grounds useless.

The fragmentation of stream habitat and fish populations has adversely impacted fish community diversity, fish population levels and fish survival. In order for the average rural landowner to understand these issues and undertake the task of constructing proper stream crossing, several areas of concern and difficulty need to be identified.

4.1 Water Quality

When livestock have access to, and when machinery enters a watercourse, bacteria levels in the water may increase and bank erosion can take place, resulting in degraded water quality both on the owner's property and others downstream. Poorly constructed stream crossings can have negative aspects as well. The proper installation of a structured stream crossing has the potential to:

- Reduce stream bank erosion,
- Decrease stream bed and stream side erosion,
- Reduce sediment deposition into the waterway
- Are non disruptive to existing vegetation and their functions
- Improve fish and wildlife quality,
- Improve water quality

Landowners who are ignorant to water quality and its potentially adverse impacts may unwittingly degrade water quality during and after construction of a stream crossing. The importance of maintaining water quality must be communicated to the landowner as simply as possible.

4.2 Best Management Practices

Alternatives to traditional construction and stream management practices must be made available to landowners in a form that is easy to understand. Landowners may know the consequences of their actions are on their property, but not the adverse effects they are generating downstream. New ideas such that incorporate stream and bank remediation should be promoted. As most farmers are 'do-it–yourself' individuals, easy-to-follow instructions and plans for construction of this and other stream crossings should be made available at no cost. This is beyond the capabilities of this report or any generated modules and will require engineering services. Other, remediation and vegetative erosion control guides should be available as well. Having guides available will make implementation seem more doable even if an application is required.

4.3 Legislation and Application

Landowners who need to construct a small-scale stream crossing are required to obtain a work permit from the Ministry of Natural Resources to ensure that the requirements of the *Public Lands Act* and the *Lakes and Rivers Improvement Act* have been complied with. They must then consult the local Conservation Authority, as they may have other Regulations under their jurisdiction that must be adhered to before a stream crossing is installed. Finally, there may be municipal restrictions, especially if the stream is used for drainage. These processes can seem overwhelming for someone who wants to get from one bank to another especially if the stream is seasonal. Landowners are subject to an unfair amount of paperwork doubling and sometimes tripling the workload while waiting weeks for approvals for a job that may take less than a day. In addition to developing site plans and getting the property surveyed, the technical jargon must be rephrased for ease of use. A module that outlines the required paper work and where to get it has been attached in the appendix, but further streamlining is needed such as the filing of one application that is automatically forwarded to the required organizations.

4.4 Professional Advice

The advice of consulting engineers can provide design expertise that is crucial to the successful development and implementation of stream crossings but can be prohibitively costly for rural landowners on such a small project. Funding is available to assist with these costs but needs to be better advertized along with the open door policies of Conservation Authorities and Ministry of Natural Resources Staff.

5.0 Poor Planning and Installation

The continuity of streams, as well as their connection to riparian and upland areas, is necessary to the well being of all species that inhabit or are associated with stream ecosystems. Site conditions are unique from crossing to crossing making replication of one ideal structure almost possible. Inadequate sizing and placement of stream crossings can jeopardize the fate of the crossing and act as a barrier to fish and wildlife movement to all upstream water. Recognizing poor stream crossings and their consequences is an important step to mitigating these mistakes in the future. Crossings should in essence be invisible to fish, maintain appropriate flows and substrate. Originally functioning structures, after many years, may now be barriers due to stream erosion, failure of the structure and changes in the upstream or downstream channel or shape. The following conditions define stream crossing failure.

5.1 Perched Crossings

Perched culverts are situated above the elevation of the stream bottom at the culvert outlet (downstream end) presenting a physical barrier to upstream fish passage. Perched culvert conditions are the result of improper installations or develop over time via years of excessive scour and erosion of the streambed at the culvert outlet or freeze/thaw conditions. Stream crossings should be open bottom, sunk in the bed to prevent perching or utilize other technologies.

5.2 Shallow Water Depth

Stream crossings with shallow water/sheet flow conditions are due to insufficient water depth that can prevent the movement of fish. Crossings should have open bottoms or be sunk into the streambed to allow for substrate and water depths that are similar to the surrounding stream.

