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# Bridging the Gap: A Comparative Look at Fish Passage Guidelines Across Jurisdictions

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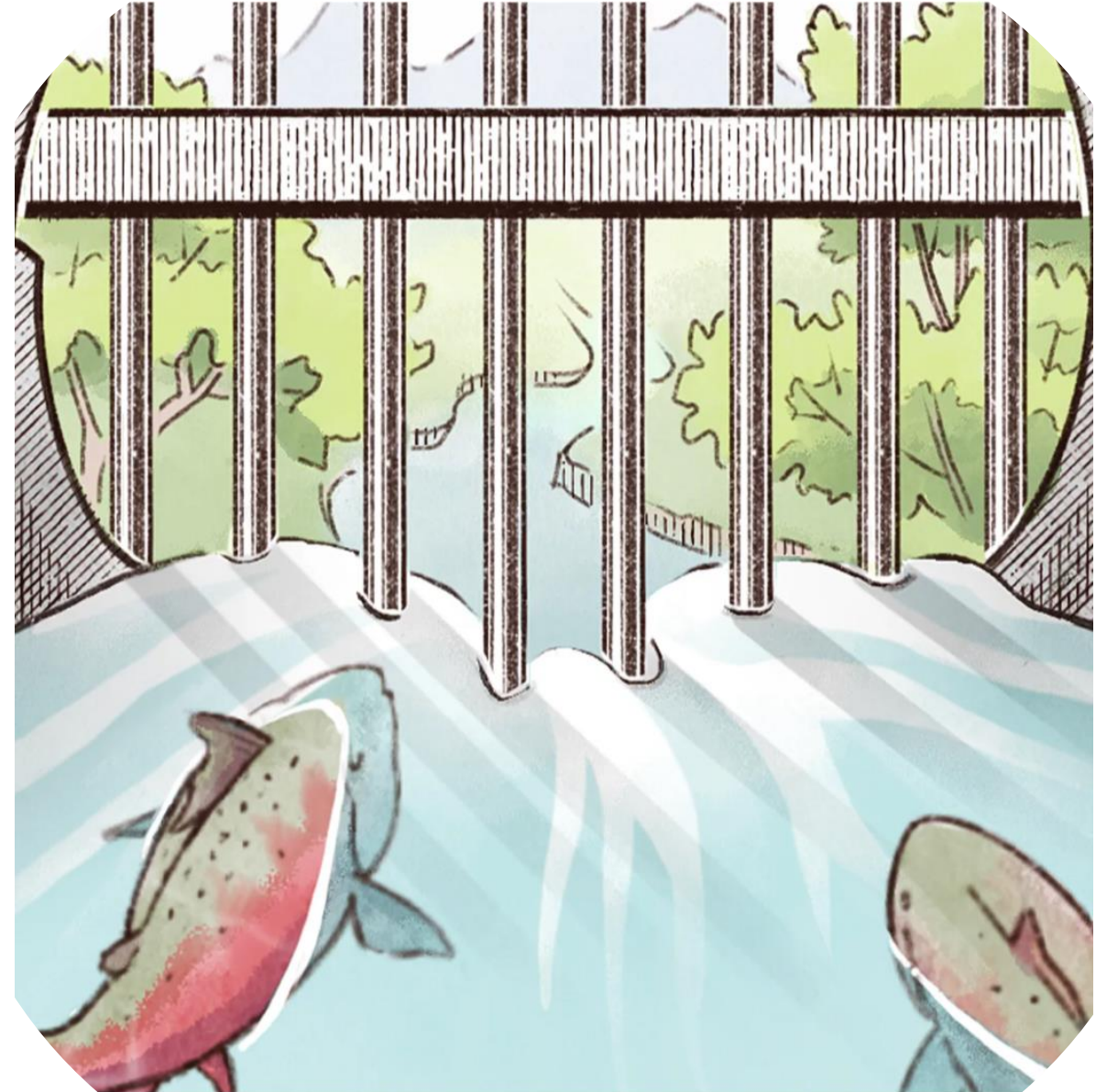


Image credit: Seattle Times, 2024



Image credit: DFO, 2022

# Agenda

1. Why fish passage?
2. Culverts as barriers
3. The challenge
4. Where guidelines align
5. Where guidelines diverge
6. Let's design a culvert
7. Comparing culverts
8. Takeaways



# Why Fish Passage?

- **Fish passage:** ability of fish / other aquatic species to move through a water system
- Migration is essential for spawning and other lifecycle behaviours
- Anthropogenic barriers to fish passage disrupt movement
  - Dams
  - Weirs
  - **Culverts**

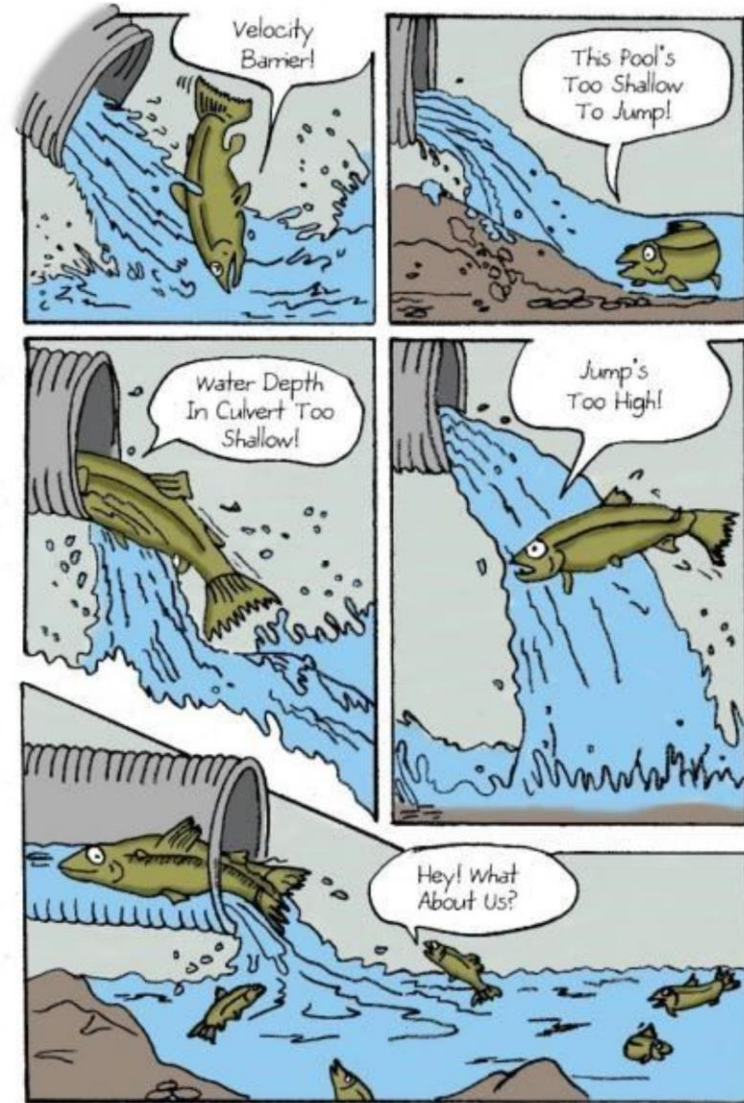


Image credit: Washington State Department of Transportation (WSDOT)



# Culverts as Barriers

- Culverts historically designed primarily for **hydraulic conveyance**
  - **HADD** potential
- Recent recognition of importance of **ecosystem connectivity**
- **Stricter DFO requirements** for fish passage at crossings

