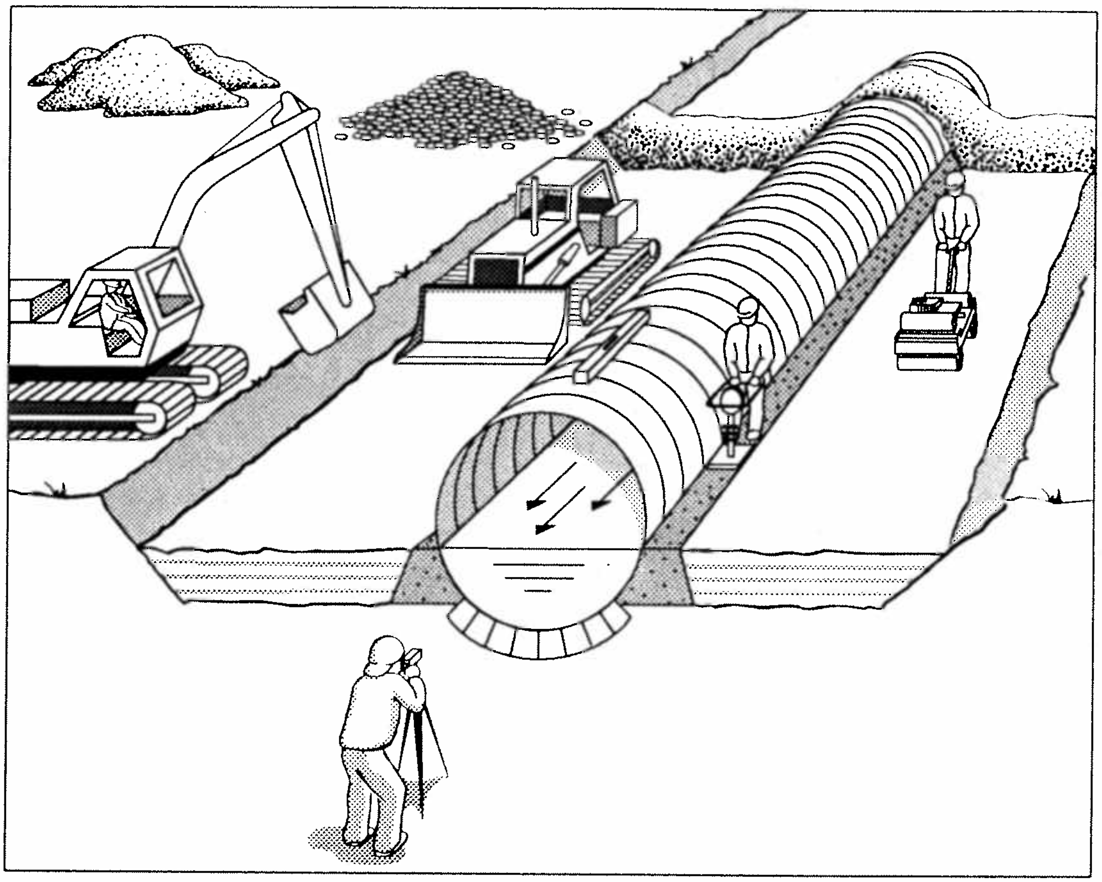
CSP Culvert Installation at Water Crossings on Forest Access Roads

Technical Note TN-013
May 1996

by R. G. Wilson



Ontario

Ministry of Natural Resources – Gogama

For Installers of Corrugated Steel Pipes (CSP)

This information in this technical note is intended for installers of round (less than 3 m diameter) galvanized culverts at water crossings on forest access (gravel) roads in summer conditions. Typically these culverts have a helical seam pattern and a diameter greater than 500 mm, based on stream or river conditions. A diameter of 3 m or more qualifies as a bridge, for which special engineering assistance is required on design and installation.

For the purposes of this technical note, it is assumed that the culvert size selection has been done. If you will be installing Multi-Plate CSP or other shapes such as ellipse and arch, contact your supplier for manufacturer's recommendations.

Maximize Your CSP Investment.

Take this technical note, especially the attached quick reference field card, to your work site!

THIS TECHNICAL NOTE WILL
make you aware of the importance of:

- why you must compact the soil
- step by step installation
- fish passage
- beaver control

Why you must compact the soil !

Pipe performance: You must thoroughly compact the soil, especially at the sides of the pipe, or the pipe will deform and not perform as required.

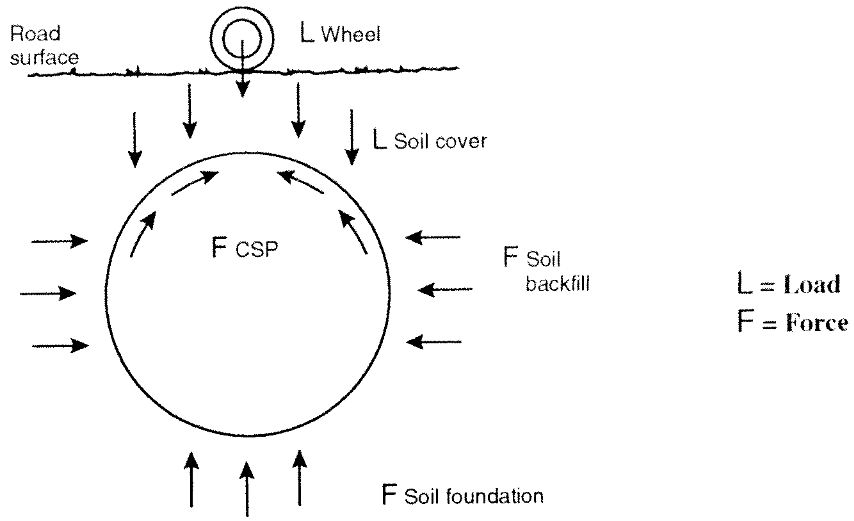


Figure 1 Theory
The loads spread in the soil and push downward. The forces resist. The CSP is a flexible thin steel ring that transfers the wheel and soil loads to the backfill and foundation forces to support the loads.

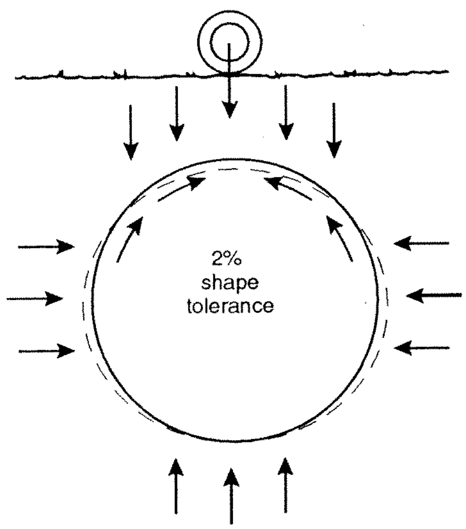


Figure 2

With soil forces
(with compaction)
Culvert supported
(dotted line)

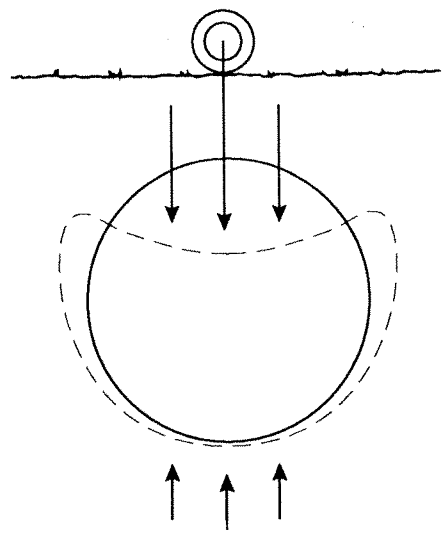


Figure 3

Without soil forces
(without compaction)
Culvert deflects and settles
(dotted line)

Corrugated steel pipe (CSP) supports loads by soil/steel interaction. Soil/steel interaction describes how the soil and the steel pipe work together. The soil around the pipe takes much of the load that is imposed on the pipe. Loads include the vehicle wheel loads and the soil cover above the culvert.

