Environmentally Sensitive Maintenance for Dirt, Gravel, and Low-Volume Roads

Center for Dirt and Gravel Road Studies

PA State Conservation Commission

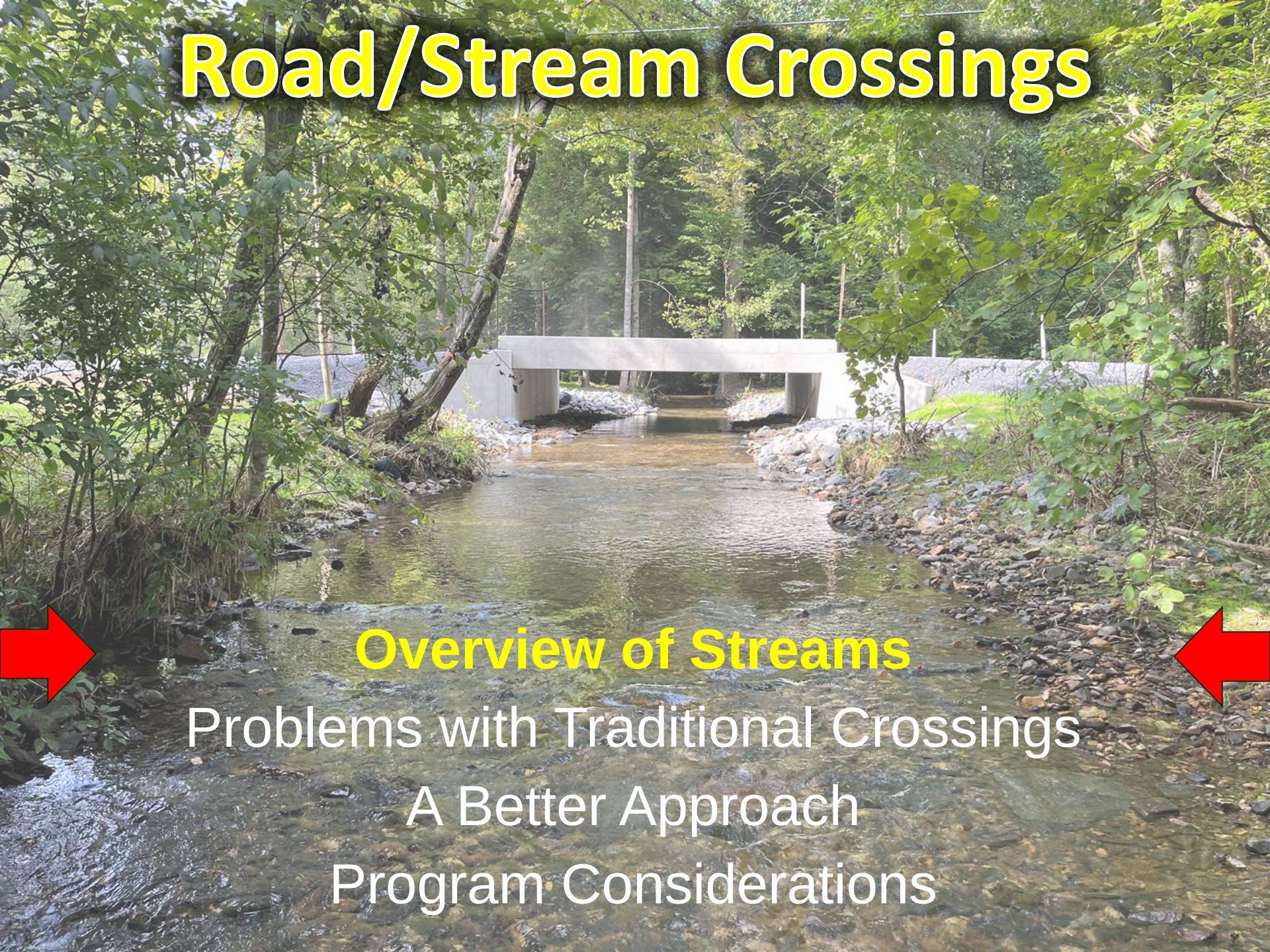
PA Dept. of Conservation and Natural Resources Forestry

Stream Crossings

ESM Modules

Introduction
Orientation
Low Volume Roads
ESMP Intro
Off ROW
Geosynthetics
Road Base
Entrenched Roads
Road Banks
Stream Crossings
Stream Stabilization
Surface Maintenance
Ditches
Ditch Outlets
Infiltration
DSA

Road/Stream Crossings



Overview of Streams

Problems with Traditional Crossings

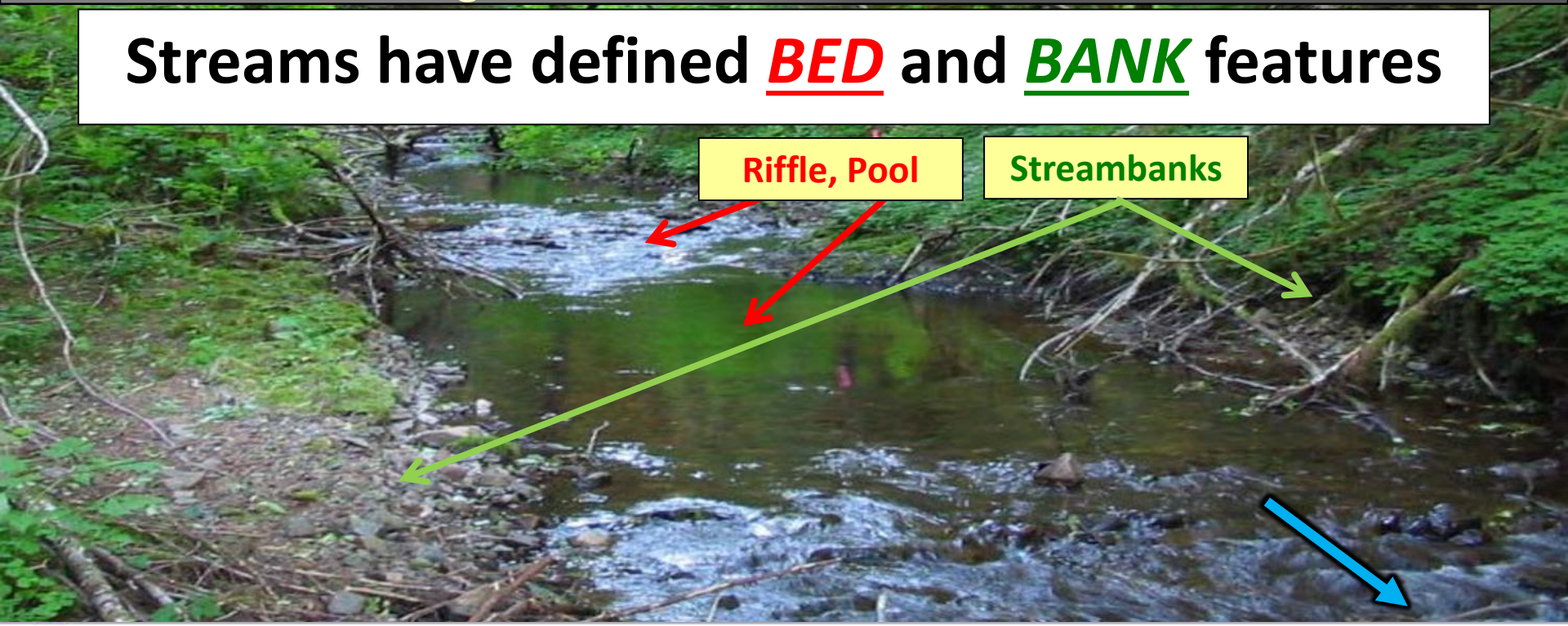
A Better Approach

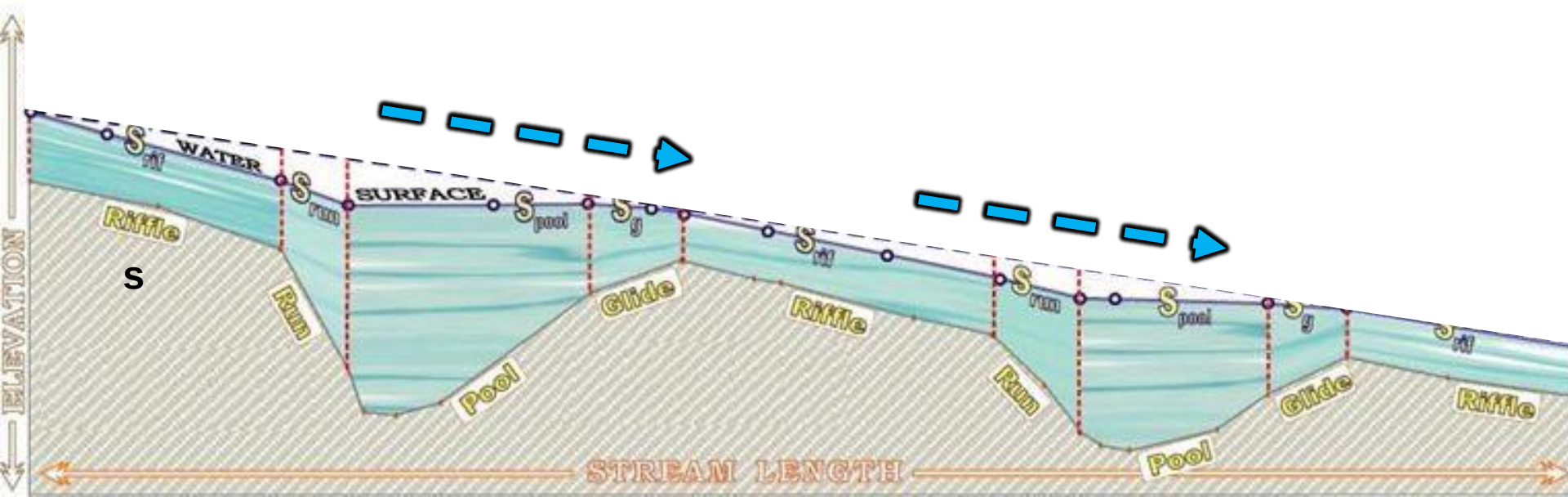
Program Considerations

This section deals with STREAMS, not drainage.