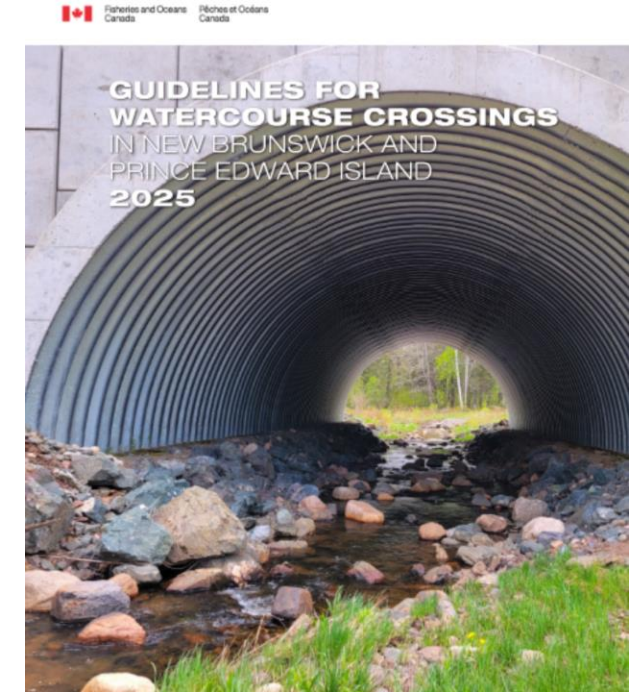
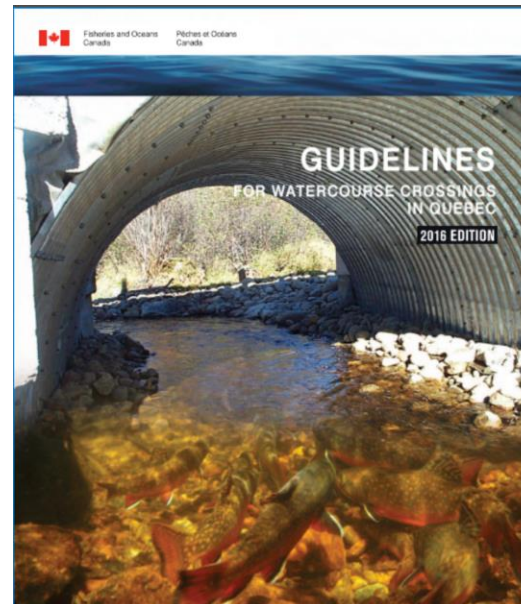
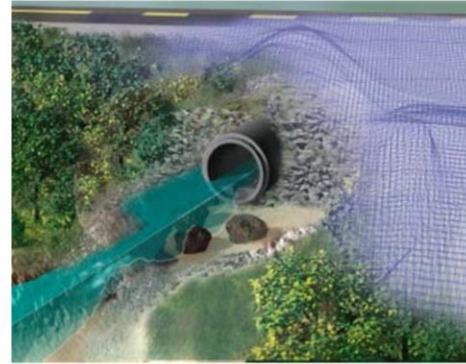
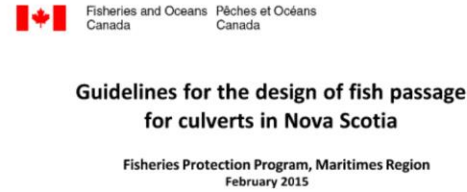


Image credit: US Forest Service (USFS), 2009



# The Challenge

- A patchwork of guidance documents to navigate
- In Canada:
  - Non-unified guidelines from DFO for **some provinces** (e.g. NS, PEI, NB, Quebec, NL, BC, MB)
  - Provincial transportation/**culvert hydraulic design** guidelines





# The Challenge

- In U.S.:
  - Similar to Canada, select **state-issued guidelines** are available
  - **Federal guidelines** available from U.S. Forest Service
  - **Fewer discrepancies** compared to Canadian documents





Image credit: Department of Fisheries and Oceans Canada, 2016

## Where Guidelines Align

Open-bottom always preferred



Image credit: Minnesota Department of Transportation (MDOT), 2019

## Where Guidelines Align

Maintain adequate water depth under low-flow conditions (min. 150-200 mm typically)