For a flexible pipe to function properly underloading, the top arc of the pipe must deflect downward slightly, (less than two percent of the pipe diameter). This downward movement results in an outward movement of the sidewalls. The dotted line in **Figure 2** shows this movement at an exaggerated scale. The outward movement must be contained and supported by the backfill material compacted along the sides or the pipe deflects too much, as in **Figure 3**.

The support provided by a firm foundation and compacted side fill allows the soil/steel interaction to achieve equilibrium or stability. Without the critical side support, the structure will not achieve the full load carrying capacity that is possible with proper soil/steel interaction.

Piping: Additionally, compaction densifies the soil around the pipe preventing piping, (i.e. slow water movement along the outside of the pipe), which erodes small soil particles, leading to washouts.

Step-by-step culvert installation

CSP culverts at water crossings will not perform properly when you:

- Install the wrong culvert length
- Fail to prepare a proper foundation
- Fail to provide adequate compaction

Follow these steps for a fast and effective installation. Fast installation means less time in the streambed and less disturbance to the environment. Effective installation means longer culvert life, and less maintenance.

1) Assemble the CSP
2) Acquire backfill
3) Dewater the work area
4) Prepare the foundation
5) Place and compact backfill
6) Provide erosion control

1) Assemble the CSP

This section describes:

- CSP specifications
- Couplers
- Length
- Handling
- End treatment

CSP Specifications

Be aware of CSP design specifications so you can tell the culvert designer what works best in the field. **Table 1** lists steel thicknesses typical for the round CSPs addressed in this Technical Note. Helical refers to the manufactured spiral seam pattern. SPCSP refers to structural plate corrugated steel pipe where the plates must be bolted together at the site or assembly yard. SPCSP has an annular corrugation pattern with the corrugations at right angles to the length of CSP.

Be cost-effective. Match the pipe diameter with the least expensive corrugation and steel thickness combination. For example, purchasing a 1400 mm diameter helical pipe with a 125 x 26 mm corrugation and steel thickness of 2.0 mm may be less expensive than a 1400 mm diameter helical pipe with a 68 x 13 mm corrugation and a steel thickness of 2.8 mm. Talk to your supplier.

Pipe Diameter	Corrugation	Steel Thickness
Helical CSP		
500-2400 mm	68 x 13 mm	1.6, 2.0, 2.8, 3.5, or 4.2 mm
1200-3000 mm	76 x 25 mm &	1.6, 2.0, 2.8, 3.5, or 4.2 mm
	125 x 26 mm	2.0, 2.8, 3.5, or 4.2 mm
SPCSP		
1810-2980 mm	152 x 52 mm	3.0, 4.0, 5.0, 6.0, or 7.0 mm

Table 1 Typical CSP Specifications

Couplers

Couplers join two lengths of CSP. The joint flexibility can increase curvature on alignment. The amount of curvature depends on the pipe diameter. For example, two couplers on a 2000 mm diameter 18 m long pipe, made of three 6 m lengths, can provide 180 mm of alignment change. Note that each joint gives 0.57 degrees or 60 mm of movement over a 6 m length of pipe. The change at the second coupler results in 120 mm of movement over the last 6 m of pipe. If more alignment change is required, use elbows.

A variety of couplers are available, including, universal (dimpled), corrugated, and hugger-band. Select one to withstand the rigors of installation and degree of waterproofing required. A 300 mm wide bolted-corrugated coupler is standard up to 1200 mm diameter. Use a 600 mm or wider, wide bolted-corrugated coupler to add handling stability for larger diameters. Match the coupler type to the pipe when purchasing.

If the (native) backfill cannot be compacted densely, import compactible material or consider water proofing the coupler to minimize leaking and erosion along the pipe. Wrap the joint with non-woven geotextile then apply the coupler. If waterproofing is essential, include o-ring or neoprene gaskets.

Length

Length can affect cost and stability.

Reduce transportation costs by bulk ordering various lengths and diameters of pipes, which fit inside each other. Reduce delivery time by ordering readily available standard stock lengths of 3, 6 or 7 m. Consider minimizing field assembly time by ordering the longest lengths possible. Custom lengths up to 18 m can be ordered from some suppliers. Order exact lengths to avoid field cutting. Lengths with rerolled ends (for annular couplers) are limited to 12 m. If the water crossing is at a remote location, consider the balance of delivery time and handling long custom lengths against the quick easy delivery and assembly time of SPCSP.

If coupling three varying lengths of CSP, (e.g. two 7 m and one 3 m), to form a culvert, position the shortest length in the middle, (i.e. put the 3 m between the two 7 m lengths). The longer continuous lengths will provide better resistance to potential uplift by ice or hydraulic pressure at the inlet and outlet.

Handling

Use a sling support when off-loading CSP from the delivery truck and when aligning it onto the prepared foundation. Wrap the CSP with rope, strap or cable at the two outside one-quarter points along the length of pipe. For safety and structural reasons, connect to cable slings that form a 45 or more degrees between the quarter points and the hoisting hook, (see **Figure 4**). Do not connect cable slings to lugs bolted or welded onto CSP. Lifting at lugs, or point sources, can overstress the pipe.

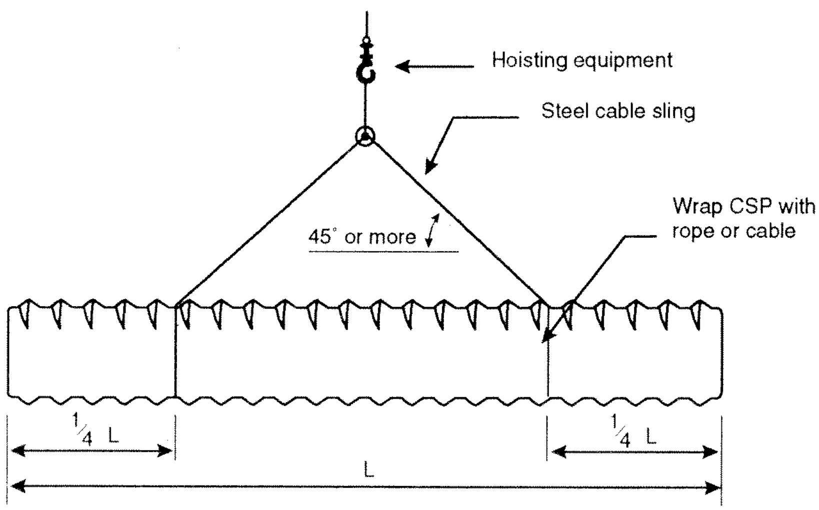


Figure 4 Moving CSP Culverts

End Treatment

Three end shapes are described: projecting, step-bevel and headwall. Typically the designer will have selected one for both the inlet and outlet of the culvert. Total dewatering is required to be able to install step-bevel ends with cut off-walls and for headwall ends.

Projecting End: This is the standard square-cut end supplied by the manufacturer; the common installation at water crossings on forest access roads. Because roadfill embankment slopes are set at 2H:1V and pipes are usually aligned at 90 degrees to the road, the correct length is "road top" width plus four times the height between the top of the road and the bottom of the streambed, (see **Figure 5a**). Skewed or angled pipe would have to be longer. Be aware that shorter pipes will encourage erosion on the embankment. Do not extend pipes more than one meter beyond the toe of slope. They will be susceptible to damage by scour and uplift pressures from fast water and ice.