The difference is important…
(different practices, different rules)

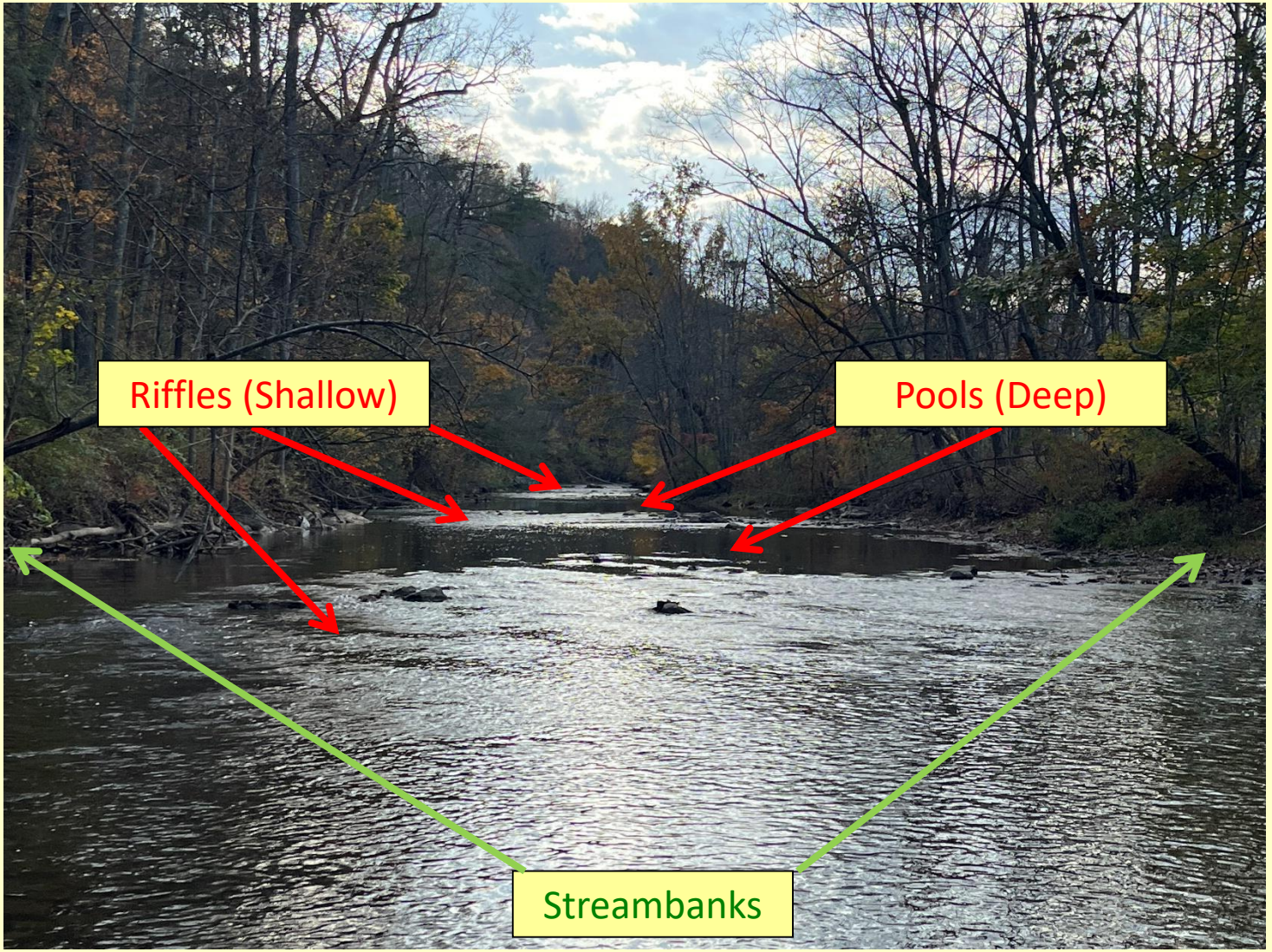
Streams have defined ***BED*** and ***BANK*** features





Streams have defined ***BED*** and ***BANK*** features

And can be ANY SIZE



Streams have defined *BED* and *BANK* features

And can even be DRY

Overview of Streams

Streams move more than just water!

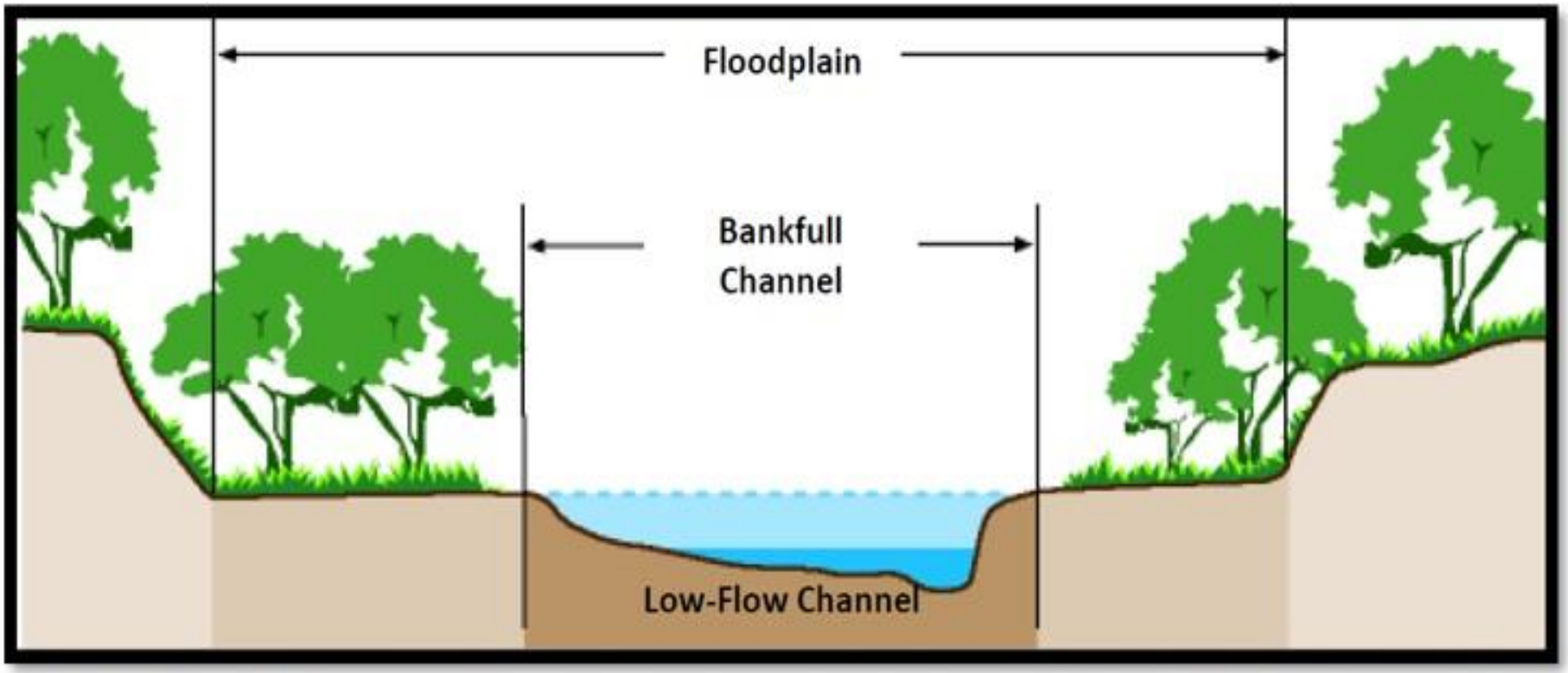
- ***Sediment (gravel, cobble, etc.)***
- ***Debris (wood, etc.)***

Any sediment/debris that gets into this channel eventually ends up in a larger stream!

The **SHAPE** of the stream determines how effectively it moves this material.