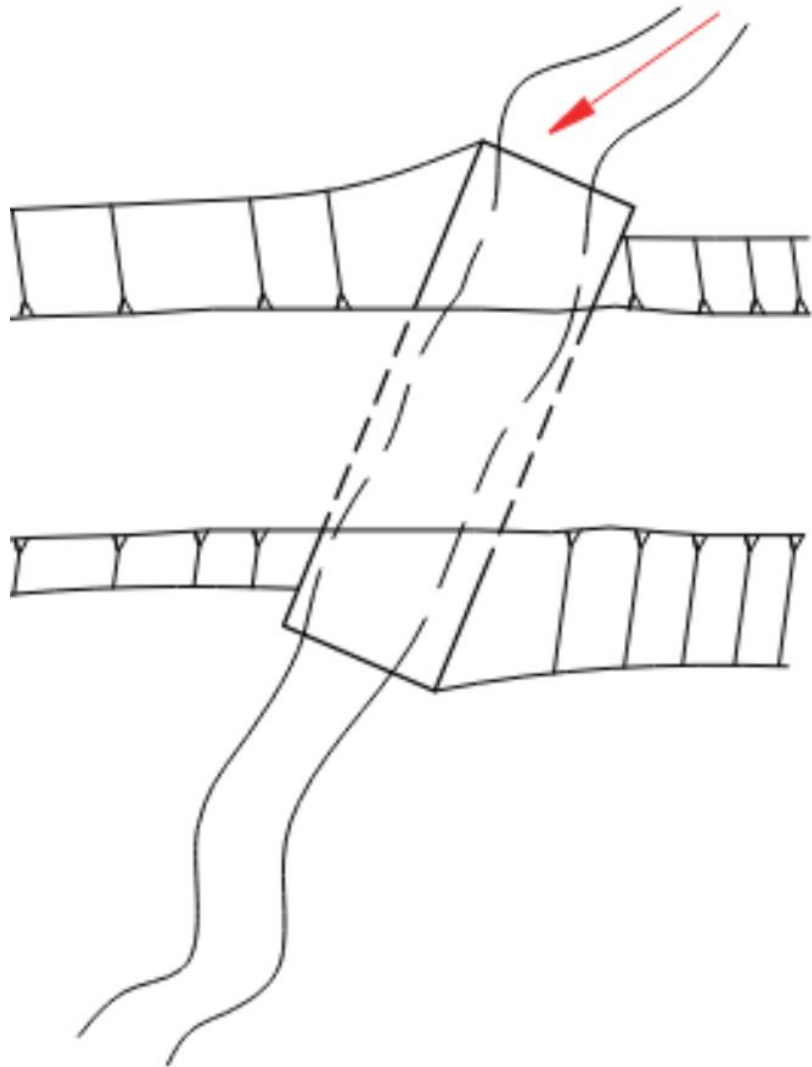


Image credit: USFS, 2009

## Where Guidelines Align

Align culvert with natural channel to extent possible



Image credit: MDOT, 2019

## Where Guidelines Align

Avoid excessive velocities, max. 0.6 – 1.2 m/s typically

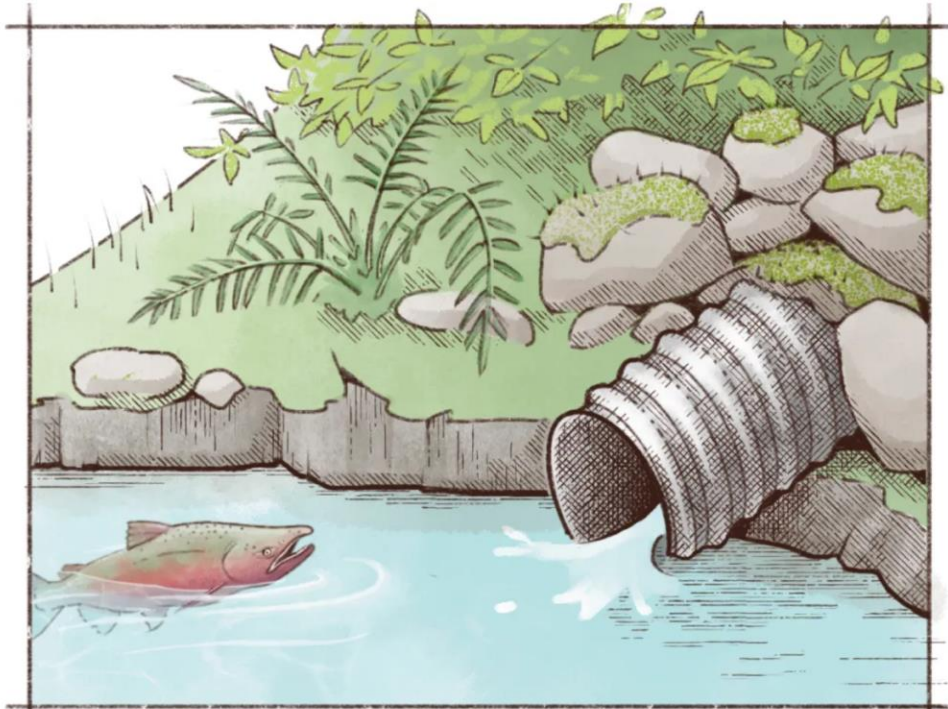


Image credit: Seattle Times, 2024

## Where Guidelines Align

Follow channel slopes, ideally at maximum 6%



Image credit: USFS, 2009

## Where Guidelines Align

Avoid elevation drops/perches



# Where Guidelines Diverge: Three Main Culvert Design Approaches

## Stream Simulation

- Mimics natural channel substrate and slope

## Hydraulic Simulation

- Span larger than bankfull width
- Needs steady sediment regiment

## Hydraulic Design

- Best ecological option; mostly discussed in U.S. guidelines
- \$\$\$



Image credit: USFS, 2009



# Where Guidelines Diverge: Three Main Culvert Design Approaches

Stream Simulation

- Span equal to or larger than bankfull width

Hydraulic Simulation

- Recreates hydraulic diversity
- Relies on oversized substrate

Hydraulic Design

- Mostly discussed in newer Canadian guidelines
- \$\$

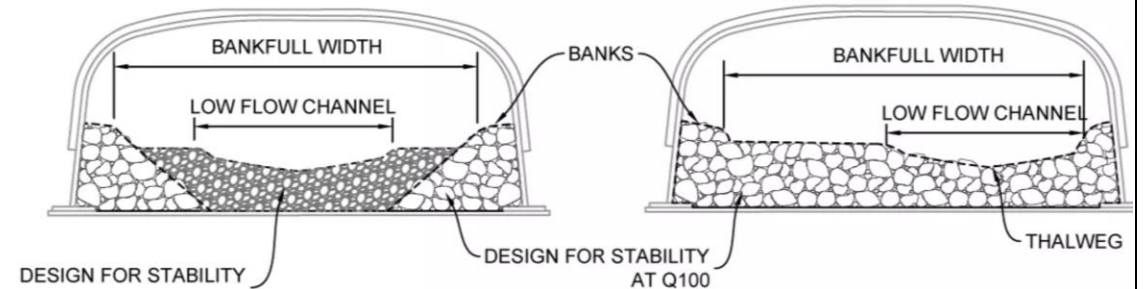


Image credit: U.S. Fish and Wildlife Service (USFWS), 2025



# Where Guidelines Diverge: Three Main Culvert Design Approaches

Stream  
Simulation

- Meets species-specific criteria
- Often smaller spans

Hydraulic  
Simulation

- May use baffles
- In some older DFO guidance, but recently discouraged

**Hydraulic  
Design**

- \$



Image credit: DFO, 2016



# Let's Design a Culvert!

Imagine you are a highway engineer tasked with designing a fish passable culvert. You consult DFO guidance to do so.

Your site presents:

- Road width = 12 m
- Channel slope = 1%
- Bankfull width = 5.8 m
- Brook Trout present
- $D_{84} = 120$  mm
- Urban system with very little sediment load

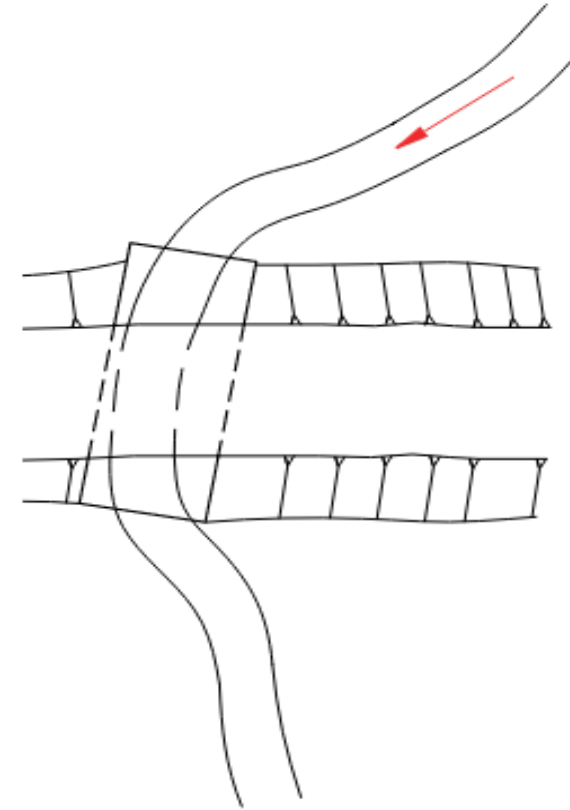


Image credit: USFS, 2009



## Let's Design a Culvert!

### Open-Bottom Stream Simulation

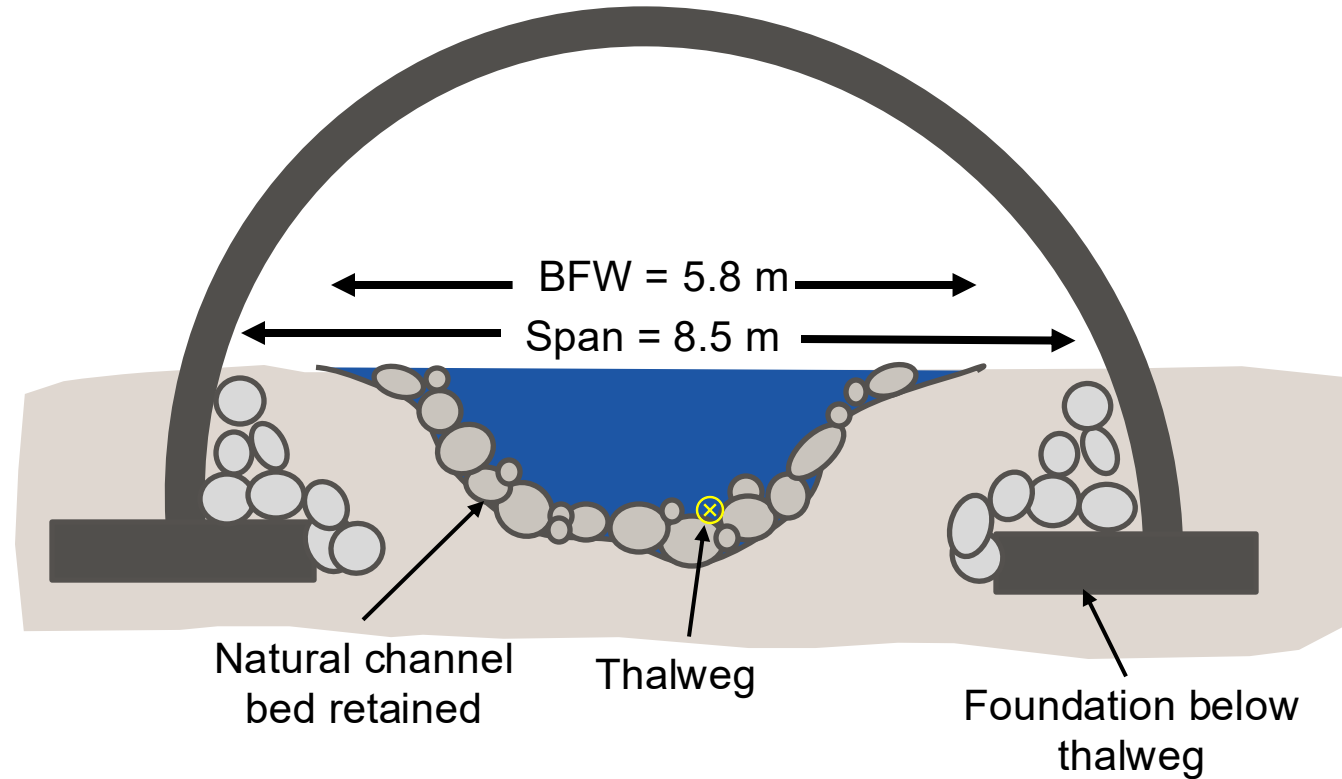
Using DFO guidelines for **PEI/NB (2025)**