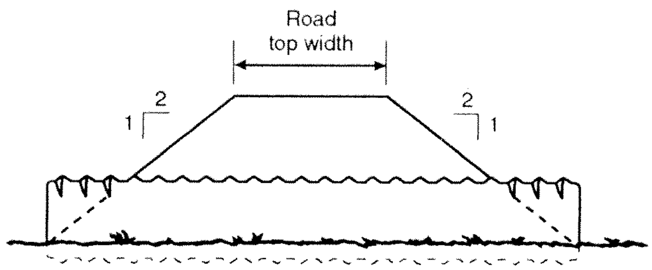


Figure 5(a) Projecting End

Step-Bevel End: This end is shaped to match the road fill slope. Water flow through the culvert is improved. Step-bevels have vertical cuts, or steps, at the top and bottom of the pipe for strength reasons. The pipe is sloped between the steps, (see **Figure 5b**). Avoid long cut ends for slopes flatter than 2H:1V. If helical pipe is used, bevelling ends is not recommended because of potential structural loading problems.

It is critical to understand that bevel-ended CSP is more susceptible to deformation from uplift and side pressures, and these issues must be addressed. Three techniques that can be used to strengthen bevel-ended CSP are:

- Tie back and deadman systems for side pressures
- Rolled angle lip stiffener
- Roll angle cutoff wall treatments for resisting uplift

Bevel ends may be factory or field fabricated. Factory cuts provide better quality control. Field cuts and zinc rich paint require attention to worker safety and environmental concerns.

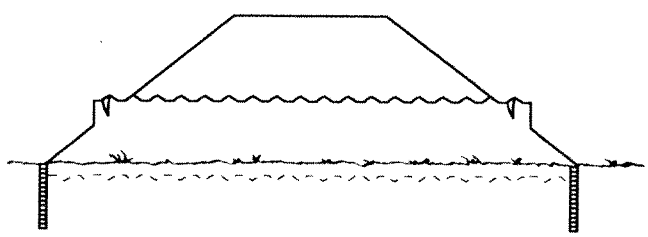


Figure 5(b) Step-bevel End

Headwall End: Headwalls protect the ends of CSP against ice, uplift and erosion. They also improve water flow and allow for a shorter pipe to be used. Fish passage is improved. Construct headwalls at least 200 mm above the top of the pipe and a minimum 900 mm below the bottom of the pipe, or below frost level, (see **Figure 5c**).

The advantages of reduced pipe length and improved water flow may pay for the extra cost of the headwall. Use prefabricated galvanized end-sections for structures up to 1800 mm diameter. To protect the ends of larger CSP structures construct concrete headwalls or anchor galvanized steel sheeting or pile drive headwalls. The use of culvert headwalls does not necessarily eliminate the need to protect the adjacent roadfill embankment against erosion. Consider additional rip rap or retaining walls.

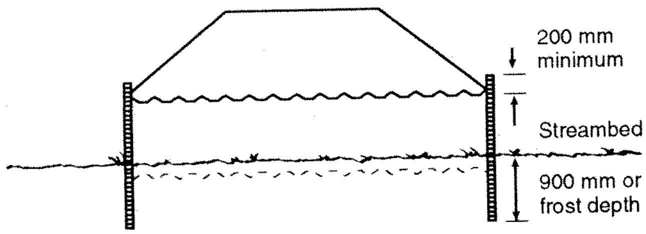


Figure 5(c) Headwall End

2) Acquire backfill

Ensure adequate quantity and quality of backfill at the site before foundation preparation.

Compactible soil is required within one diameter beside the pipe. The preferred backfill material, best first is:

- Well-graded sand and gravel, with sharp, rough grains (e.g. crushed gravel)
- Compactible sand or gravel (e.g. pit-run)
- Mixed soils: clay, silt, sand, gravel (at the site, or pit-run)

Use granular type soils as structural backfill around the pipe because they are easiest to compact and provide best support. Optimum moisture content is required for easiest and best compaction efforts. Most clays are not compactible because they are too wet. Wet clay is weak structurally – the CSP is less durable. Clay can be dried to optimum moisture content but it takes time and equipment. Clay compaction also requires non-vibratory equipment.

For structures up to 1200 mm, diameter used where preferred soils are not economically available, add extra cover or increase the CSP wall thickness and corrugation to offset lack of compaction. In very soft ground areas like the Clay Belt in northeastern Ontario road construction may have to be staged, allowing the soil around the culvert to consolidate for a year prior to final gravelling.

For structures over 1800 mm diameter, use backfill material meeting a design specification. See **Table 2** for specification based on weight of material passing through a series of screens.

Soil	Particle Size	% passing by weight (range)	
Silt	0.075 mm	0-12%	(example for sand:
Sand	1.000 mm	10-60%	Dry backfill sample then
Gravel	5.000 mm	30-90%	screen out particles 1.00 mm
	25.000 mm	70-100%	particles and smaller. They
	75.000 mm	100%	should weigh between 10
			and 60% of total sample.)

Table 2 Typical Specification for Well-graded Granular

Field test foundation or backfill material to address sediment control. Establish approximate percentages for soil particles by volume. Put a representative sample into a one-litre glass jar (fill half water, half sample) shake it vigorously then let it sit until the water is fairly clear. The soil particles will settle in layers, largest particles first smallest last. Measure the layers and convert to a percent (portion) of the total thickness in the jar. For example, if the sand layer is 30 mm and the sample is 100 mm: 30/100 x 100% = 30% sand, by volume.

The volume test gives a rough estimate of particle size distribution, useful for sediment control planning. But for large CSP installation the accepted method for quality control is drying, screening and weighing because you are more interested in quality of backfill rather than quantity. This is especially applicable for the backfill located within one diameter of the CSP.

3) Dewater the work area

It is very important to note that all culvert installations are site specific. While dewatering will provide for better foundation preparation and backfill compaction, you must always be aware of environmental concerns. Know the site and adjust installation to suit it. Use total, partial or no dewatering.

You are the installer. You've walked the proposed road right-of-way centerline, well ahead of the road construction, and find yourself at the water crossing site for the first time. A designer has selected the culvert size (diameter) during planning. As a responsible field operator, visualize the construction and ask yourself:

- Are the soils actually what was anticipated? Is importing necessary?
- Is the water deeper, wider or faster than what was anticipated?
- Will access to the far shore be necessary or possible?
- Are the road approaches steeper than what was anticipated?
- What vegetation can I preserve while accessing the site?
- Does the stream contain warmwater or coldwater fish species?
- Can I install this culvert at the scheduled date without negatively impacting fish passage?
- What erosion/sediment controls are necessary?
- Should I drop the culvert proposal and recommend an arch or bridge?

Assuming a culvert and the timing is acceptable, ask yourself:

How can I reduce the amount of water in work area to maximize the quality control especially compaction?

You'll need to know because the CSP manufacturer recommends in-the-dry installation, the government approval agencies will be asking you, and most important, you want the culvert to function properly for a long time with minimal maintenance costs.

Total dewatering or in-the-dry is preferred, especially for larger diameter pipes.
Some advantages include:

- Accurate grade and alignment control
- Best compaction, especially with native backfill material
- Less expensive CSP (thinner wall steel)
- Assurance that the crossing will withstand long-term loading
- Increased ability to control sediment

There are some potential disadvantages to in-the-dry installation. Some are:

- Cofferdams or ditch diversions may impact the environment more than brief but intense instream installation
- Construction cost may far outweigh the culvert benefits.