5.3 Undersized Crossing

Undersized crossings restrict stream flow, particularly during the spring and flood conditions, and cause various problems including bank scouring, erosion, high flow velocity, clogging and ponding. Undersized crossings have been completely displaced by excessive water velocities. Flow velocities can be concentrated within the main body of a culvert at the inlet or outlet sections preventing upstream fish movement. Velocity problems also typically occur within smooth bottom and concrete box culverts that do not contain natural streambed substrates and lack channel roughness.

Proper installation and sizing of stream crossings that anticipate flood conditions are key to mitigating the prevention of fish movement and costly mistakes.

6.0 Indicators of Stream Crossing Concern

When designing Stream Crossings considerations must be given to the entire fish and wildlife community, not just large or small fish species. The following is a list of indicators of stream crossing concern that can be utilized by rural land owners to identify areas of concern for proactive measurement before they become major issues.

6.1 Debris Accumulation

Debris accumulation can block fish passage. Crossings become blocked due to woody debris, leaves, other material and beaver activity. Issues can becomes suddenly worse if flood conditions arise. Beaver deceivers and other routine management will help prevent this problem.

Causes: Undersized Crossings, poor management

6.2 Low Flow

Low water flow is a problem for species movement within streams. Low flow can lead to stagnant and oxygen deficient conditions within the crossing that are undesirable for most fish species. However low flow is attributed to seasonal conditions can be considered normal.

Causes: Shallow Crossings, Perched Crossing

6.3 Unnatural Bed Materials

Metal and concrete are undesirable substrates for fish and benthic species. The substrate of the crossing bed should match that of the stream bed to maintain natural conditions. This may not be applicable for low level/shallow crossings but maintaining a natural bed should be a goal during construction.

Causes: Perched/shallow crossing

6.4 Scouring and Erosion

In undersized crossings, high flow rates can scour natural vegetation and substrates within and downstream of the crossing degrading habitat. High water velocities may also erode stream banks. Scour pools often develop downstream of culverts and may undercut them. These situations can jeopardize the structure and should be rectified.

Causes: Undersized crossing, perched crossing, unforeseen flood event

6.5 High Flow

Water velocity is higher in a constricted crossing than it is upstream or downstream. High flow degrades wildlife habitat and weakens the structural integrity of crossings. During floods, undersized crossings can fill with fast-moving water and problems associated with poorly designed crossings increase.

Cause: undersized Crossing

6.6 Ponding

Ponding describes the backup of water upstream of an undersized crossing. This can occur year round, during seasonal high water or floods and when crossings become clogged. Ponding can lead to property damage, road and bank erosion and severe changes in upstream habitat.

Cause: Undersized crossing

All of the indicators of concern for poor stream crossing are related to under sizing, improper installation and poor management. A module has been developed to help landowners identify these. Unfortunately site specific photographs are currently not available but can easily be inserted by the ORCA.

7.0 Best Management Practices (BMPs) For Streams and Small scale-Stream Crossings

Streams are long, linear ecosystems. The processes that nourish these ecosystems are interrelated and dependent on "continuity" of the stream corridor. When designing and installing stream crossings, the needs of invertebrates, fish, amphibians, reptiles, and mammals must be taken into account. These animals rely on being able to move unimpeded, both daily and seasonally, through the stream and adjacent areas. Finding shelter, escaping danger, searching for food, and maintaining genetic diversity are some of the many activities that require stream continuity and connection to the watershed.

7.1 Seasonal Construction Windows

Stream crossing construction projects can severely degrade stream fish habitat and water quality and certain construction activities can delay or even prevent migratory movement of resident fishes through a project site. Consequently, seasonal construction windows in late summer and early autumn when stream flows are lowest are optimal times to work in the stream channel. This is often the time of year when it is easier to control soil erosion, sedimentation and fewer fish are undergoing migrations. Stream crossing structures should maintain the pre-installation stream conditions to the maximum extent possible.