- Design to retain channel bed

#### Design Checklist:

- Alignment ✓
- Slope ✓
- Span ✓
- Substrate ✓
- Length ✓

Cross-section view of designed culvert



Culvert slope	1%
Culvert length	15 m
Culvert alignment	Directly with channel



**Let's Design a Culvert!**

## **Open-Bottom Stream Simulation**

### **Design Implications**

- Excellent ecologically
- \$\$\$



Image credit: USFS, 2009



## Let's Design a Culvert!

### Closed-Bottom Stream Simulation

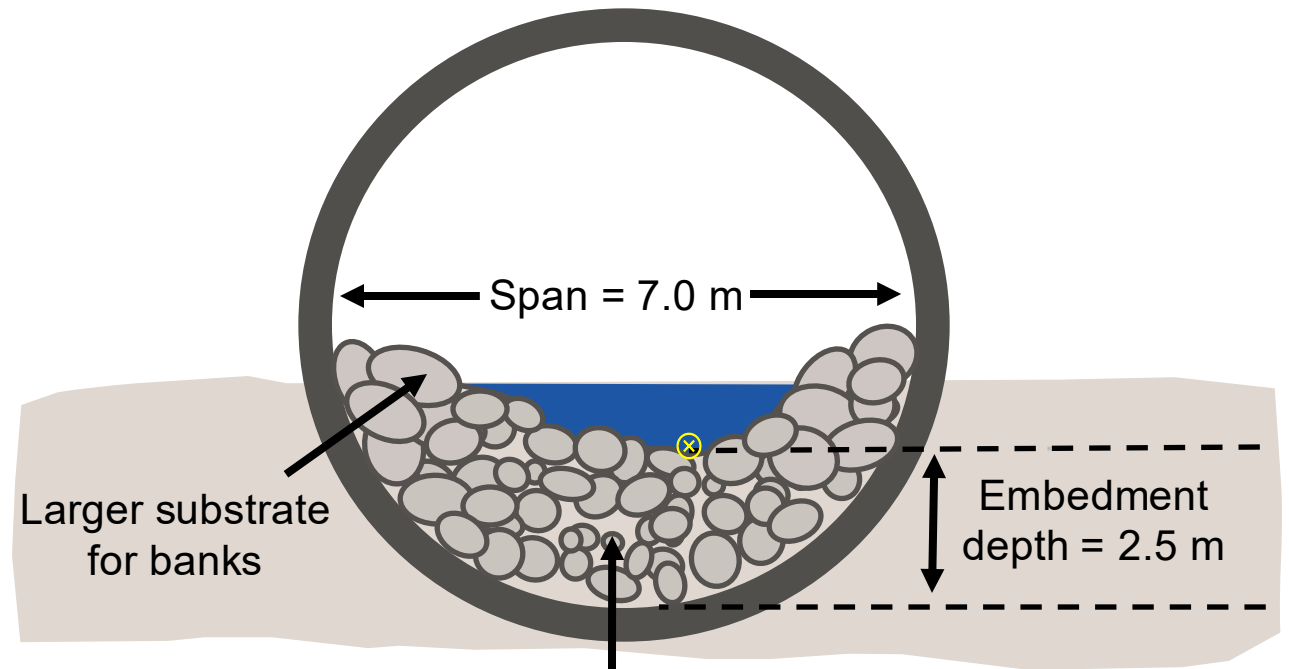
Using DFO guidelines for **PEI/NB (2025)**

- Design to recreate channel bed
- Substrate to be stable under design flow
  - Analyzed to be 180 mm

#### Design Checklist:

- Alignment ✓
- Slope ✓
- Span ✓
- Substrate ✗
- Length ✓

Cross-section view of designed culvert



Bed substrate sized based on natural channel ( $D_{84} = 120$  mm)

Culvert slope	1%
Culvert length	15 m
Culvert alignment	Directly with channel



## Let's Design a Culvert!

### Closed-Bottom Stream Simulation

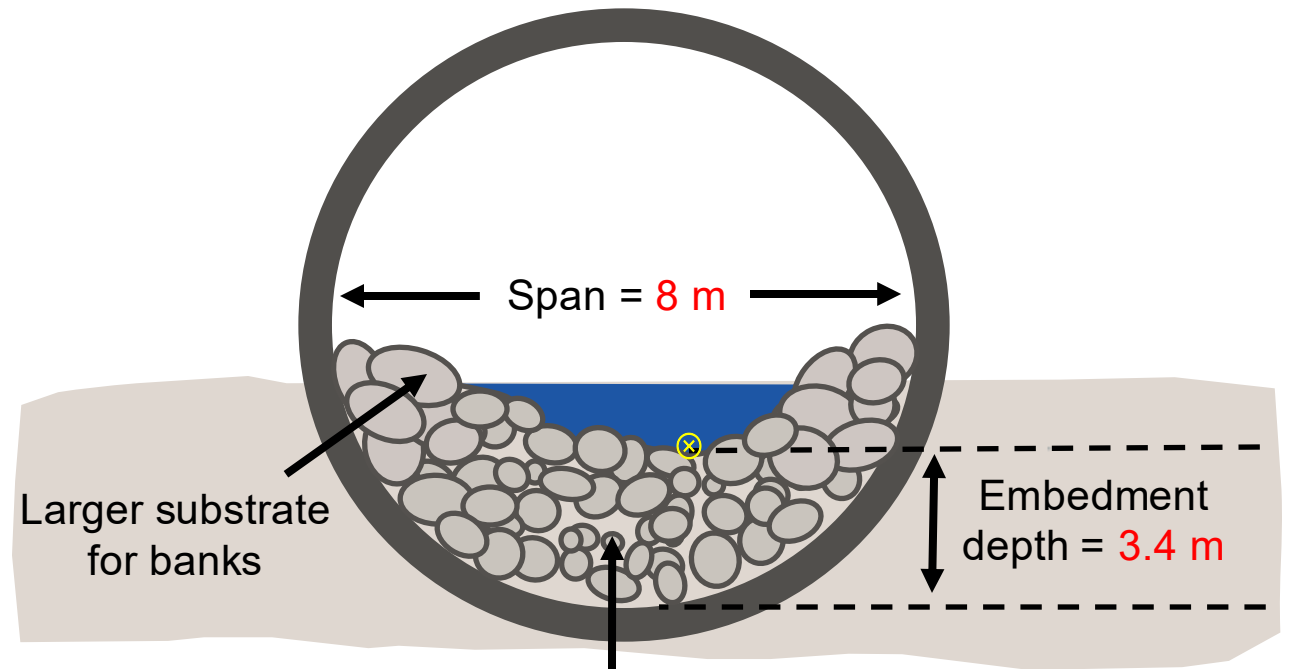
Using DFO guidelines for PEI/NB

- Revising design to meet substrate criteria
  - Resulting in increased span

#### Design Checklist:

- Alignment ✓
- Slope ✓
- Span ✓
- Substrate ✓
- Length ✓

Cross-section view of designed culvert



Bed substrate sized based on natural channel ( $D_{84} = 120$  mm)