Partial dewatering, or in-the-wet, is acceptable only in specific circumstances. The challenge of partial dewatering is to properly place the backfill below the CSP haunches, and to compact backfill within any remaining water. If water remains, use a good quality clean pea-size stone backfill material under the haunches to provide full contact and long-term pipe support. It may also be advisable to increase pipe steel thickness from that normally used for the given size and loading conditions. Contact your supplier to match the steel thickness to the method of installation.

No dewatering is a practical compromise in some circumstances, (e.g. culverts up to 1200 mm diameter in flat swamps with deep organics and slow moving water). Diverting water would greatly disturb the environment and partial dewatering is ineffective due to high seepage flows through the organic ground. It may be optimum to roughly prepare the foundation allowing for camber (see page 14) and ensuring that grade and water depth will allow for fish passage once culvert is set in place. A non-woven geotextile can be used as a separator and reinforcement between the natural foundation material and the bedding material the installer chooses to use. A good pea-sized stone will provide the best bedding under these circumstances.

Site environmental requirements will vary so be prepared to provide a sediment control plan (SCP) to the Ministry of Natural Resources (MNR), at their request, describing the procedures you will use to dewater the work area. The following two sections briefly describe partial and total dewatering procedures.

Install culvert in-the-wet: Partial Dewatering

You can minimize dewatering costs if:

- The water can be waded safely for manual measurement
- The streambed is firm
- You can prepare the culvert foundation with a backhoe in several hours (site specific)
- The fish habitat is not sensitive to disturbance, or is easily repaired
- Total dewatering will do more environmental harm compared to in-the-dry benefit

Once the foundation is prepared with the backhoe, check the design grade and alignment. Roll or sling the culvert into place. Carefully place sandbags or pile backfill beside the inlet and outlet of the culvert to divert all the stream water through the culvert. Check the grade again. Pump the water from along the sides of the culvert to a filtering area in the forest, (see **Figure 6**). Self-priming pumps operate at up to 10 percent mud (by volume); trash pumps up to 25 percent.

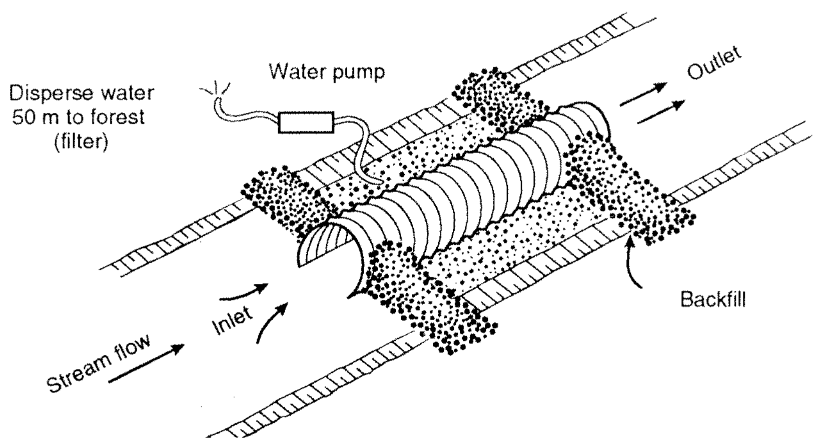


Figure 6 Partial Dewatering Work Area

Install culvert in-the-dry: Total Dewatering

Dewater the work area if:

- The water cannot be waded safely for manual measurement
- The streambed is not firm
- You cannot prepare the culvert foundation with a backhoe in several hours (site specific)
- The fish habitat is very sensitive to disturbance
- Total dewatering will not do more environmental harm compared to in-the-dry benefits

Place temporary cofferdams upstream and downstream, positioned to create adequate working space inside the protected area. Cofferdams may be constructed from a variety of materials:

- Sand bags
- Granular material
- Rock rip rap
- Steel or wood sheet piling.

Material selection may be dictated by site conditions such as the nature of the streambed or concern over siltation. Use pumps, pipes or ditches to pass water from the upstream cofferdam beyond the downstream cofferdam, (see **Figure 7a**). Consider lining bypass channels with geotextile to minimize erosion. Set overlaps (1 m minimum) to suit flow. On larger streams, and where seasonal water flows allow, cofferdams can be installed to create a narrowed channel adjacent to the CSP installation area. For multiple structure installations, install and partially backfill one culvert in-the-dry then allow water to flow through it by cofferdamming the remaining work area, (see **Figure 7b**).

Other options for total dewatering include creating a new stream alignment, leaving natural cofferdams and installing the culvert then allowing the stream to flow through the new alignment. For a slow moving stream, build the upstream cofferdam high enough to store water for a time long enough to allow foundation preparation, placing of culvert and initial backfilling without the requirement to pass water during culvert installation. Be aware of seasonal water flow and the weather.

Prior to removing cofferdams, complete all slope stability and all erosion control below the water level. Remove the downstream cofferdam first, let the water accumulate in the culvert then remove the upstream cofferdam. If the cofferdam material is suitable, use it to complete erosion control above the water level.

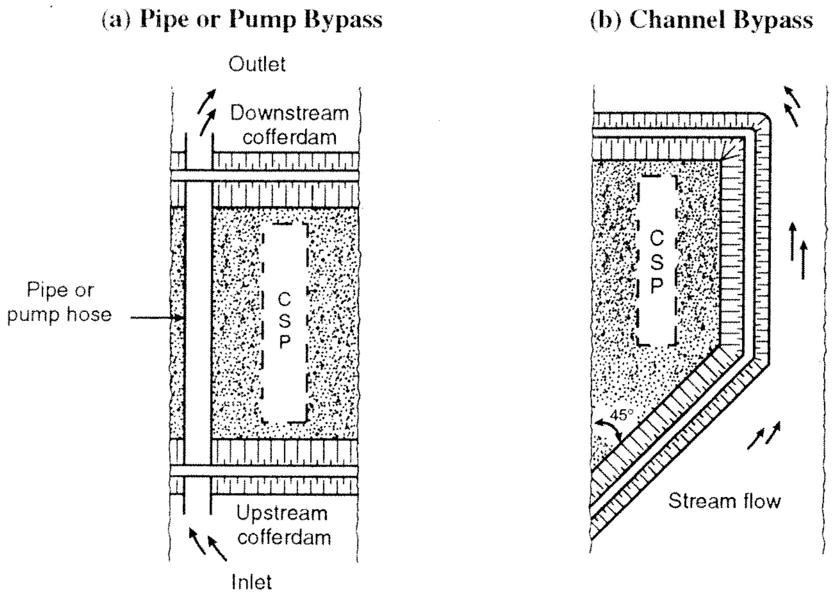


Figure 7 Total Dewatering Work Area(s) - aerial view

4) Prepare foundation

The foundation, sometimes called the pipe bed, must provide adequate bearing capacity to support the pipe and the road fill. A proper foundation limits settlement-stress on the pipe. Remove all vegetation, loose sediment and rocks larger than 75 mm. Expose firm soil. Remove material of poor or non-uniform load-bearing capacity.

Set the correct alignment and grade for the pipe. Failure to provide for adequate fish passage is a violation of the Federal Fisheries Act (FFA). Refer to Fish Passage for more details.

Alignment: Culverts restrict the stream flow and can cause water to speed up through the pipe. Align the pipe to avoid increased erosion on downstream banks. Install a pipe that is long enough to direct the water as naturally as possible. Long culverts can be aligned on a slight curve. Use deflection at the joint couplers to slightly increase curvature.