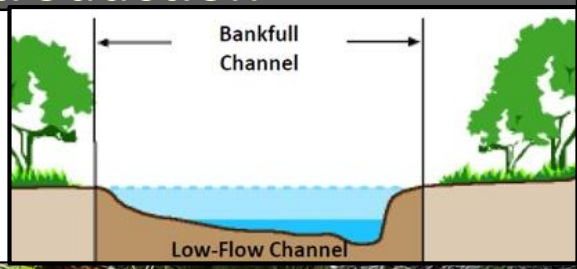
Channel Shape:

- **Bankfull Width**: Width of stream channel just before water reaches its floodplain
- This level of flow defines common stream features (shape, slope, streambed material)



Bankfull Width:

- Width where flow accesses floodplain
- Usually associated with a ~1.5 year flood event



Low Flow Width 6’

Bankfull Width:

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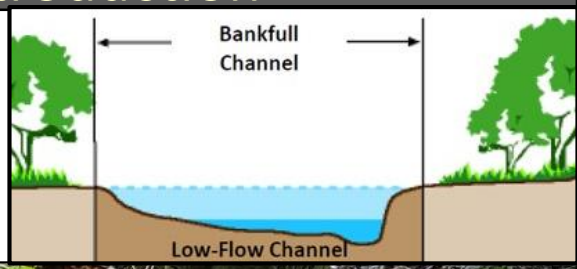

Bankfull
Width 11’

floodplain

floodplain

Low Flow Width 6’

Bankfull Width:

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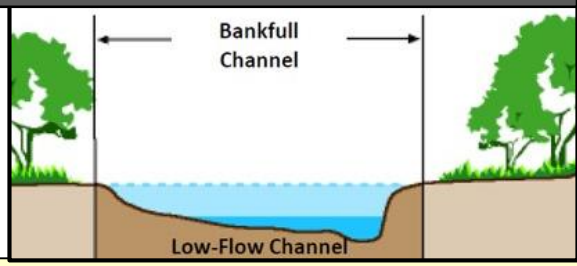

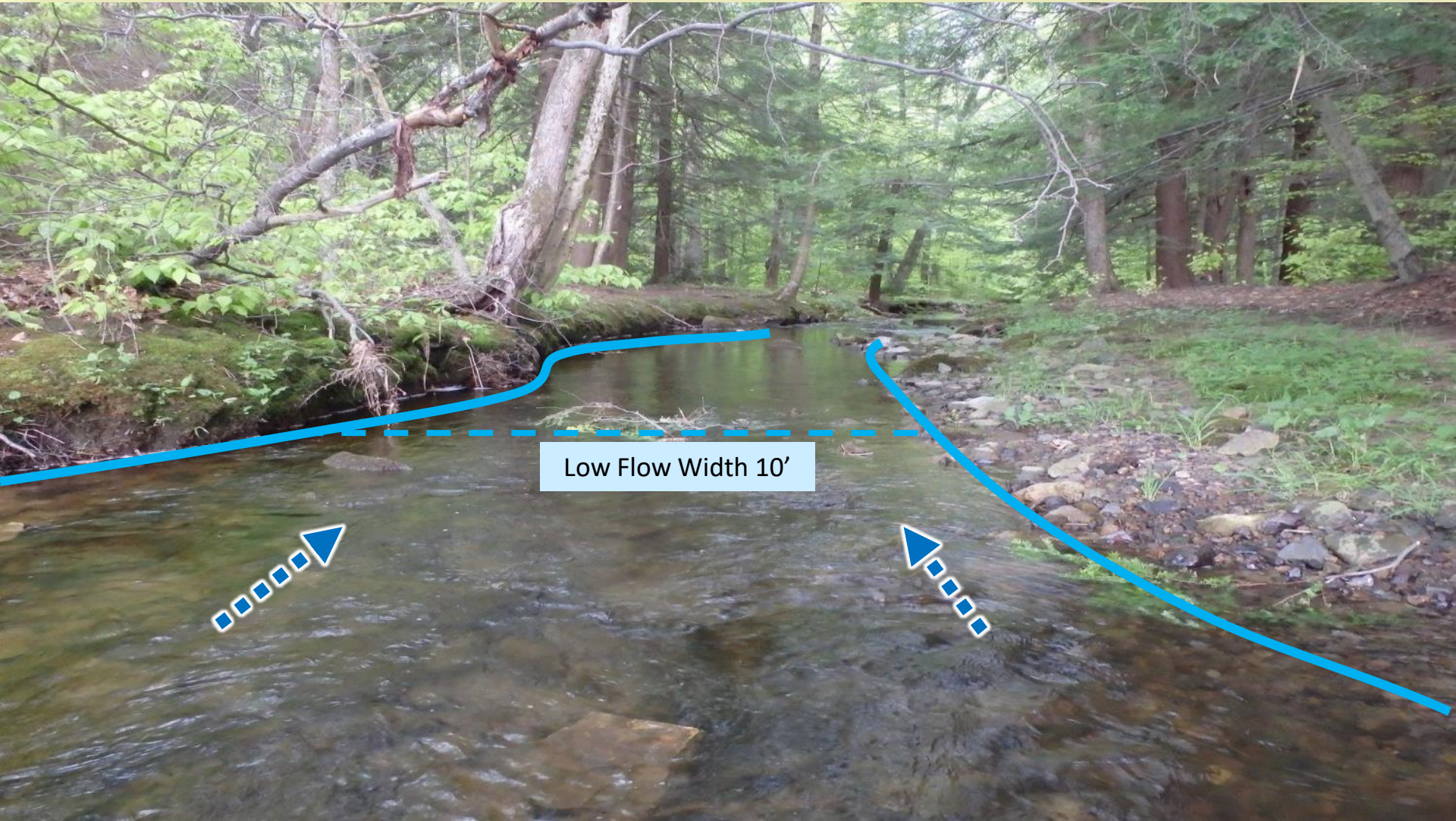

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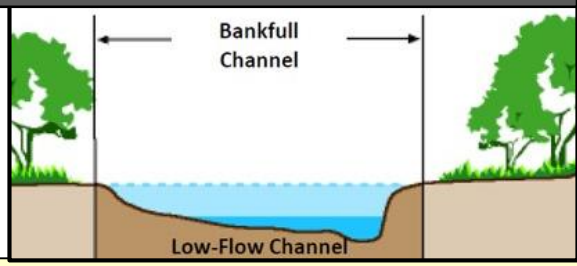
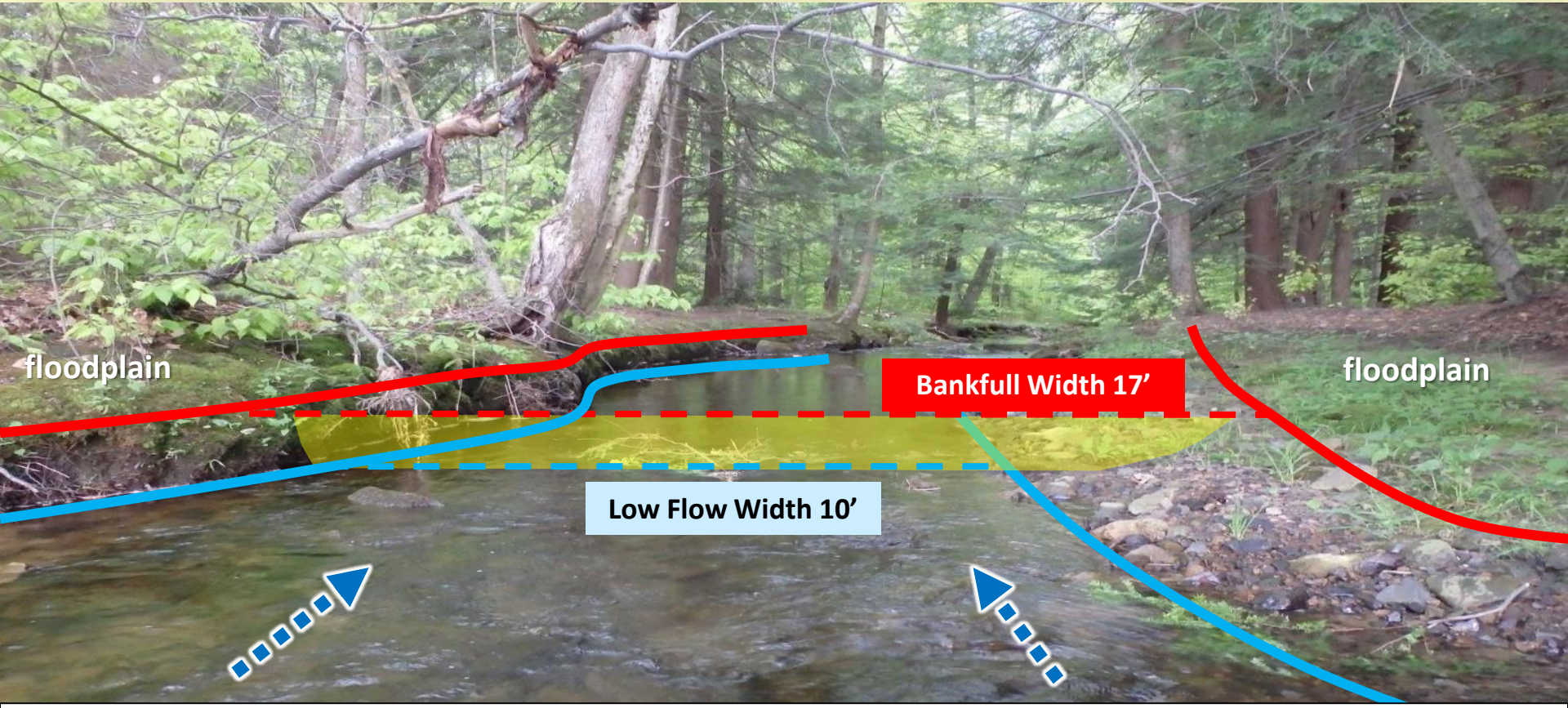




Bankfull width and the low-flow channel will become the “foundation” for how the stream would be built through a DGLVR funded replacement structure…

let’s look at how that is applied…

Bankfull Width 13’