7.2 Prevent Deleterious Substances from Entering Streams

The Fisheries Act dictates that no one may carry out work that harmfully alters, destructs or destroys fish habitat unless there is clear authorization. Land owners are not permitted to deposit harmful substances in water frequented by fish. Silt is also considered a harmful substance under this Act. Violating provisions of the Fisheries Act can mean substantial fines, risk of imprisonment, or paying the costs of returning the site to its natural state.

Fuels, lubricants, and other toxic materials should be stored outside the riparian management area of the stream, in a location where the material can be contained. Equipment should be checked for leaks of hydraulic fluids, cooling system liquids, and fuel, and should be cleaned before fording a stream. All fuelling operations should also be done outside of the riparian management area. In addition uncured concrete or grout can kill fish by altering the pH of water and special considerations must be under taken if constructing concrete stream crossings.

7.3 Erosion and Sediment Control

All appropriate erosion and sedimentation controls should be established prior to and during all phases of construction. Placement of scour protection measures such as riprap should be minimized as much as possible. During periods of heavy or persistent rainfall, work activities should be suspended if they could result in sediment delivery to the stream that would adversely affect aquatic resources. Minimizing disturbance to stream banks is a top priority during stream crossing construction.

Straw bales are best suited where temporary and relatively minor erosion control is needed while more permanent solutions are being devised. When properly used, straw bales can be effective in intercepting sheet flow runoff at the base of an exposed cut bank, fill slope, or swale, or in acting as a check dam in low flow streams. Silt fences on the other hand are short-term structures made of wood or steel rebar and resilient permeable geotextile. Silt fences retain soil on the site and reduce runoff velocity across areas below the fence. They are effective boundary-control devices and can be used to intercept soil from cut slopes and ditch lines, and to isolate the general work area from the stream.

7.4 Riparian Zone Protection

Damage to riparian vegetation disturbed during construction should be minimized and damages that occur should be re-established in a timely manner upon crossing completion. Vegetative soil stabilization is the most cost-effective, long-term surface erosion control method as it controls sediment at the source. Species selected for planting should be non invasive and of local flora. Instream habitats can often be lost or modified due to placement of a stream crossing, installation of enhancement structures such those listed below can offset habitat impacts:

- Rootwads – The lower trunk and root fan of a large tree. Individual wads are placed in series and utilized to protect stream banks along meander bends. A revetment can consist of just one or two rootwads or up to 20 or more on larger streams and rivers.
- Boulders - Along streams, the most erosion prone area is the toe of the streambank. Generally, the lowest third of the stream bank experiences the highest erosive forces. Failure at the toe of the streambank can result in failure of the entire bank and lead to large influxes of sediment to the stream. Boulder revetments serve to protect the most vulnerable portion of the stream bank. Boulder revetments are often combined with bank stabilization for the streambank area above the revetment.
- Lunkers - Crib-like, wooden structures installed along the toe of a stream bank to create overhead bank cover and resting areas for fish. A lunker consists of two planks with wooden spacers nailed between them.

7.5 Cattle Mitigation

Often livestock have access to land on both sides of the stream making crossing of the watercourse necessary. When livestock have access to streams and ditches, bacteria levels in the water may increase and bank erosion can take place. Livestock trampling the stream banks may increase the sediment load entering the water-course which can smother out aquatic habitat and sometimes result in expensive drain clean outs. If the stream crossing will be used by livestock, it is important to fence the stream so that livestock use the crossing and stay out of the stream. Areas of the stream where cattle are directed to for drinking should have shallow slope banks and maintain a solid bottom.

7.6 Crossing Maintenance

If small scale stream crossings are installed correctly, very little maintenance should be needed. Crossings should be checked after storms for debris that streambed and banks are intact. Areas where erosion is occurring must be repaired immediately.

8.0 Types of Stream Crossings

Fish and other aquatic organisms need healthy ecosystems to feed and reproduce. Most species activities usually occur along stream banks and near shore areas of lakes. When proposing the removal or change of sediment, debris and/or vegetation from a stream, landowners must be confident that the works are necessary and will serve a legitimate purpose. All options must be considered including those that do not include a crossing. The choice and design of fish-stream crossing structures are determined by a number of factors including sensitivity of fish habitats, engineering requirements, cost and availability of materials, and cost of inspection, maintenance, and deactivation. Noted below are the three main categories of stream crossings. Though there are many different interpretations and possibilities that can be combined and manipulate as well they must suit the specific site.