Grading: Proper grading will encourage formation of a shallow sediment layer in the pipe, and ensure enough flow depth for fish migration. Set the culvert grade as level as possible. Set the elevation of the culvert invert (bottom) so that 10 percent of the culvert diameter will rest below the existing streambed and provide a minimum of 200 mm water depth, (see **Figure 8**). During flood periods, the sediment layer will quickly erode to provide full use of the culvert for the design water passage. This practice will also minimize future undercutting or scour at the culvert inlet and outlet.

Shaping bedding: Shaping reduces the time and effort required to place and compact material under the haunches. Excavate and shape the foundation soil to fit the pipe. Remove all embedded boulders to provide a uniform surface and mitigate piping, (i.e. long-term erosion below the bottom of the pipe). Shaping should allow for any additional bedding material required to ensure full pipe-ground contact. Before placing bedding material, especially on soft ground, consider placing non-woven geotextile in order to separate native ground from bedding, and to provide additional bearing capacity to the foundation. Bedding material may not be required if the foundation soil is firm and supports a person leaving only a slight footprint impression. In this situation, loosen the soil to a depth of 150 mm for a width of one-half diameter to provide a cushion directly under the pipe. Ensure that the pipe corrugation makes full contact with the soil.

Shaping streambanks: Remember that you are constructing a soil/steel structure. For example, don't visualize a 2 m diameter CSP. Visualize a 6 m wide soil/steel structure with 2 m for the CSP plus 2 m each for the side compaction. **Figure 8** shows some minimum guidelines. Use minimums where the streambank soil is naturally stable and dense.

Spacing: If you are installing more than one CSP, place them one-half diameter or more apart but ensure enough space for backfill soil placement and compaction equipment.

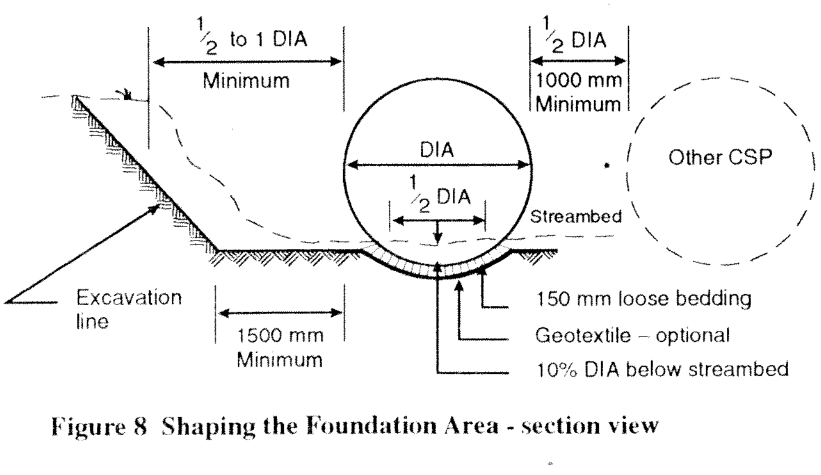


Figure 8 Shaping the Foundation Area - section view

Camber: Soft foundations will ultimately settle, distorting the pipe, reducing the flow capacity of the pipe and potentially blocking fish passage. If the CSP is to be positioned under a high road fill or on a foundation that you anticipate will settle, like a swamp, create the foundation and build camber. Soft foundation preparation requires extra excavation and bedding, (see **Figure 9a**).

Camber describes positioning the centre of the pipe higher than normal in relation to the ends of the pipe, so when settlement occurs, the pipe moves down to the optimum position. Build a camber by grading the upstream half of the foundation level and the downstream half on a steeper grade to make up the total grade of the pipe from inlet to outlet, (see **Figure 9b**).

If settlements greater than five percent of the pipe diameter are expected, seek professional geotechnical advice. Base expected settlement on either practical experience or a site-specific geotechnical investigation. Be aware that settlement of the pipe may not be as great as settlement of the fill on either side of the pipe, because the area of the pipe is air not fill.

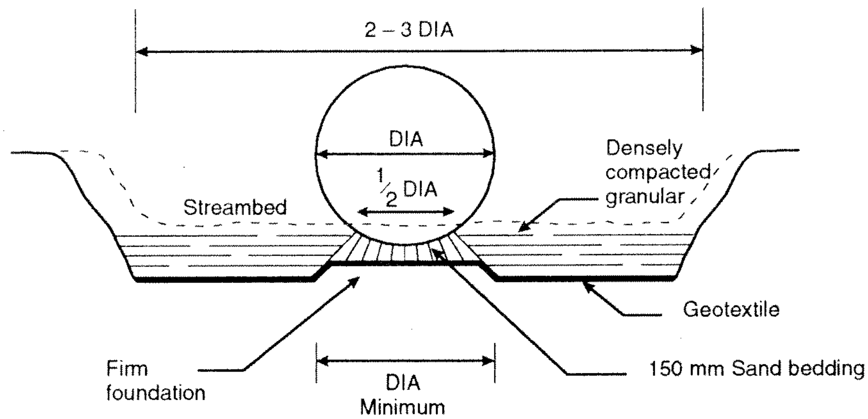


Figure 9(a) Excavation and Bedding for Soft Foundations - section view

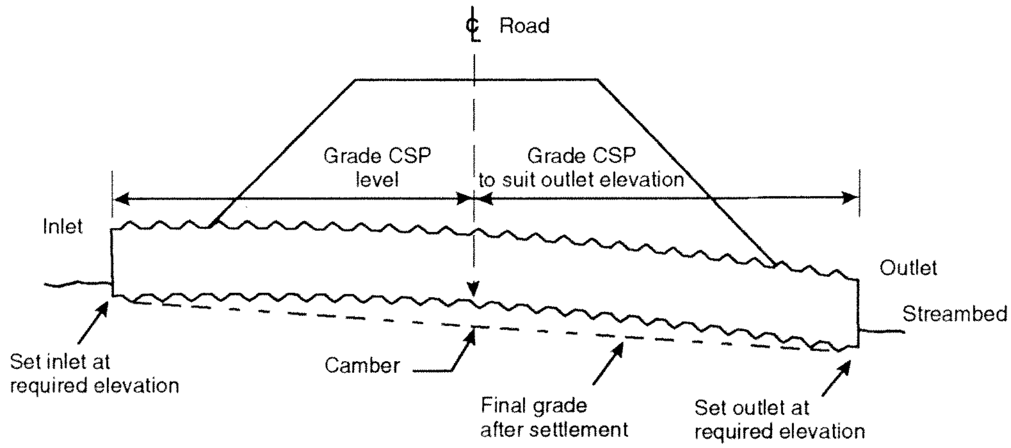


Figure 9(b) Camber - profile view

Figure 9 Foundation Preparation - for Soft Foundation or High Road Fill

5) Place and compact backfill

This section describes shape control and procedures to place and compact material at several locations around the pipe, from bottom to top. Compaction specifications and equipment are also described.

Shape control: Material placement and compaction must be done carefully to control pipe shape. The recommended tolerance is plus or minus two percent of the rise for round pipes. Refer back to **Figure 3**. For example, if the pipe is 2.00 m in diameter, the final in-place vertical dimension should be between 1.96 m and 2.04 m. Monitor the diameter as the backfill is placed and compacted to the one-quarter, half and top of pipe.

Placement and compaction of the bottom, or bedding, material has already been discussed in the section Prepare Foundation. **Figure 8** shows a 150 mm thick cushion layer of loose bedding shaped and/or placed.

Under the haunches: Once the CSP is in-place over the bedding use a pole or 2" x 4" lumber to hand-tamp under the haunches, (see **Figure 10a**). Ensure complete soil-pipe contact.