Low Flow Width 7’

bank margins

floodp

Road/Stream Crossings

Overview of Streams

Problems with Traditional Crossings

A Better Approach

Program Considerations

Problems with Traditional Stream Crossings

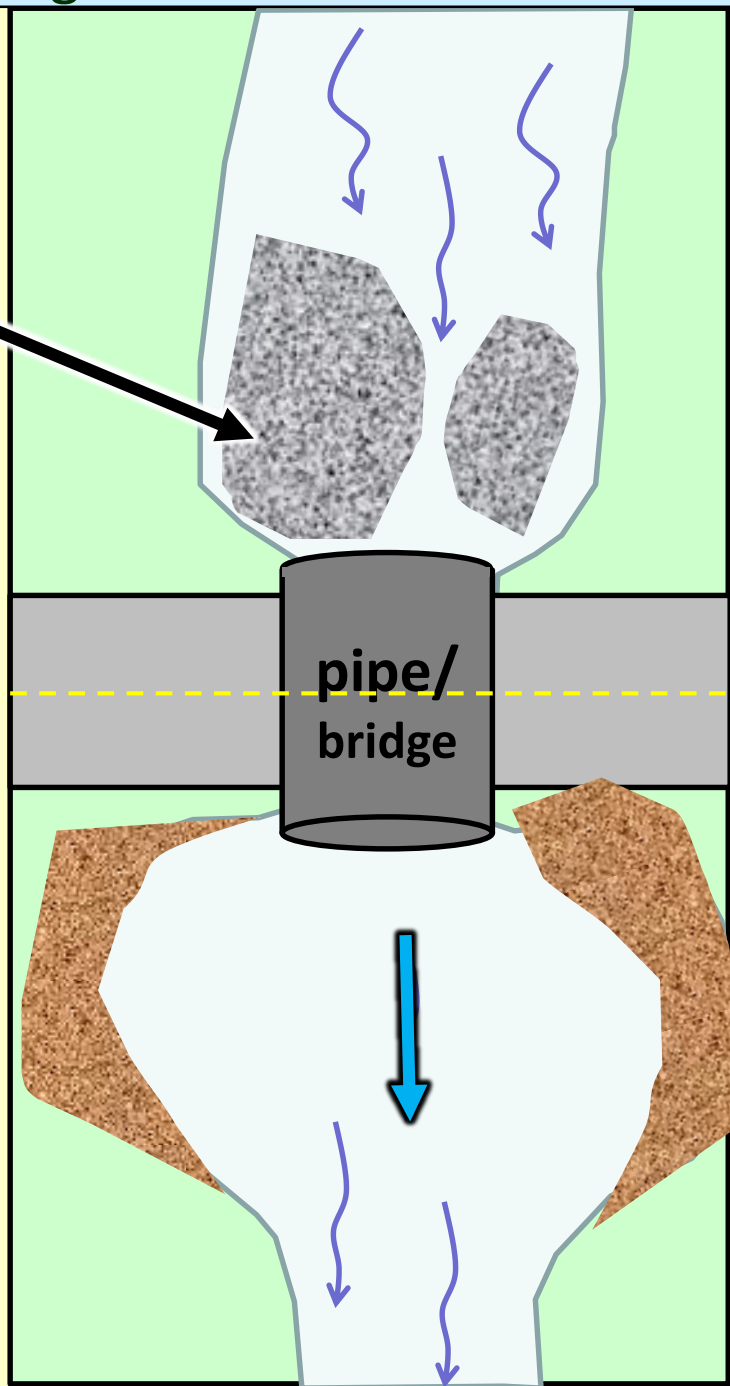
- **Undersized structures**
- Poor structure alignment
- Multiple structures
- Road profile at the crossing

Undersized Pipes:

- Erosion of banks/road and sediment to stream
- Frequent maintenance and flooding
- Aquatic organism passage barrier

Upstream issues

- Gravel bar formation
  - Stream widens / meanders
  - Capacity reduced
  - Increased flooding / washouts
  - **More maintenance!**

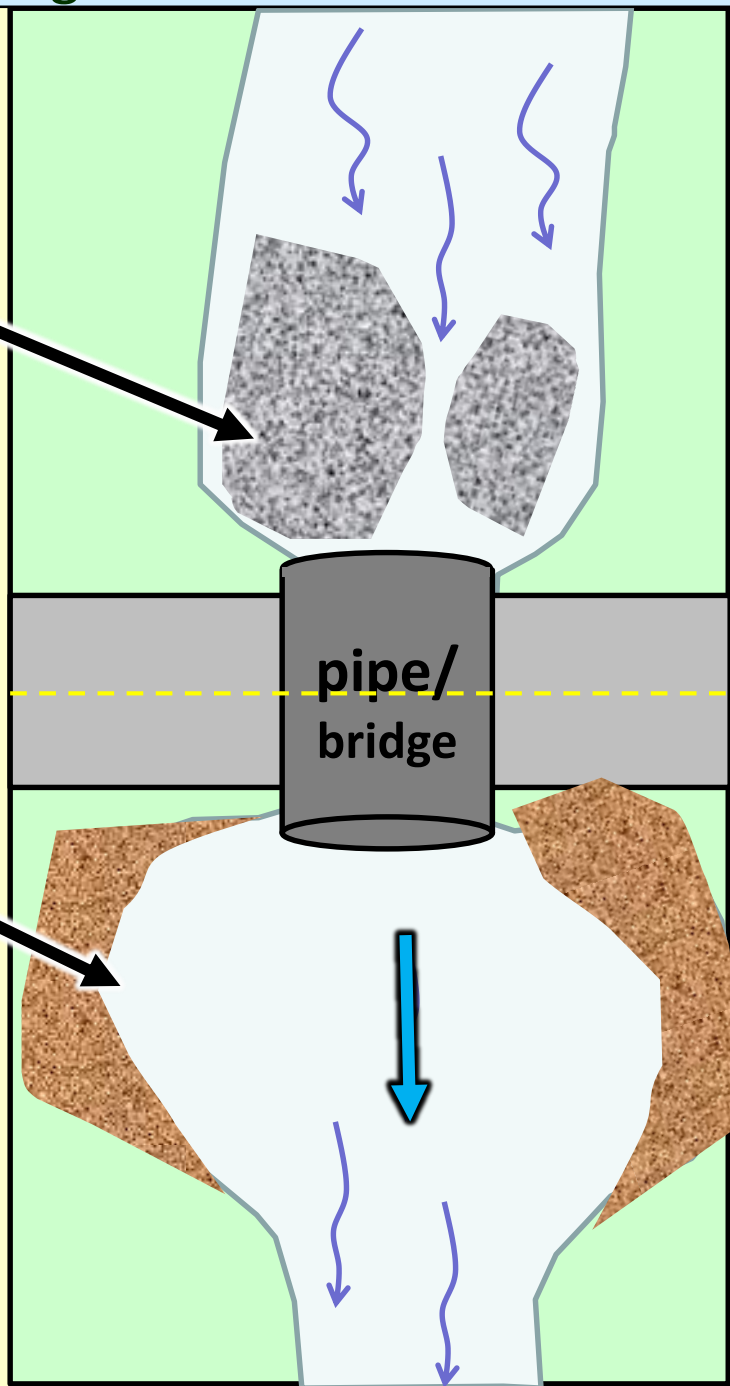


Upstream issues

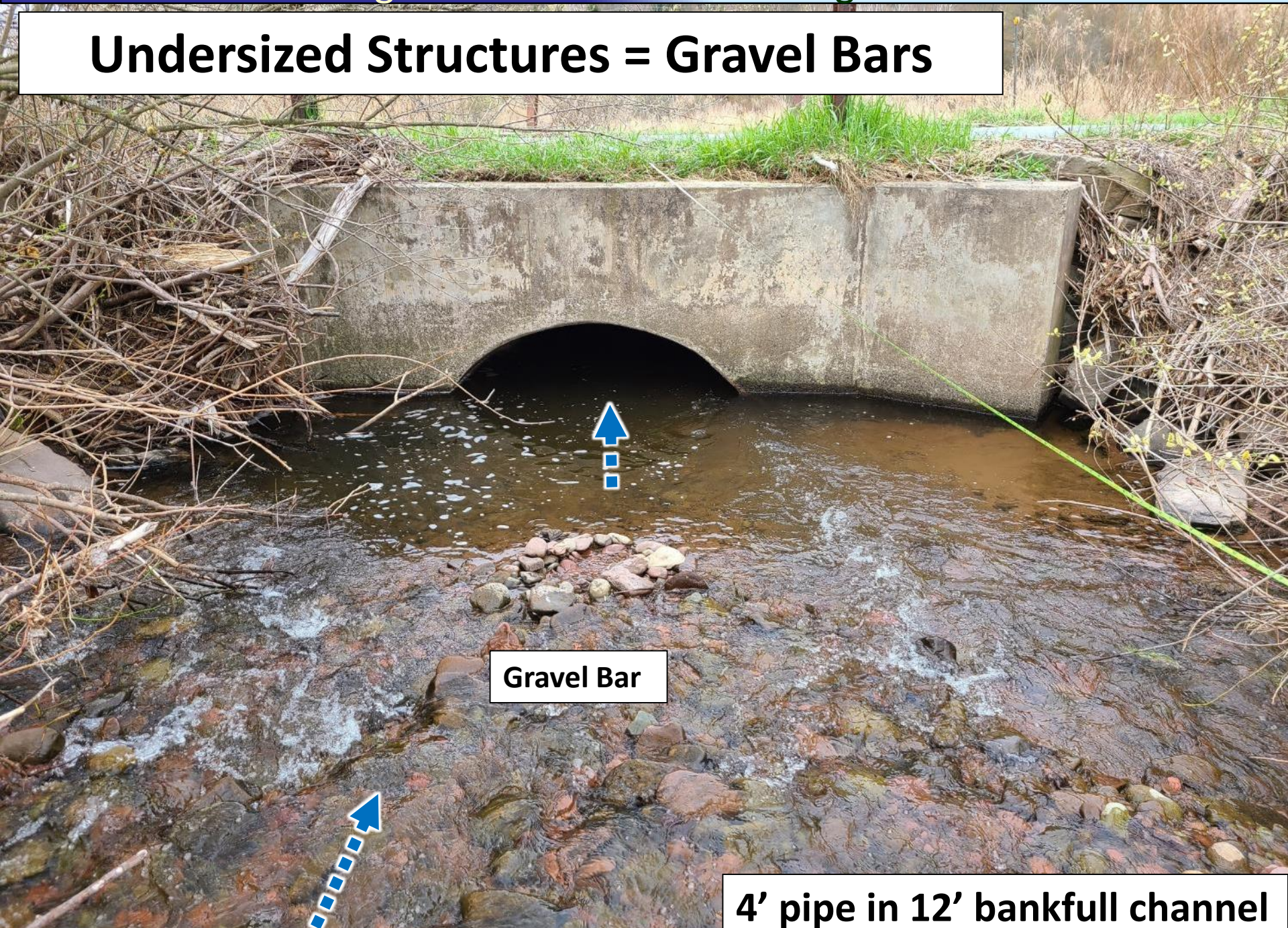
- Gravel bar formation
  - Stream widens / meanders
  - Capacity reduced
  - Increased flooding / washouts
  - **More maintenance!**