8.1 Low Level Crossings

Low level water crossings are built below the surface of the water or sited at crossings with low and seasonal stream flows keeping it functional while providing a buffer for negative aquatic environmental impacts. Essentially the riverbed is coated with a durable surface such as precast concrete units, a fillable textile that can be filled with gravel such as geoweb or gravel and cobblestones. This provides a durable surface that will not stir stream sediment. Low level crossings are implemented for infrequent cattle and vehicles crossing to stop or greatly reduce the amount of sediment pollution and bank degradation at the crossing location.

8.2 Raised Crossings

Raised crossings are designed for areas of high usage and streams with year round flows, usually used in conjunction with heavier traffic where use would warrant the increased cost. The crossing system is raised out of the water column, more like a bridge, and allows the flow of water to continue under the crossing by having in stream supports allowing the movement of water and aquatic life underneath. This is beneficial in areas of extremely sensitive aquatic habitats and allows for complete removal in the event of stream disturbance.

8.3 Culverts

There are two types of culverts, open and closed bottom. The most common is the closed bottom meaning it is complete cylinder t hat matches in size to the flow rating of the stream and is fairly common. Open-bottom culverts are utilized when fish and wildlife are major concerns. Biologists and environmentalists prefer structures that pose the least risk to migration and open-bottom culverts preserve the natural creek substrate. This method does have with it a higher cost due to the fact that landowners will be building around the streambed rather than through it.

In regards to small scale stream crossings, landowner uses must be combined with the requirements of stream being crossed. For seasonal flows and very low water levels, a low level crossing would be best. By straying from culverts costs easily decrease. High use crossing and deeper all season streams require raised stream crossing for optimal performance. For instances where culverts are desired; the open bottom culvert should be chosen to maintain natural function and substrate of the stream while causing minimal impacts. Yet even with costly installation closed bottom culverts are still an industry standard.

9.0 Conclusion

The purpose of the ORCA small-scale stream crossing project is to develop modules and collect sources of information that will aid the communication of technical information and best management practices (BMPs) to rural landowners. Though it was beyond the capabilities of the students to engineer a classification system for designation of stream crossings, a volume of relevant literature was consolidated and specific issues with landowner confusion were identified. This is a particular success as no peer reviewed journal articles pertaining to small scale stream crossings were accessible through Trent University's online databases. Research on this topic appears to be limited.

However, two modules were initiated that will assist in the demystification and clarification of the technical application process and stream crossing maintenance. This project fulfills all of the requirements outlined in the agreement and hopefully this project will enhance the community-based stewardship capacity within the ORCA watershed region.

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11.0 Appendix

11.1 Obtaining Approvals – Information Requirements

11.2 Common Consequence of Poor Stream Crossings

Common Consequences of Poor Stream
Crossings

The following is a list of indicators of poor stream crossings

Debris Accumulation

Debris accumulation can block fish passage. Crossings can become blocked due to woody debris, leaves,
other material and beaver activity. Issues can becomes suddenly worse if flood conditions arise. Beaver
deceivers and other routine management will help prevent this problem.

Scott Jackson photo

Causes: Undersized Crossings, poor management

Low Flow

Low flow is a problem for species movement within the stream. Low flow can lead to stagnant low oxygen conditions within the crossing.

Scott Jackson photo

Causes: Shallow Crossings, Perched Crossing

Unnatural Bed Materials

Metal and concrete are undesirable substrates for fish and benthic species. The crossing bed should match that of the streambed to maintain natural conditions.

Ethan Nedeau photo

Causes: Perched/shallow crossing

Scouring and Erosion

In undersized crossings, high flow rates can scour natural vegetation and substrates within and
downstream of the crossing degrading habitat. High water velocities may also erode stream banks. Scour
pools often develop downstream of culverts and may undercut them.

Riverways photo

Causes: Undersized crossing, perched crossing, unforeseen flood event

High Flow

Water velocity is higher in a constricted crossing than it is upstream or downstream. High flow degrades wildlife habitat and weakens the structural integrity of crossings. During floods, undersized culverts can fill with fast-moving water and problems associated with poorly designed culverts are heightened.