Beside the pipe: After the haunches are compacted use small compaction equipment. Remember the soil-steel structure (minimum) dimensions indicated in **Figure 8**. Place material on both sides of the pipe and spread in layers 150 to 300 mm thick depending on the type of compaction equipment being used, (see **Figure 10b**). Thin layers must be used to ensure complete compaction. Maintain fill at the same grade (tolerance 400 mm) on each side of the pipe at all times.

As the layers rise, hand-compact within 300 mm of the CSP to avoid damaging the steel. Use small jumping jacks or vibrating plates. Do not use backfill with stones larger than 75 mm close to pipe.

Away from the pipe, use vibrating or tamping equipment operating parallel to the pipe, (i.e. along the pipe). Maintain this direction until three-quarters (3/4) of the pipe's height is compacted.

Compaction specification and field test: Compact side backfill to minimum 90 percent Standard Proctor Dry Density (SPDD). SPDD is a testing specification and requires Standard Proctor testing equipment. For a rough "boot test" of 90 percent SPDD for a well-graded granular material check if your boot leaves any footprints (it shouldn't) or if jamming your heel against the soil to be tested leaves more than a 15 mm dent (it shouldn't).

Moisture content: Granular backfill should be kept moist at all times. Compacting at optimum moisture content will ensure best results. With the soil at the correct moisture, the compactive effort packs the soils closely to expel most of the air; too dry and the soil stays loose; too wet and the soil becomes mud.

Armtec Construction Products

Equipment: Use equipment not heavier than 7300 kg (e.g. D-4 dozer) for spreading material and not heavier than 1000 kg (e.g. Bomag BW-75S, Dynapac LG 700) for compacting. Bomag's "Light Equipment Compaction Guide" indicates the BW-75S will compact 90 cubic meters per hour with four passes over a granular lift thickness of 300 mm. That is about two hours of compacting for a 2 m diameter CSP 20 m long, compacting 2 m each side. If you are unsure of your equipment's effectiveness:

- Select a layer thickness and pass your compactor over two to four (2 to 4) times
- Check compaction within the entire layer as you pass
- Vary the layer thickness until the specified compaction can be achieved in four (4) passes

Above the pipe: Once the sides are backfilled, carefully place a loose 300 mm thick top arc cushion of granular. Operate the construction equipment perpendicular to the pipe, i.e., along the roadway, (see **Figure 10c**). Do not operate parallel to the CSP. Do not cross over the pipe with compaction equipment until the side fill is even with the top of the 300 mm cushion.

Minimum cover: Ensure a minimum cover of 300 mm or diameter/6, (e.g. 3000/6 = 500 mm), before placing and compacting the design road fill. Road fill design may require more than 90 percent SPDD. Once the total backfill pipe cover is 600 mm or greater, heavier equipment may be used spread and compact road embankment fill. Construct to the road surface grade.

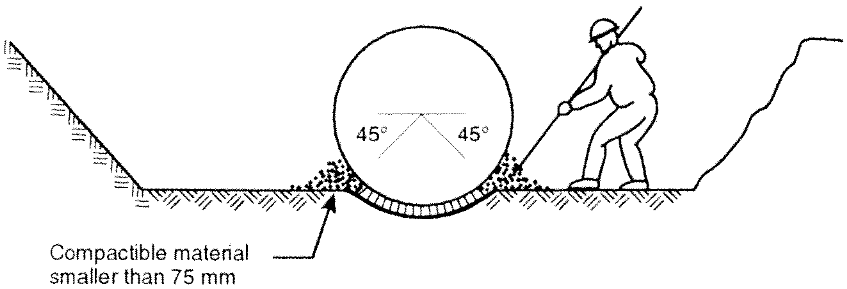


Figure 10 (a) Foundation - hand tamp below haunches

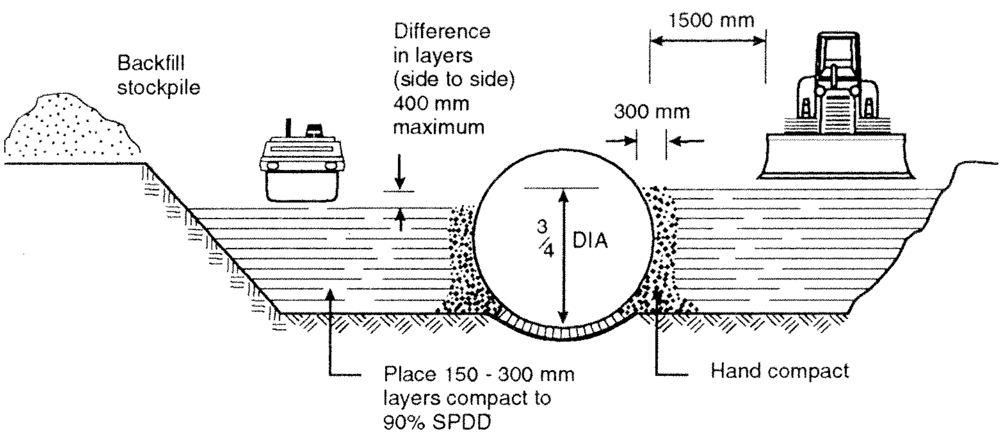


Figure 10 (b) Up to 3/4 Dia High - place & compact parallel to CSP

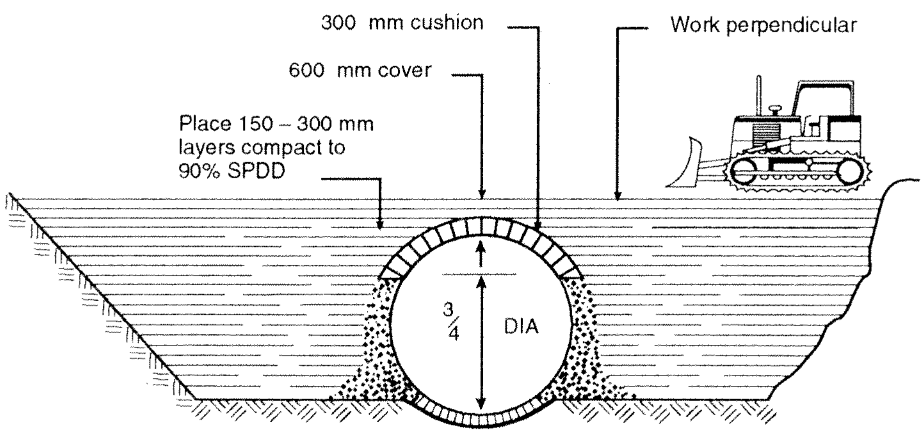


Figure 10 (c) Over 3/4 Dia High - place and compact perpendicular to CSP

Figure 10 Place and Compact Steps - haunches, sides and top

In rare situations, if compaction will be limited by the construction equipment or the backfill material at site, place extra road fill and/or use thicker steel. Be aware that extra road fill may or may not be acceptable with respect to the road design grade. **Table 3** lists steel thickness and minimum cover for standard installation and poor installation.