Downstream issues

- Erosion of bed and banks (Firehose effect)
  - Stream widens
  - Waterfall at outlet
  - Bank failure
  - Structure undermined
  - **LOTS of sediment made!**

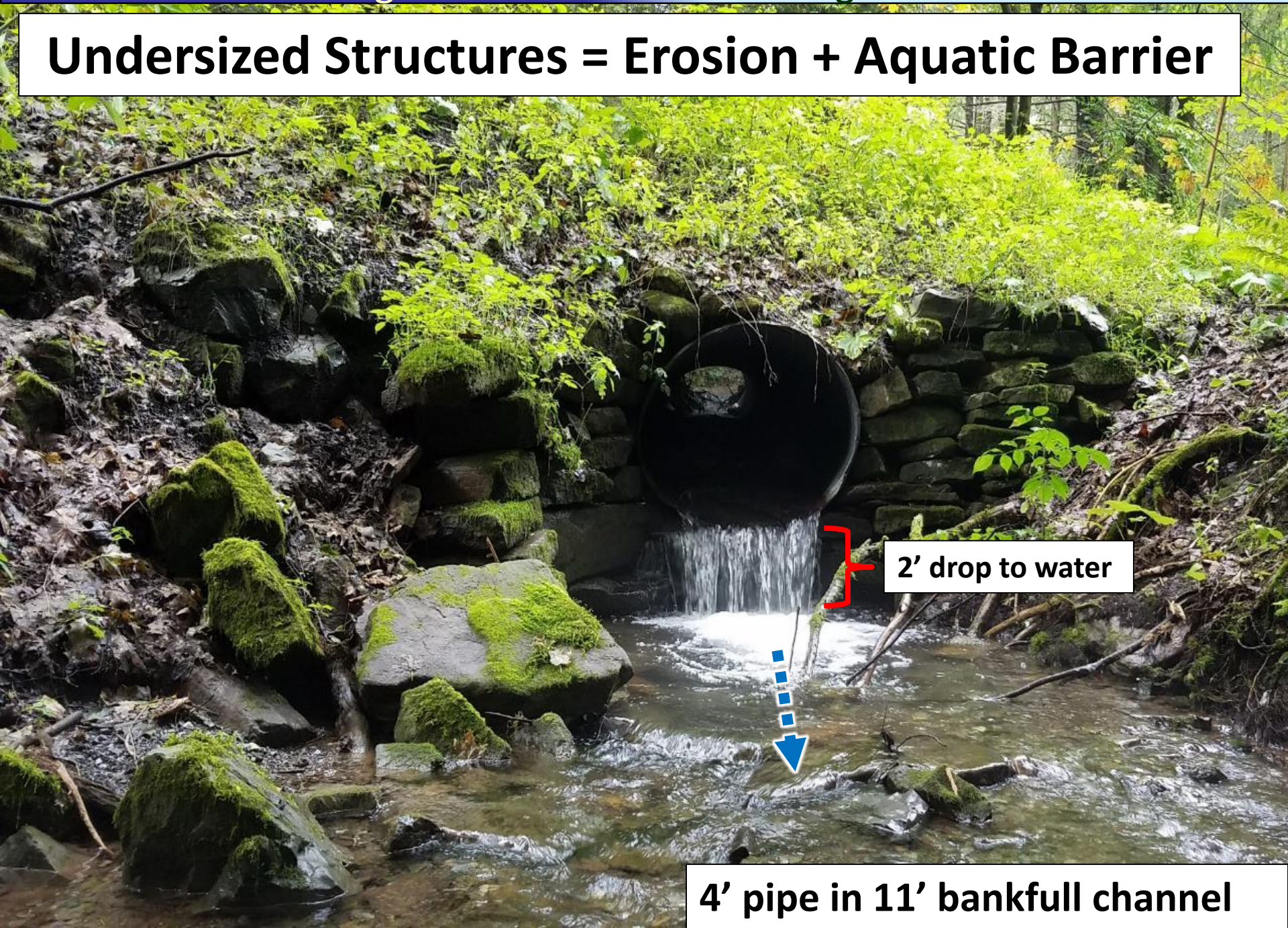


Undersized Structures = Gravel Bars



Undersized Structures = Clogging

Undersized Structures = Erosion + Aquatic Barrier



Undersized Structures = Pipe Washout

3’ pipe in 12’ bankfull channel

Undersized Structures = Road Washout

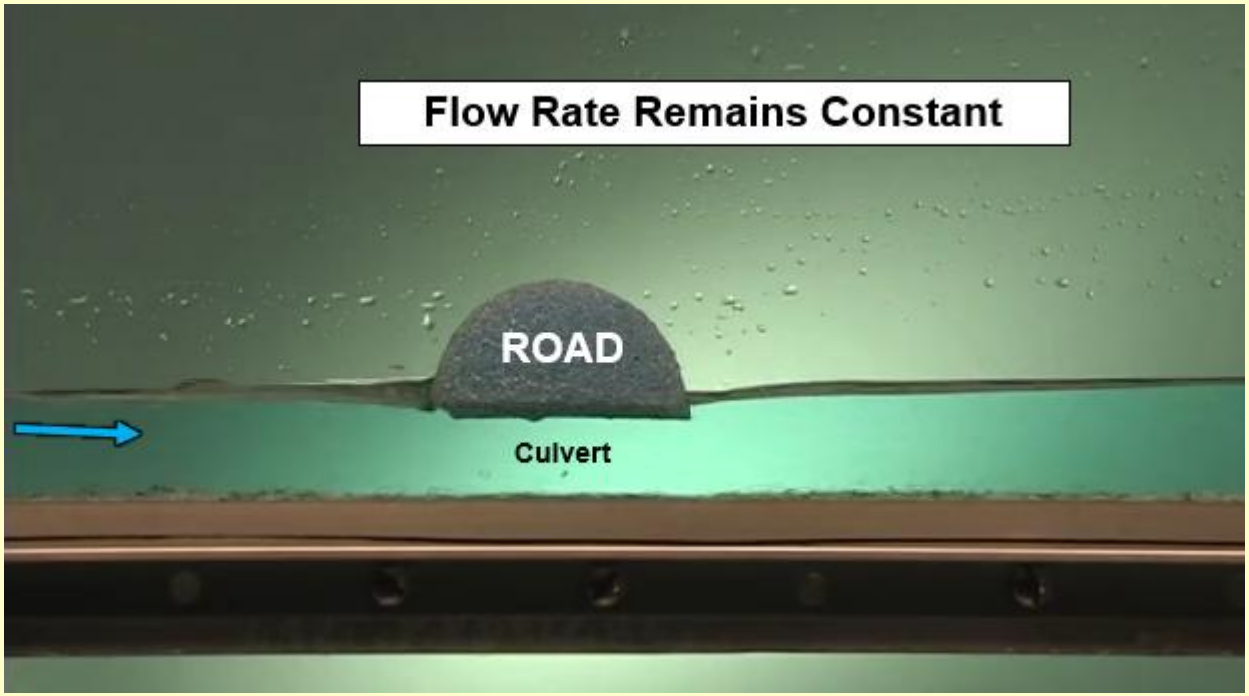
5’ pipe in 16’ bankfull channel

Undersized Structures = Road Washout

7’ pipe in 18’ bankfull channel

VIDEO:

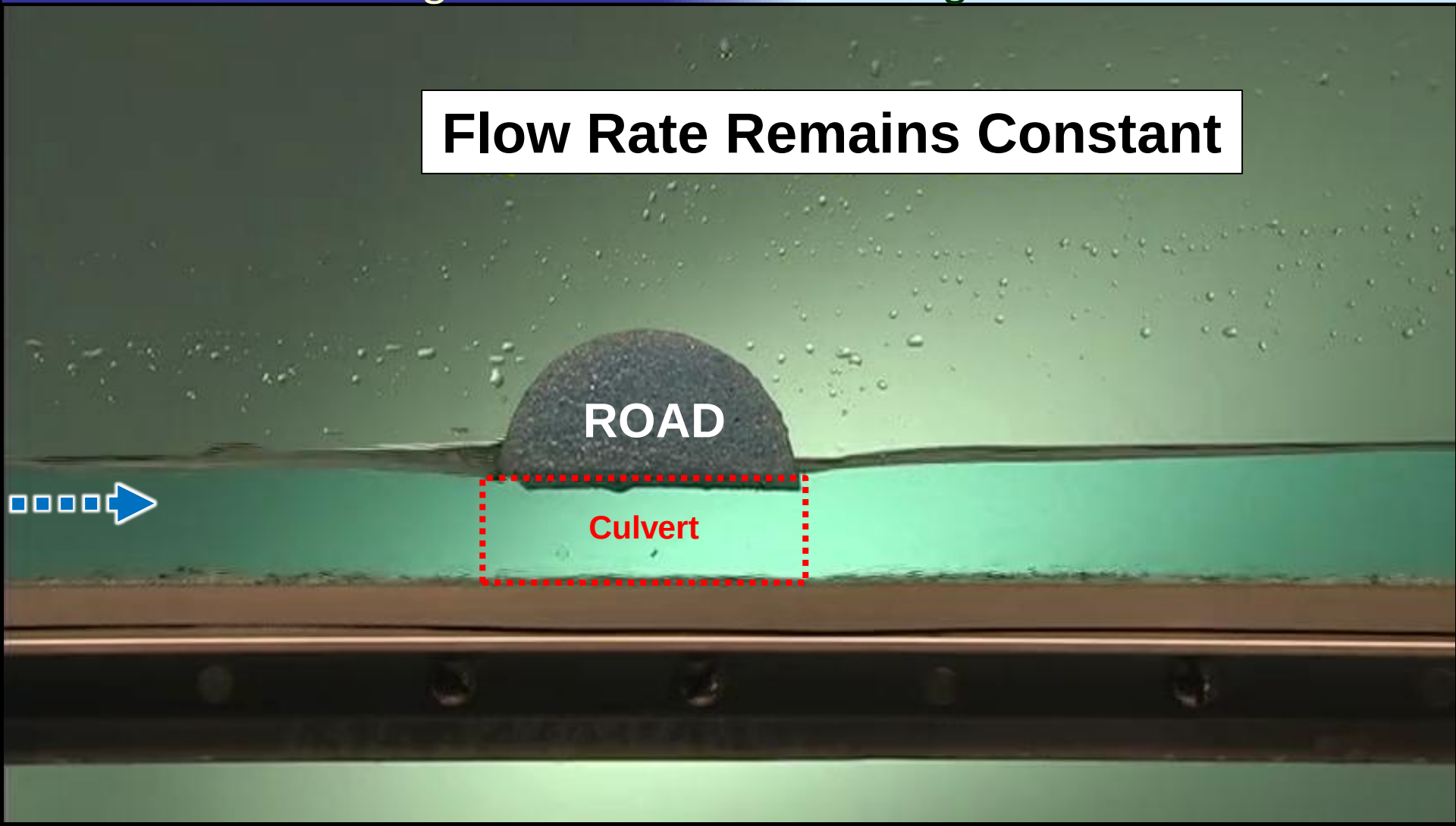
- Water flow volume remains constant
- Sand added to simulate sediment movement



MISSOURI DEPARTMENT OF NATURAL RESOURCES

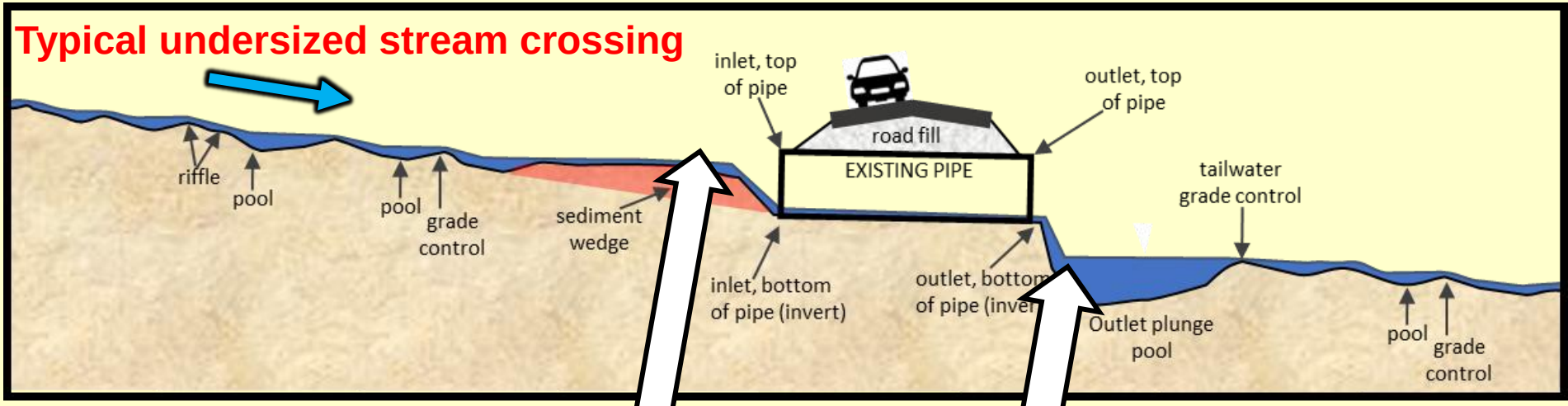
emriver.com

video used with permission



Streams move more than water, they move streambed!

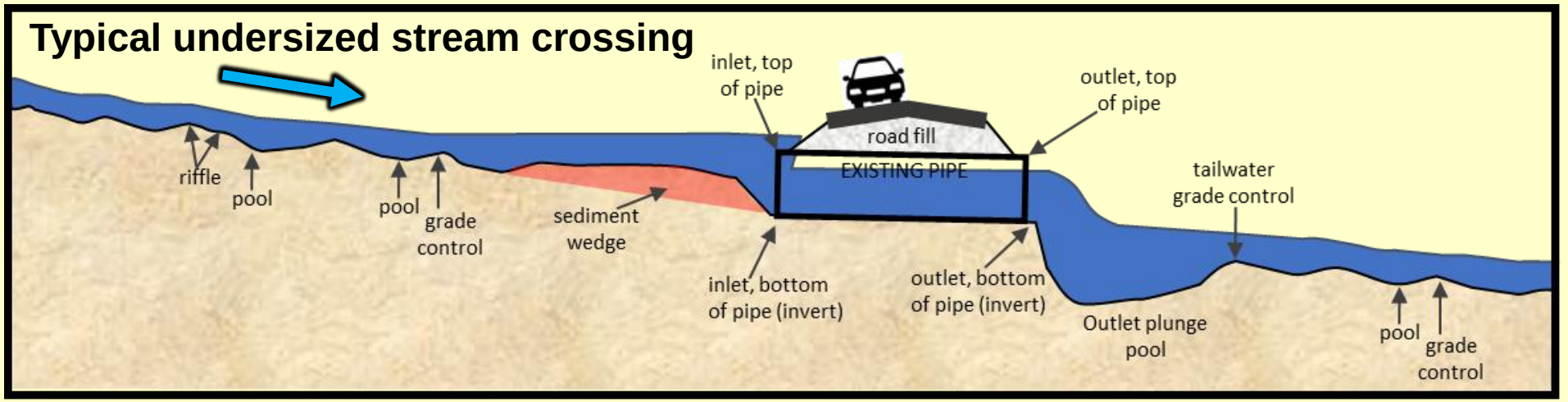
Missouri DNR, EM River, video used with permission



Trap sediment/debris upstream + Scour/undermine banks downstream

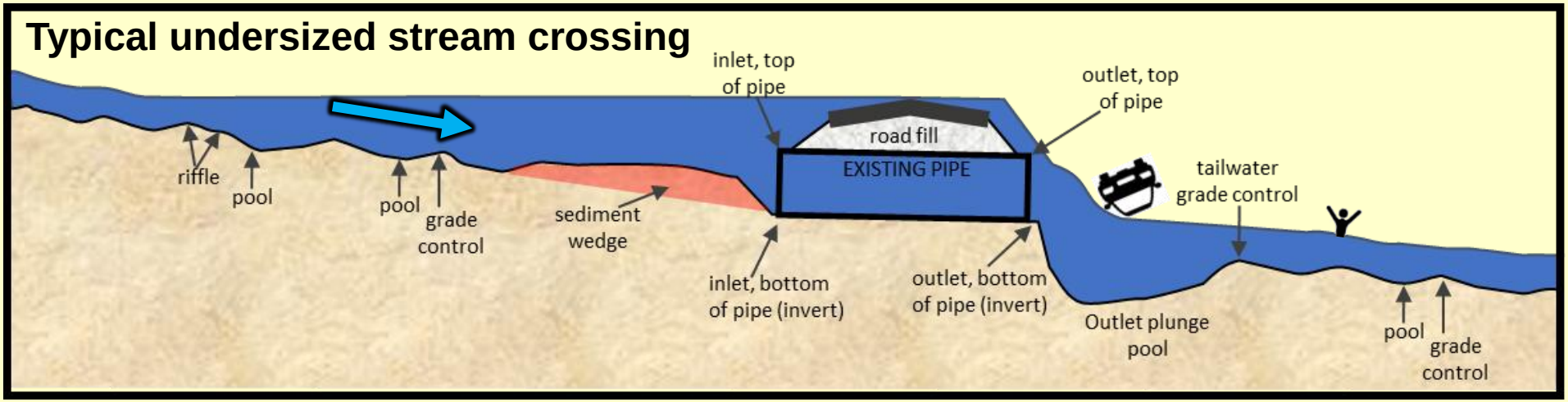
= Less capacity

= more flooding



What happens during High flows?

~1-year storm



What happens during High flows?