Culvert slope	1%
Culvert length	15 m
Culvert alignment	Directly with channel



## Let's Design a Culvert!

### Closed-Bottom Stream Simulation

#### Design Implications

- Excellent ecologically
- \$\$\$

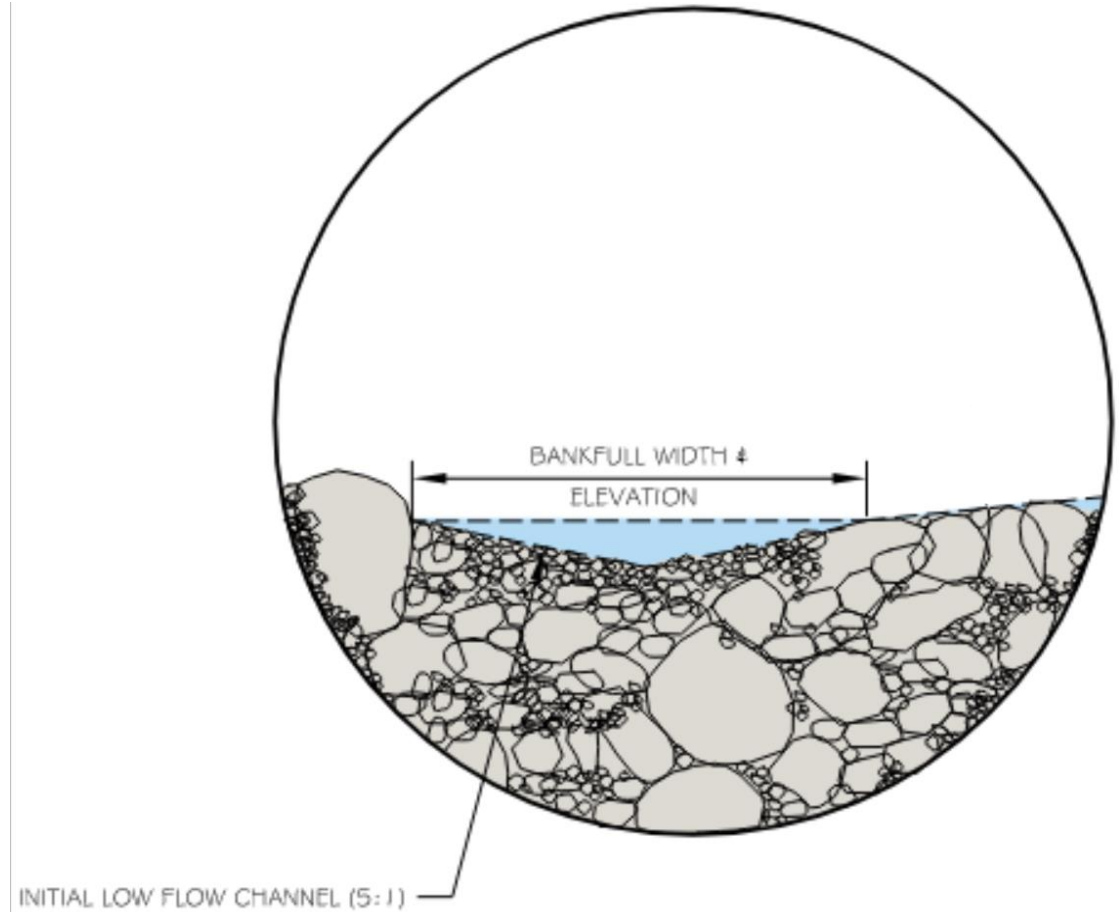


Image credit: USFS, 2009



## Let's Design a Culvert!

### Hydraulic Simulation

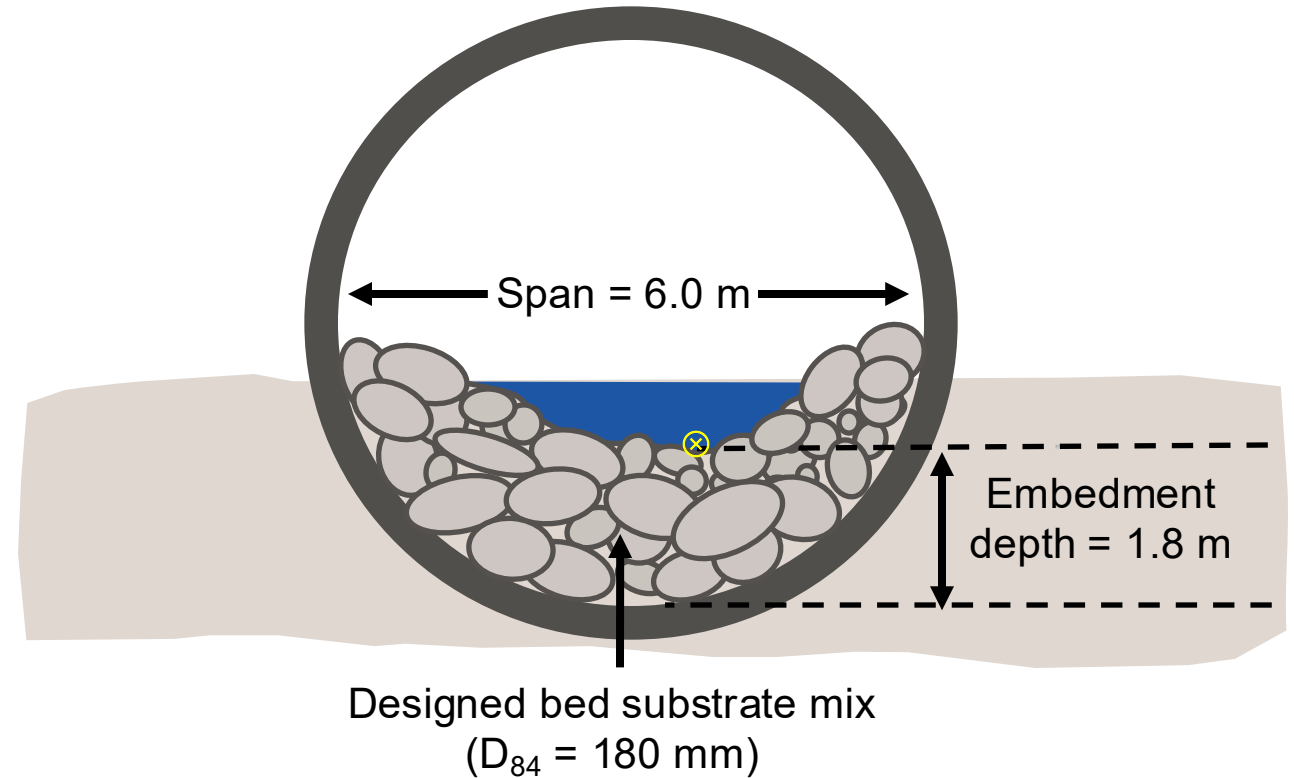
Using DFO guidelines for **Quebec (2016)**