		Standard Installation		Poor Conditions Installation		
Diameter (mm)	Corrugation (mm)	Thickness (mm)	Minimum Cover (m)	Thickness (mm)	Minimum Cover (m)	Maximum Cover (m)
500	68x13	1.6	0.30	1.6	0.30	10+
600	68x13	1.6	0.30	1.6	0.30	10+
700	68x13	1.6	0.30	1.6	0.35	10+
800	68x13	1.6	0.30	1.6	0.40	10+
900	68x13	1.6	0.30	1.6	0.45	9.5
1000	68x13	1.6	0.30	1.6	0.50	8.5
1200	68x13	2.0	0.30	2.0	0.60	9.0
	125x26	2.0	0.30	2.0	0.60	9.5
1400	68x13	2.8	0.30	2.8	0.70	10.0
	125x26	2.0	0.30	2.0	0.70	8.0
1500	152x51	3.0	0.30	3.0	0.75	10+
1600	63x13	2.8	0.30	2.8	0.80	8.5
	125x26	2.0	0.30	2.0	0.80	7.0
1660	152x51	3.0	0.30	3.0	0.85	10+
1800	68x13	3.5	0.30	3.5	0.9	8.5
	125x26	2.0	0.30	2.0	0.9	6.0
1810	152x51	3.0	0.30	3.0	0.9	10
1970	152x51	3.0	0.35	3.0	1.00	9.0
2000	68x13	4.2	0.35	4.2	1.00	8.0
	125x26	2.0	0.35	2.0	1.00	5.5
2120	152x51	3.0	0.35	3.0	1.05	8.5
2200	125x26	2.0	0.40	2.0	1.10	5.0
2280	152x51	3.0	0.40	3.0	1.15	8.0
2400	125x26	2.0	0.40	2.0	1.20	4.5
2430	152x51	3.0	0.45	3.0	1.25	7.5
2590	152x51	3.0	0.45	3.0	1.30	7.0
2700	125x26	2.8	0.45	2.8	1.35	6.0
2740	152x51	3.0	0.50	3.0	1.40	6.5
3000	125x26	2.8	0.50	2.8	1.50	5.0

Table 3 Steel Thickness and Minimum Cover - Standard and Poor Installation

Notes:

1. Standard is recommended best practice. Poor is less than best practice in whole or in part.
2. In all standard installations, the maximum cover is at least 10 m. Contact manufacturer regarding greater heights.
3. If minimum coverage for "poor condition installation" is less than that shown, increase the wall thickness. Minimum cover for "standard installation" is absolutely minimum for that pipe diameter.

√ DO	X DO NOT
• use well-graded granular • place backfill in layers 150 - 300 mm thick material • compact within one (1) dia each side of pipe • keep fill depth same both sides max. vertical difference 400 mm • use hand compaction equipment within 300 mm of pipe; limit cobbles to 75 mm • compact at optimum water content • monitor shape and grade control • compact parallel for 3/4 dia height • place 300 mm cushion on top arc • compact remaining perpendicular • add cover for protection	• use very dry or very wet material • end-dump or doze against CSP • let heavy equipment within 300 mm of CSP • use frozen material • use organic material

6) Provide erosion control

Minimize your maintenance costs at water crossings:

- Trim all disturbed ground and road embankment to 2H:1V or flatter
- Install all erosion control as soon as possible.

Sediment Control Plan (SCP): The installer, with the help of the designer, should be prepared to provide a sediment control plan (SCP) to the MNR. It will be a formal requirement for approval of the more environmentally-sensitive water crossings but is a good practice to have for all crossings. Think of a SCP simply as a construction plan with added notes and sketches addressing site specific erosion and fish habitat concerns; a handy reference for the installer and government inspectors. SCPs can be as simple as one page or as formal as a consultant's report with full size design drawings. Contact your local MNR office for their requirements.

Temporary: Address temporary erosion control in your sediment control plan; provide details for dewatering, silt fences, daily inspection, for both the water crossing and the roadway 100 m each side of the stream. The MNR "Environmental Guidelines for Access Roads and Water Crossings" and "Instream Sediment Control Techniques - Field Implementation Manual (NEST FG-007)" both describe numerous practical techniques.

Permanent: Address permanent erosion control to protect the culvert; install rip rap and/or grass seed and fertilizer, (see **Figure 11**). Rock rip rap size, for a typical water crossing, has a range of 50 to 500 mm with an average size of 200 mm. Install rip rap over a non-woven geotextile to a minimum layer thickness of one and one-half times the average rock size. If the layer is over two times the average rock size, and well-packed, the geotextile is optional but use geotextile at all ground water seepage or rapid water level fluctuation locations.

Install grass seed mixture that grows successfully on road embankment in your area. Confirm any seed impact on local vegetation. Confirm any impact of fertilizer which might be washed over time into the stream. Avoid polluting the water with harmful chemicals.

If the road fill is very coarse granular, carefully tamp impermeable soil (clay) to form a one-metre collar at the inlet and outlet to prevent water flowing along the outside of the pipe. Even slow moving water can wash away fill and ultimately cause pipe distortion or road washout. Install geotextile over the clay and cover it with rip rap. If erosion along the outside of the pipe is a serious concern and if clay is not readily available consider a prefabricated anti-seepage collar of galvanized plate or flexible polyvinyl chloride (PVC) sheet at the midpoint along the CSP – prior to backfilling.

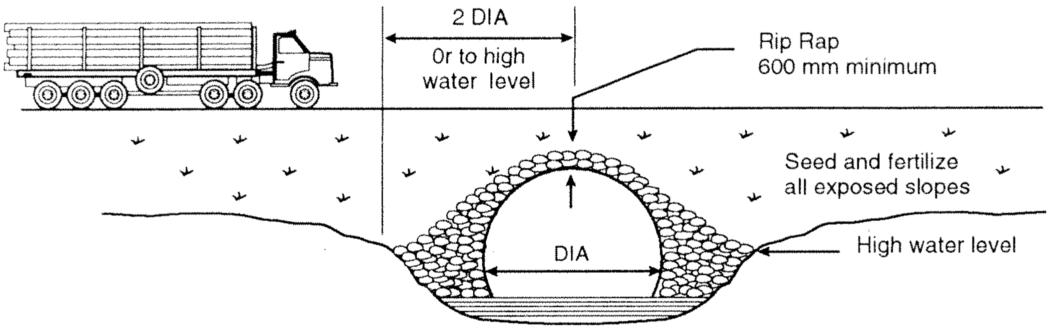


Figure 11(a) Erosion Control - Profile View

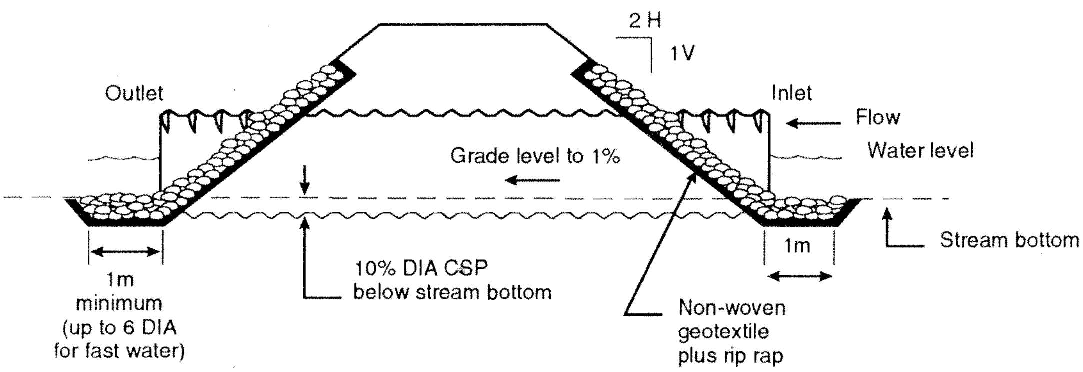


Figure 11(b) Erosion Control - Section View

Figure 11 Erosion Control

Fish passage

You are violating the Federal Fisheries Act (FFA) if you cause unauthorized harmful alteration, disruption, or destruction of fish habitat. Penalties include:

- Cost to repair
- Fines up to $1 million
- Possibly three years in prison.