~10-year storm

VIDEO:

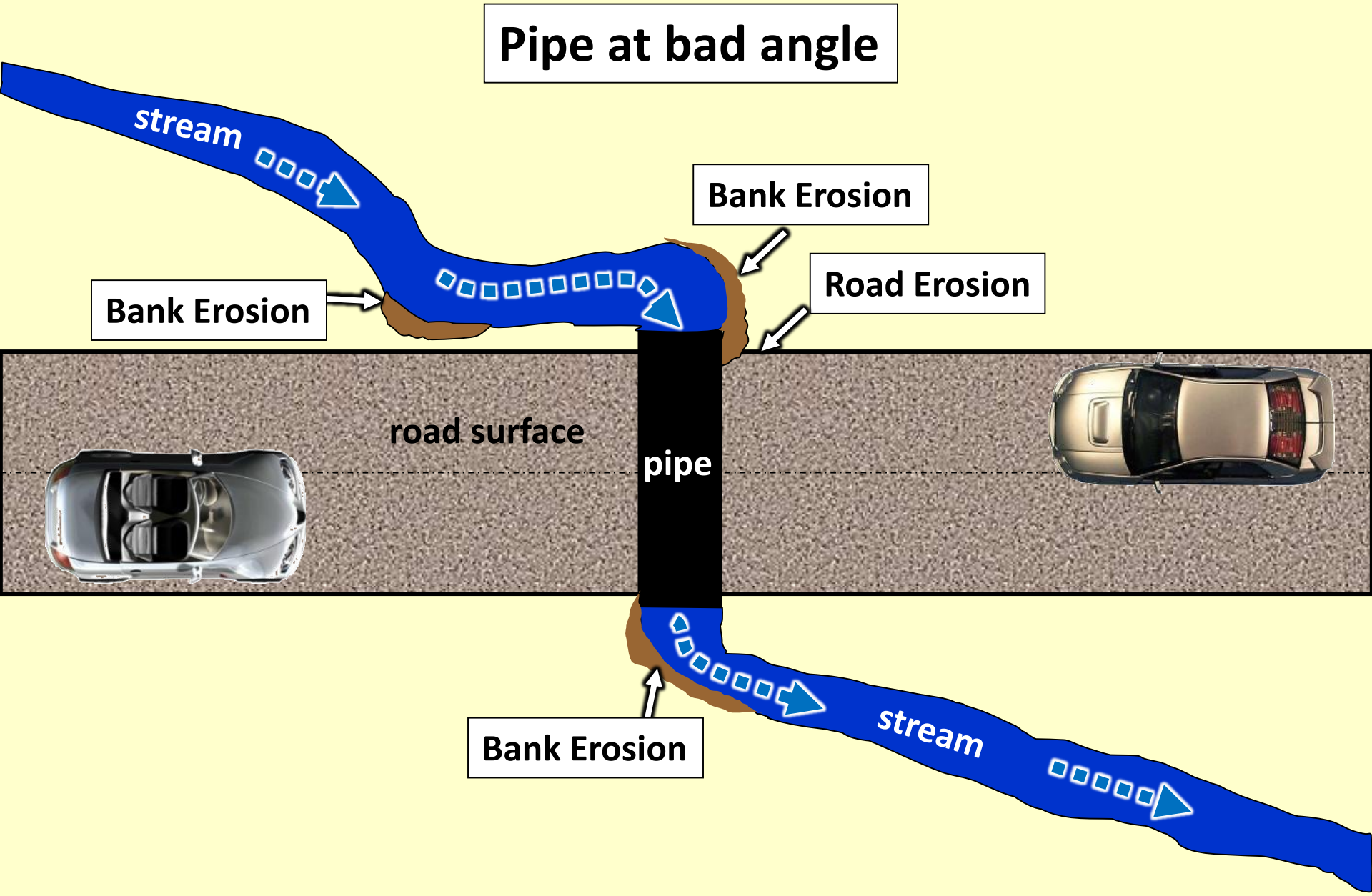
- Sand Table
- Effect of undersized pipe

video used with permission

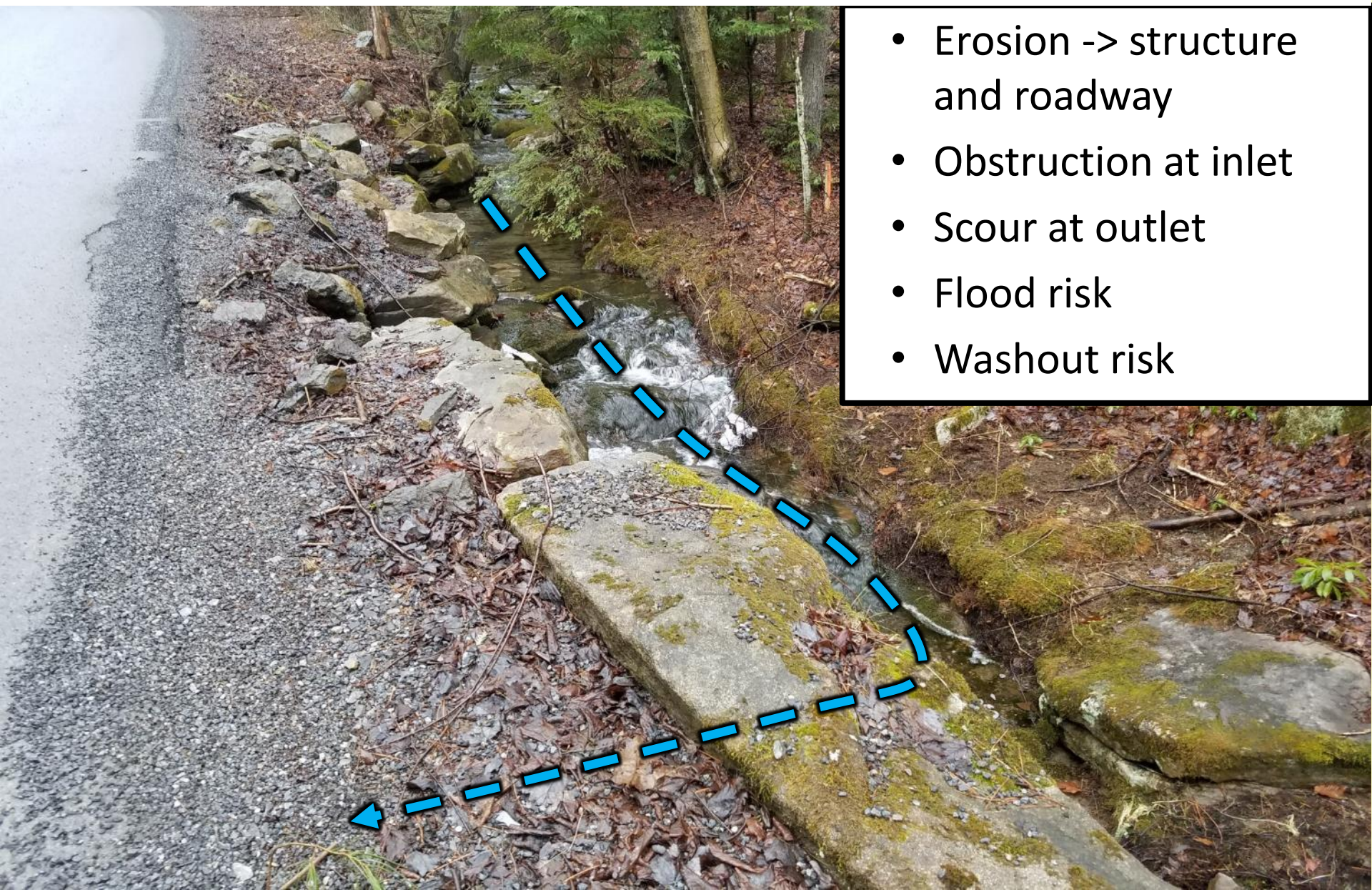
Sand Table Simulation – Undersized Structures

Problems with Traditional Stream Crossings

- Undersized structures
- **Poor structure alignment**
- Multiple structures
- Road profile at the crossing