- Oversized substrate in channel bed (stable under design flow)
- $\text{Span} \geq (2 \cdot D_{100}) + \text{BFW}$ 
  - $D_{100}$  analyzed to be 220 mm

#### Design Checklist:

- Alignment ✓
- Slope ✓
- Span ✓
- Substrate ✓
- Length ✓

Cross-section view of designed culvert



Culvert slope	1%
Culvert length	25 m
Culvert alignment	Directly with channel



**Let's Design a Culvert!**

## **Hydraulic Simulation**

### **Design Implications**

- Good ecologically
- \$\$

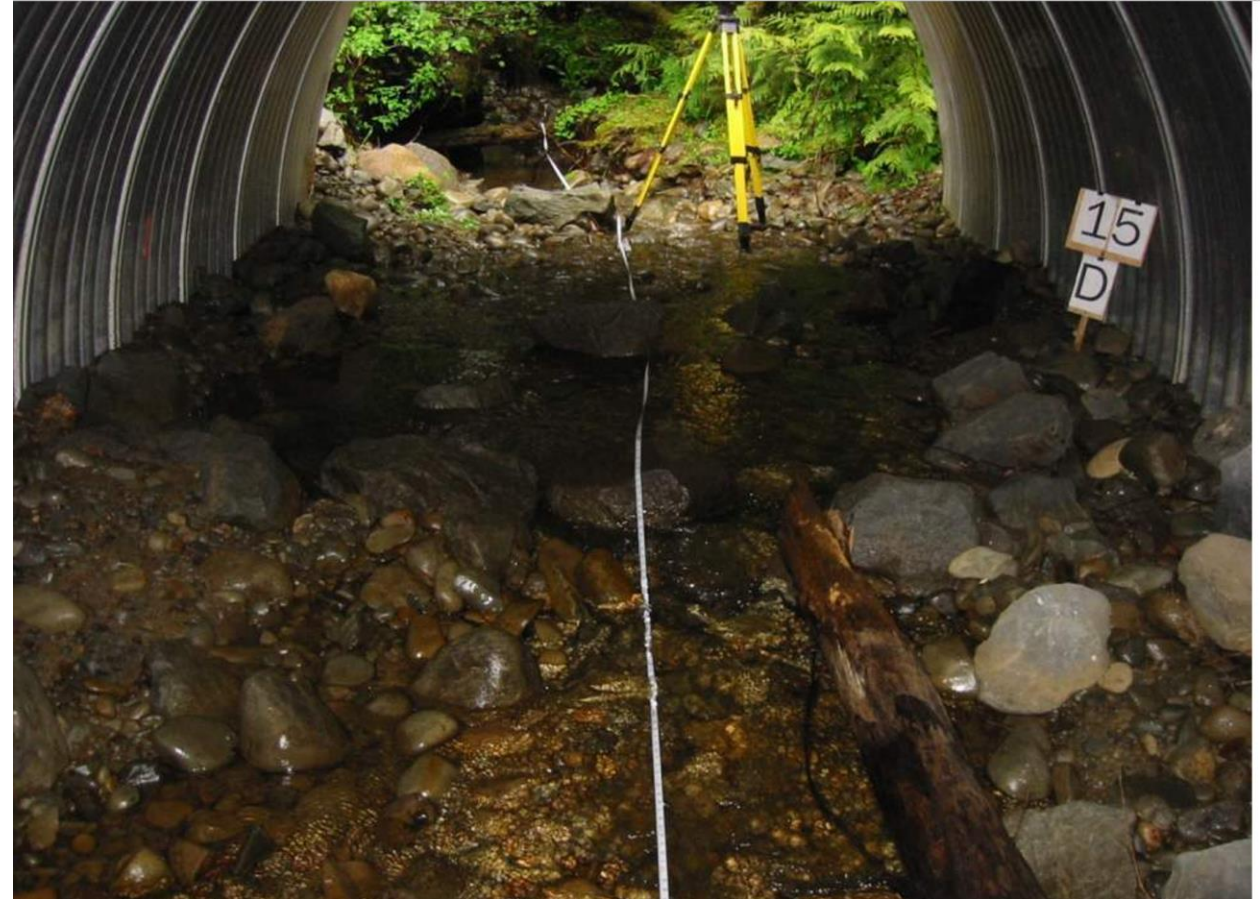


Image credit: Washington Department of Fish and Wildlife (WDFW), 2003



## Let's Design a Culvert!

### Hydraulic Design

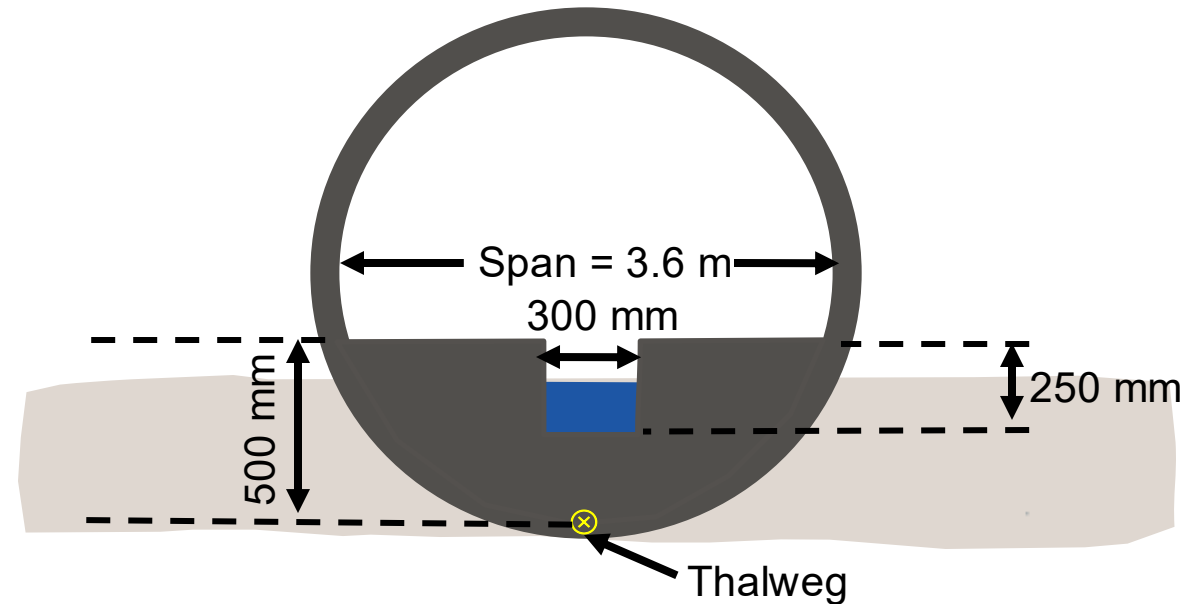
Using DFO guidelines for **Nova Scotia (2015)**

- Design for target species based on low-flow conditions
- Use baffles
- Include energy dissipation pool at outlet

#### Design Checklist:

- Alignment ✓
- Slope ✓
- Span ✓
- Substrate ✓
- Length ✓

Cross-section view of designed culvert



Culvert slope	1%
Culvert length	25 m
Culvert alignment	Directly with channel
Baffle width	300 mm
Drop between baffles	200 mm
Baffle spacing	2.0 m
Number of baffles	12