Fish habitat includes everything that fish require for food, cover and reproduction. A violation for example, is preventing fish from moving in a stream from food source to food source, or along the stream to a spawning area. Confirm site specific data and authorization with your local MNR.

The water crossing designer must address fish passage when selecting culvert diameter, length, slope or grade. Culverts can cause stream water to speed up as it passes through. Fish have to swim faster in culverts than they do in the stream. Swimming ability varies with fish species and fish size. For example, speeds for spawning walleye, white sucker and rainbow trout are limited to about 1.3 metres per second (m/s) after a 20 metre distance; and about 0.6 m/s for spawning northern pike and brook trout after a 20 metre distance. Once the culvert is selected to suit watershed water flow, the designer may limit the water speed or give the fish a resting place by:

- Flattening the CSP grade
- Creating CSP slow flow backfill, (e.g. placing boulders near the outlet)
- Increasing the CSP diameter
- Shortening the CSP by incorporating headwalls
- Adding baffles inside the CSP

The culvert installer must be very aware of setting the proper foundation grade. Consider the following:

- Perched culverts where fish have to jump up and into the culvert outlet, prevent or severely limit passage. Correctly set the culvert (or at least one of multiple culverts) so that ten percent of the culvert diameter will rest below the existing streambed and provide a minimum of 200 mm water depth.

- The slope, or grade along the culvert, dramatically affects the water speed. Set slope grades for lengths up to 25 metres, preferably level–up to one percent. For lengths over 25 metres limit the slope to 0.5 percent. Steeper streambeds, if the location is approved, may require use of baffles (fish resting areas). Seek design assistance.

The culvert installer must be very aware of any construction scheduling restrictions. The MNR restricts work during times of fish migration, spawning and egg incubation periods. Contact your local MNR office. Construction in Ontario is normally limited to:

- June 15 to November 30 warmwater fish species
- June 1 to September 30 coldwater fish species

Provide a sediment control plan for sensitive fish habitat. For a less sensitive water crossing, for example if the streambed is firm and granular, the MNR may allow culvert foundation preparation to proceed for several hours with little or no sediment control but approval will be site specific. Be aware that unauthorized harmful alteration, disruption, or destruction of fish habitat can be very costly to repair.

Beaver control

Beaver activity at a water crossing can occur periodically or it can be more of a chronic problem. Plugged culverts and road washouts are the concern. Periodic activity can generally be handled quickly with few long-term effects. Repairs are made and the beavers move on or are removed. Chronic beaver activity at a water crossing presents greater challenges for the road foreman.

Minimize chronic road maintenance costs with a small investment in fences, grills, or pond levellers, (see **Figures 12, 13, and 14**). Working around water control structures can be hazardous. Take appropriate safety measures. Beware of the following:

- Fast flowing water
- Irregular and slippery bottoms
- Cold water
- Being drawn into culverts
- Isolated work sites
- Unstable bottom

Install a grill at low activity locations. Clear the grill of debris as-required and prior to storm or flood times. Clear grill blockages for fish passage within three days during spawning activity. A pull-rod grill is shown in **Figure 13**.

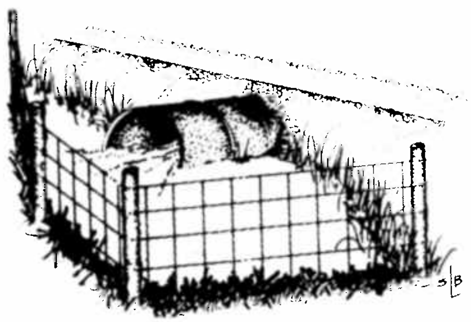


Figure 12 Beaver Fence

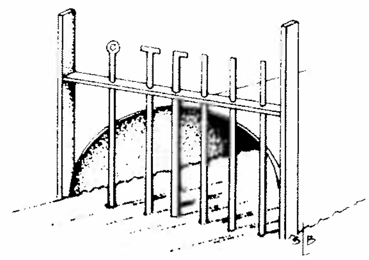


Figure 13 Removable Pull-rod Grill.

If the road is used by the beavers to create a pond, and culvert is often blocked, consider installing a pond leveller to minimize maintenance costs. The device will ensure the pond level does not rise above the road during low flows. One of many, the Clemson Beaver Pond Leveler is shown in **Figure 14**. Cleaning of the grill at the culvert will be limited to an as-required (e.g. before for storms) but less frequent basis. The culvert designer would have to account for the leveller's PVC pipe in the culvert, regarding size and fish passage.

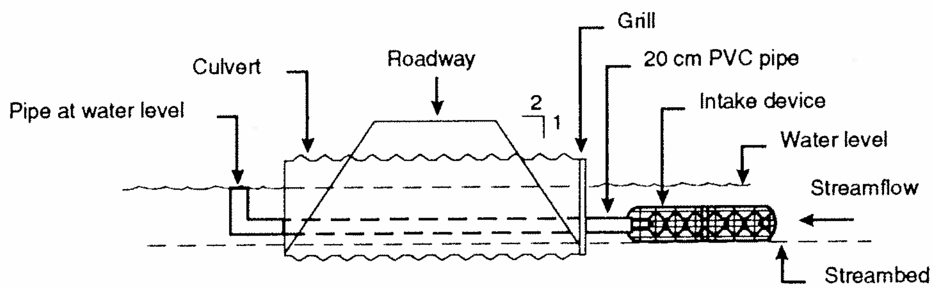
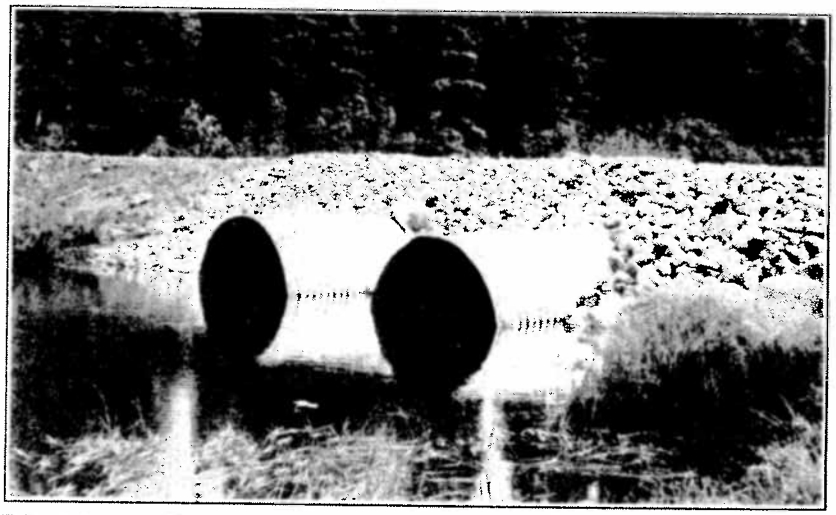


Figure 14
Clemson Beaver Pond Leveler with Culvert Inlet Grill



E.B. Eddy Forest Products LTD. – M^cChesney Lumber Division

Note to Installer:
The installation methods described in this technical note have been developed as an aid to help improve the performance of culvert pipes on gravel forest access roads, in some cases in difficult circumstances. Be aware that CSP culverts perform best when installed as recommended by standard practice, i.e. when installed in-the-dry using granular fill. Attention to the choice of backfill material and its placement and compaction will protect the design and help owners to protect their investment.

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R. G. (Bob) Wilson
Senior Project Engineer
Northeast Science
& Technology

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Telephone: (705) 360-8201
Facsimile: (705) 267-3636