Unknown photo

Cause: undersized culvert

Ponding

Ponding is the backup of water upstream of an undersized culvert. This can occur year round, during seasonal high water or floods and when culverts become clogged. Ponding can lead to property damage, road and bank erosion and sever changes in upstream habitat.

Ethan Nedeau photo

Cause: Undersized culvert

Remember all of the signs indicating a poor stream crossing and culvert are related to under sizing, improper installation and poor management. By not taking care of the culvert and crossing that you installed you can be causing more harm then good. Unregulated flows, stopping of waterways from clogged and unclean culverts and crossings cause problems that can greatly harm the environment, including the species that live in it. Taking care of you investment will lengthen the life of the crossing saving you money and unnecessary strain on the environment at the same time.

Obtaining Approvals - Information Requirements

Helpful hints to ease the permit process

When applying for a permit under the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation, you will be asked to provide specific information about your proposed work. This information will form the basis of the approval, therefore, always be sure to include the following information in your application to avoid delays:

- Property owner's name, mailing address, telephone number.
  If the applicant is an agent acting on behalf of the property owner, Otonabee Conservation requires written confirmation that the applicant is acting in this capacity. The Permit is issued to the Owner of the property.

> Helpful hints
> 1. If you are acting on behalf of a property owner you must have written permission stating the name of the owner, you and what permission is being granted. Have this signed and dated by both parties and a witness.

- Applicant name, mailing address, municipal address, telephone number's

> Helpful hints
> 1. If you do not live at or on the property that is having work done you have to include BOTH.
>   - One so reviewers can contact you at your residence for quick response.
>   - Two so the location of your project can be identified in the permit. A permit for the wrong property is no good and you will have to go through the whole process again including fees.

- A map/sketch to your location including Lot/Concession/Ward/Township, and location of proposed work

> Helpful Hints
> 1. All of this information can be found on your property tax forms or by contacting your local municipality.
> 2. An easy way of getting a fairly good quality map is by using Google earth or Google maps, its easy and simple.
>   a. Go to Google maps and search your property
>   b. Center you property and project site
>   c. Zoom in or out to get the best detail of the property
>   d. Print page

- A dated site map, survey plan or detailed sketch indicating location of buildings, property lines, grade elevation above current water level and watercourse/lake/wetland location on or near the property

> Helpful Hints
>
> 1. Same as the previous hint: A easy way of getting a fairly good quality map is by using Google earth or Google maps, its easy and simple.
>   a. Go to Google maps and search your property
>   b. Center you property and project site
>   c. Zoom in or out to get the best detail of the property
>   d. Print page
> 2. Before looking for a surveyor, you should have had one when the property was originally purchased.
> 3. For watercourse/lake/wetland locations close to your property you can purchase a base map from the Ministry of Natural Resources for $8.50 (plus tax) and this will include the land grade and elevation markers.

- A detailed description, intended location and dimensions of proposed fill, construction or watercourse alteration

> Helpful hints
>
> 1. This sounds scary to complete but its quite simple. Just clearly explain what you wish to do on your project. Here is a list of what to include
>   a. What the project is doing and why are you doing it
>   b. How you will do it and with what equipment
>   c. What you will be adding or taking away (soil, gravel, vegetation, boulders)
>   d. Anything you are or want to change in the project area (basically what you are doing for a project, i.e.; add stream crossing therefore you are changing the stream bed)
>   e. Site location on your maps
>   f. Size of he project, and measurements
>   i. Slope
>   ii. Stream Bank Height
>   iii. Seasonal measurements in the spring summer and fall of water depth and flow
>   iv. Stream width
>   v. Size of crossing, width and length
>   vi. Any other observations that are site specific or worth noting

- A cross-section of the proposed work showing existing grade and final grade and any building openings

> Helpful hints
> 1. This is not hard to do as well. Just draw or have drawn a picture of the project cut in half as if you were looking at it. Below is jus a simple example of a cross-section of a streambed. Just remember to be sure to include all of the changes you wish to make in your drawing plan.