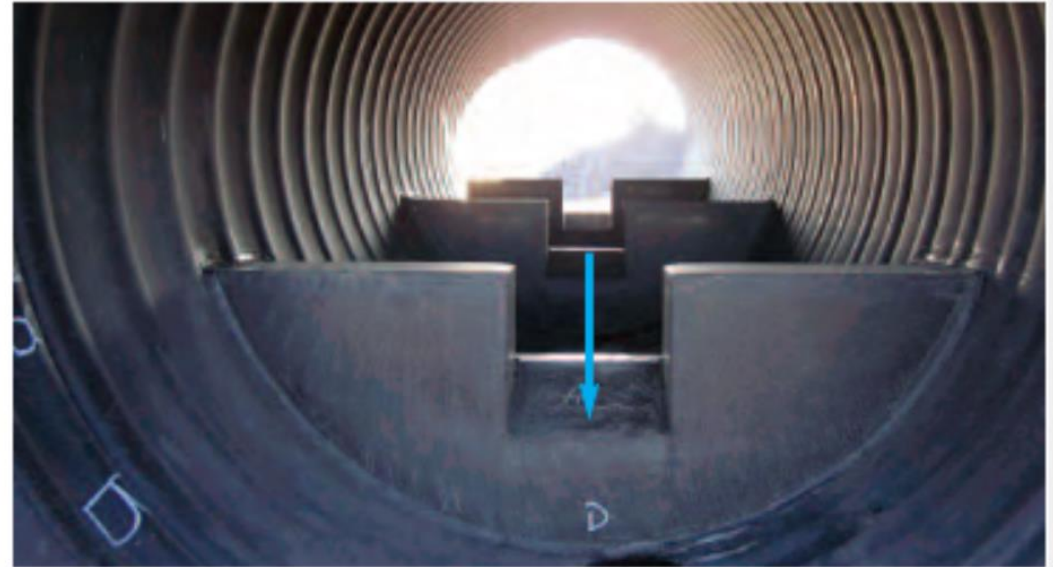


## Let's Design a Culvert!

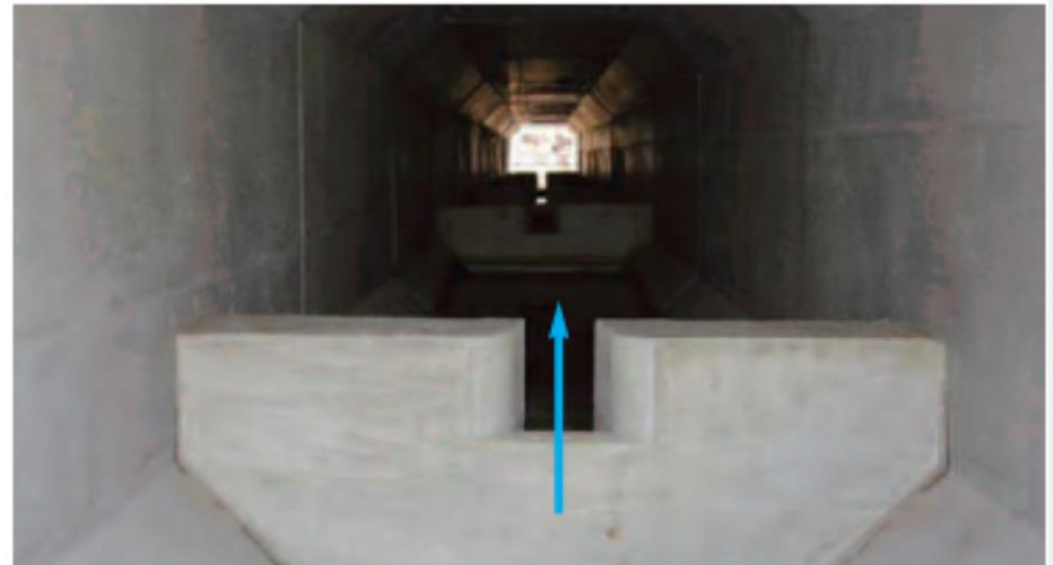
### Hydraulic Design

#### Design Implications

- Not ecologically optimal
- \$



*Polyethylene baffles (view from downstream)*



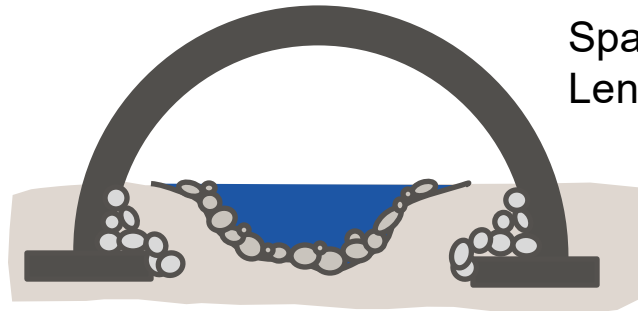
*Concrete baffles (view from upstream)*

Image credit: DFO, 2016



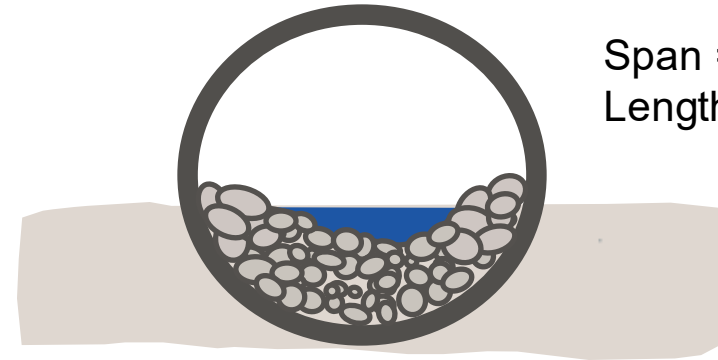
# Comparing Culverts

**Open-Bottom Stream Simulation - PEI/NB**



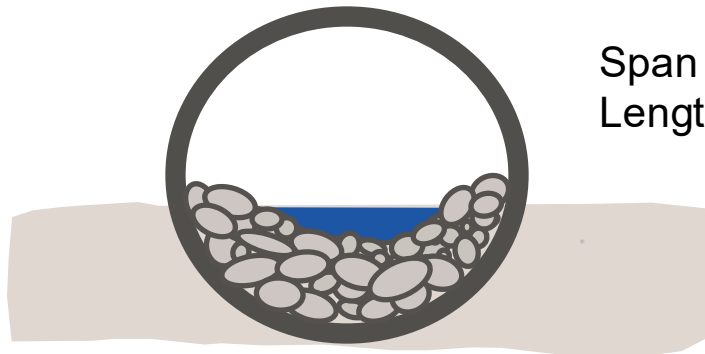
Span = 8.5 m  
Length = 15 m

**Closed-Bottom Stream Simulation - PEI/NB**



Span = 8 m  
Length = 15 m

**Hydraulic Simulation - Quebec**



Span = 6 m  
Length = 25 m

**Hydraulic Design - Nova Scotia**



Span = 3.6 m  
Length = 25 m



# Takeaways

- Not as simple as designing for specific fish **OR** designing to match natural channel exactly
- Urban environments require special consideration
- Fluvial characteristics need to be assessed
- Various ways to be successful in designing a channel crossing – know your local guidelines



Image credit: USFS, 2009



# Takeaways

- Design holistically for success
  - Consider hydraulics, ecology, fluvial geomorphology, and transportation
- Opportunity to harmonize fish passage guidance

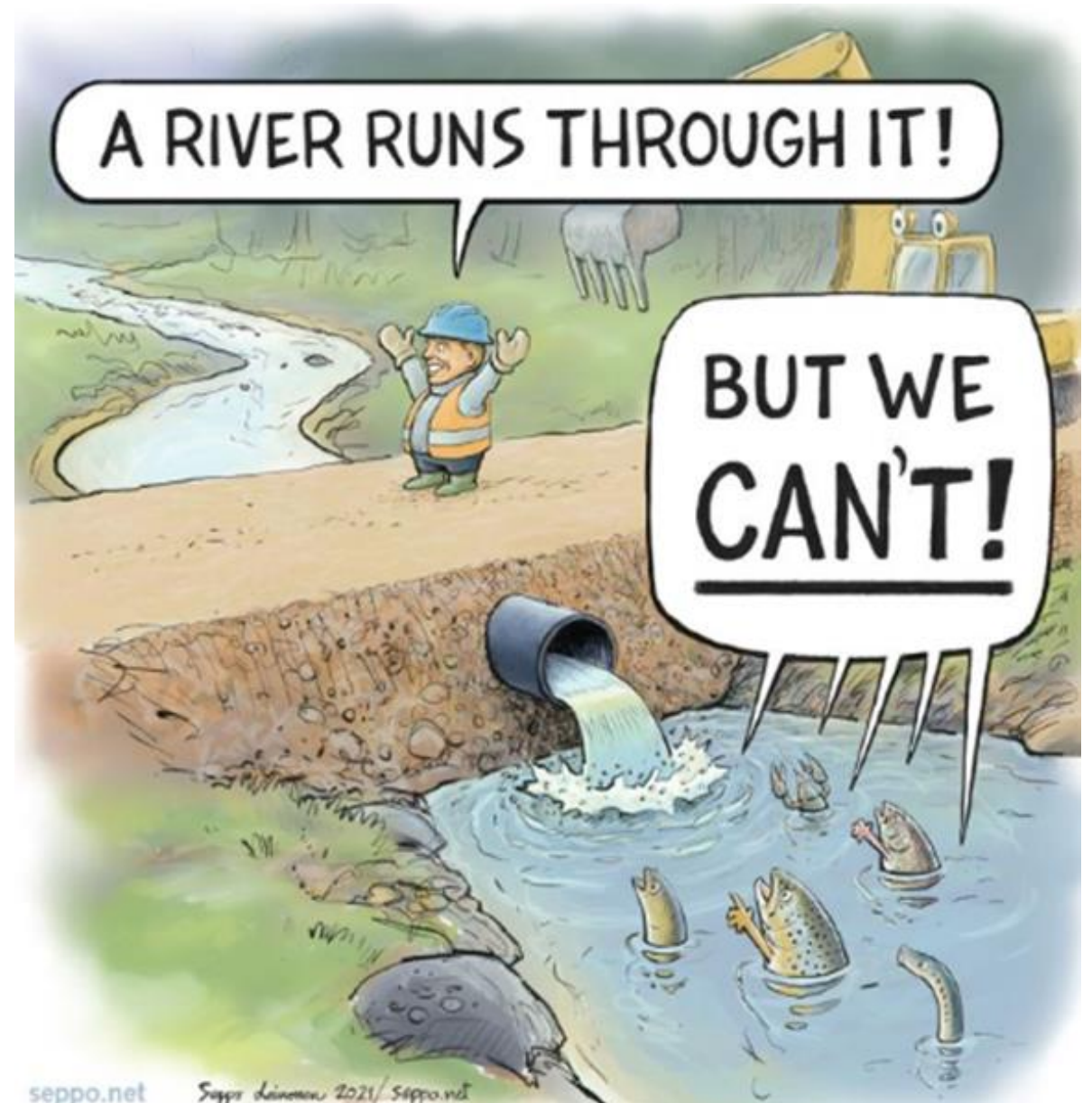


Image credit: Seppo Leinonen

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# Questions?

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[Heather.Amirault@stantec.com](mailto:Heather.Amirault@stantec.com)

# Thank you!

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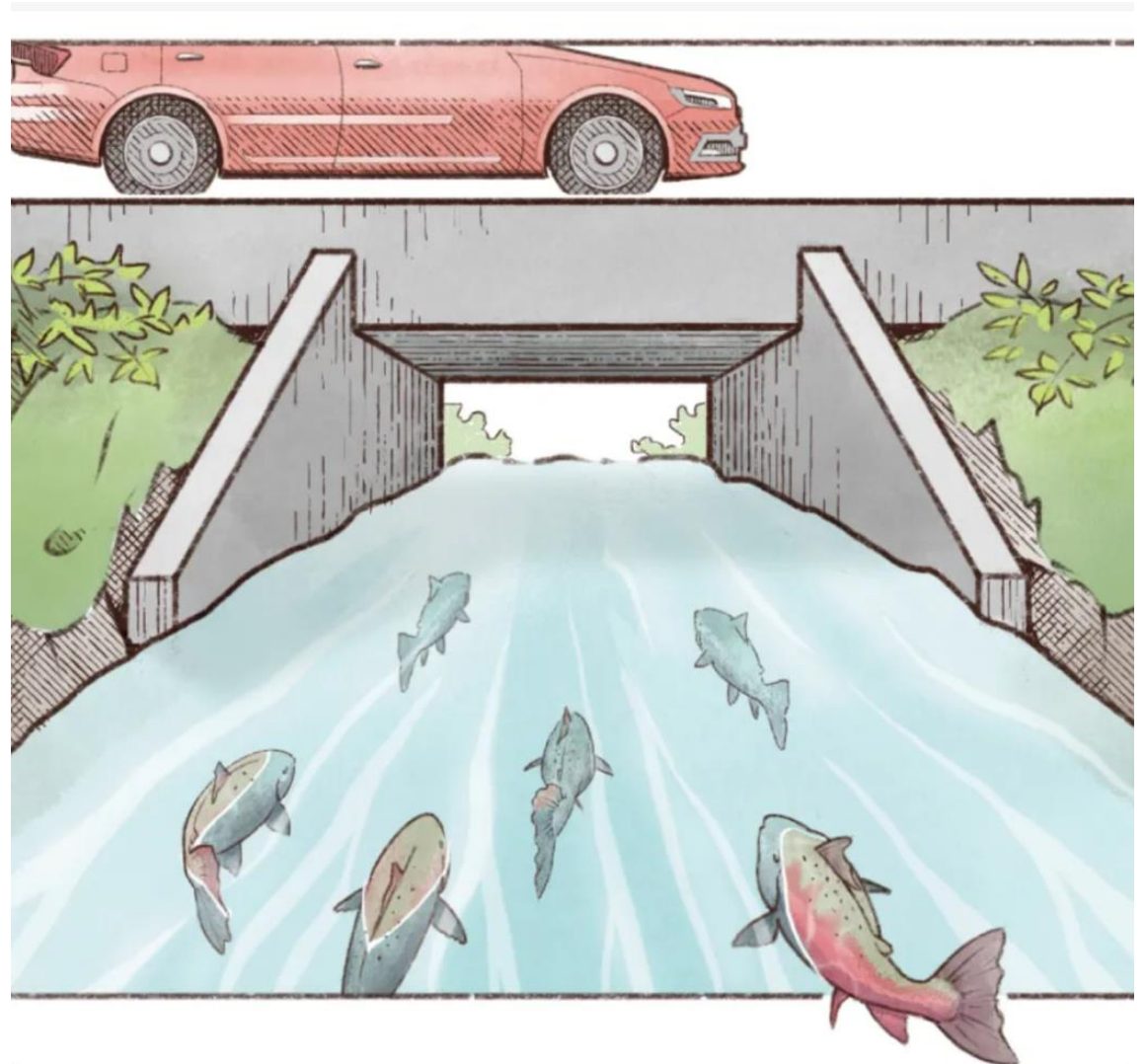


Image credit: Seattle Times, 2024



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