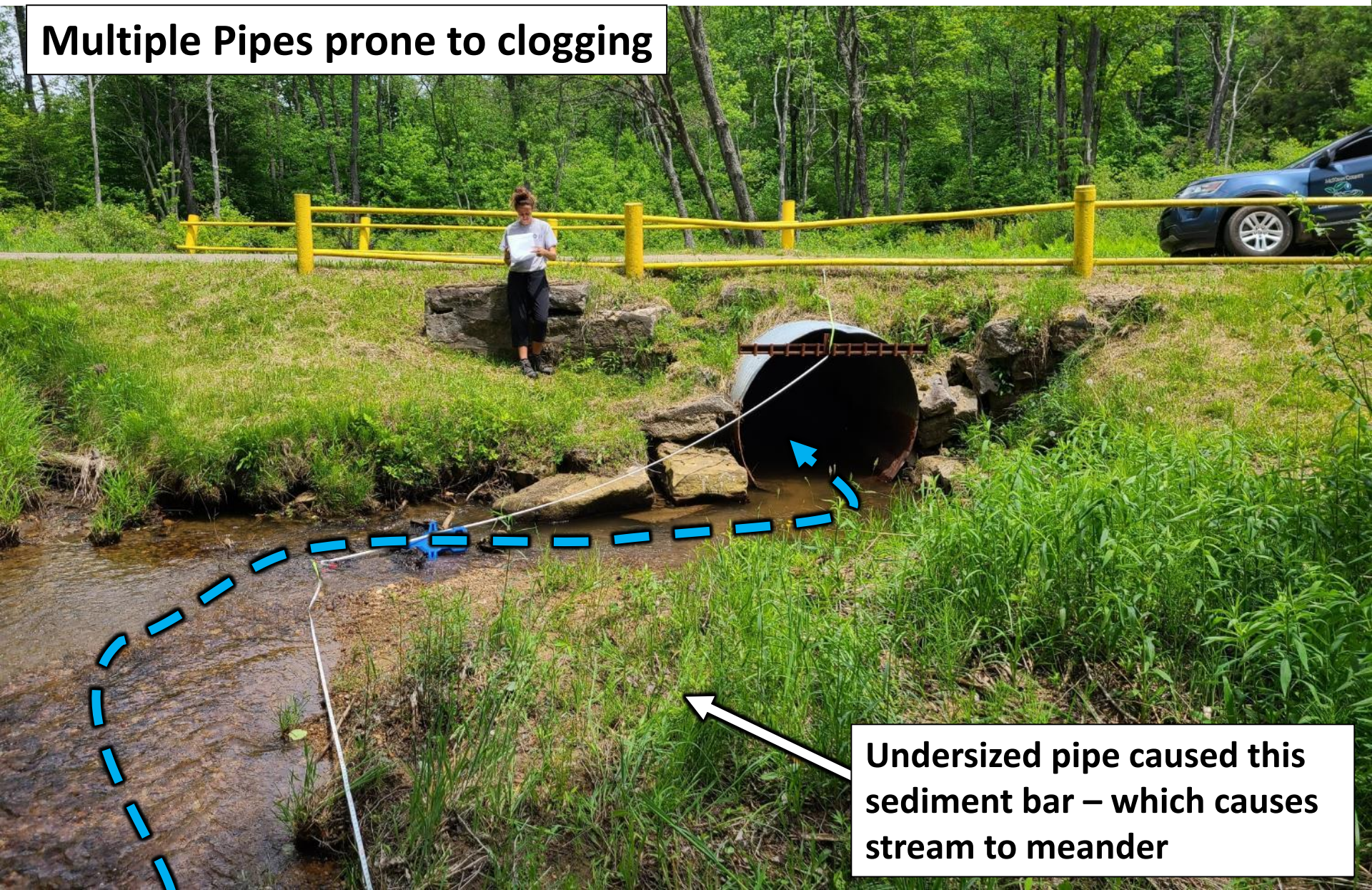

Pipe at bad angle
stream
Bank Erosion
Bank Erosion
Road Erosion
road surface
pipe
Bank Erosion
stream

Poor alignment = Poor conveyance



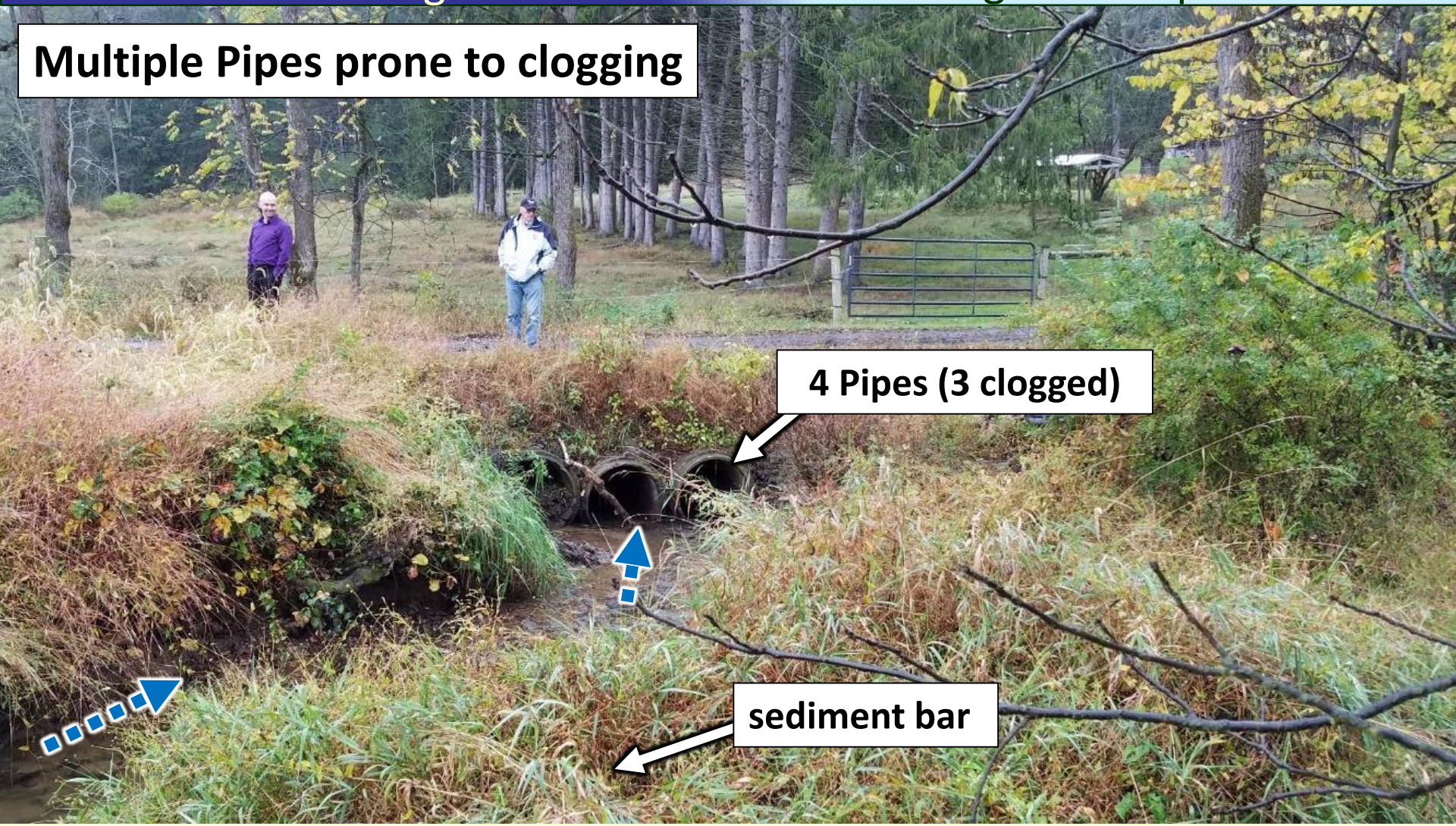
- Erosion -> structure and roadway
- Obstruction at inlet
- Scour at outlet
- Flood risk
- Washout risk

Big rocks can't fix the problem long-term…



Problems with Traditional Stream Crossings

- Undersized structures
- Poor structure alignment
- **Multiple structures**
- Road profile at the crossing



- Not enough conveyance
- Sediment deposits upstream
- Stream moves sideways => Erosion => Flooding

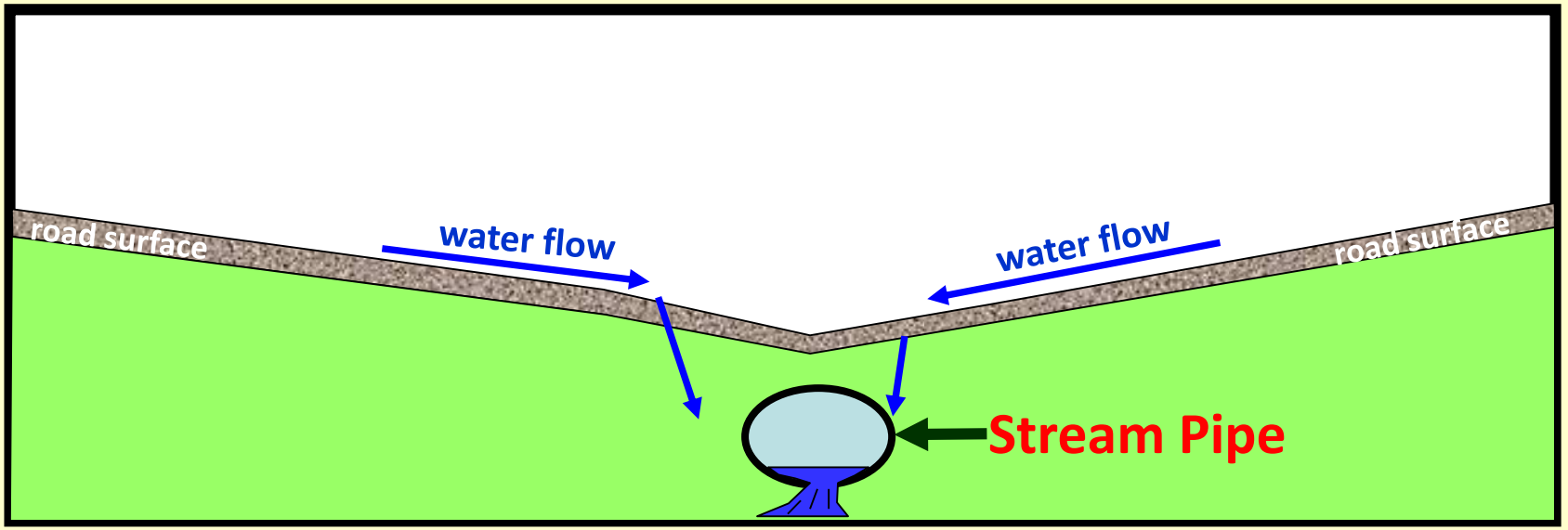

Multiple Pipes prone to clogging
Debris Jam
Three 7’ pipes in a 27’ bankfull channel.


Adding a 5th pipe doesn't fix the problem!

Problems with Traditional Stream Crossings

- Undersized structures
- Poor structure alignment
- Multiple structures
- **Road profile at the crossing**

<u>Common Practices:</u> The low point in the road is over the stream pipe.



Makes sense… Streams live in valleys

- Minimal road cover over pipe.
- Pipe is too small => disrupts stream shape
- Runoff from road concentrates at the crossing

Common Practices: Bridge deck or road surface at low point in road.

- Road debris washes onto bridge deck.
- **Flat bridge decks can't drain water**.

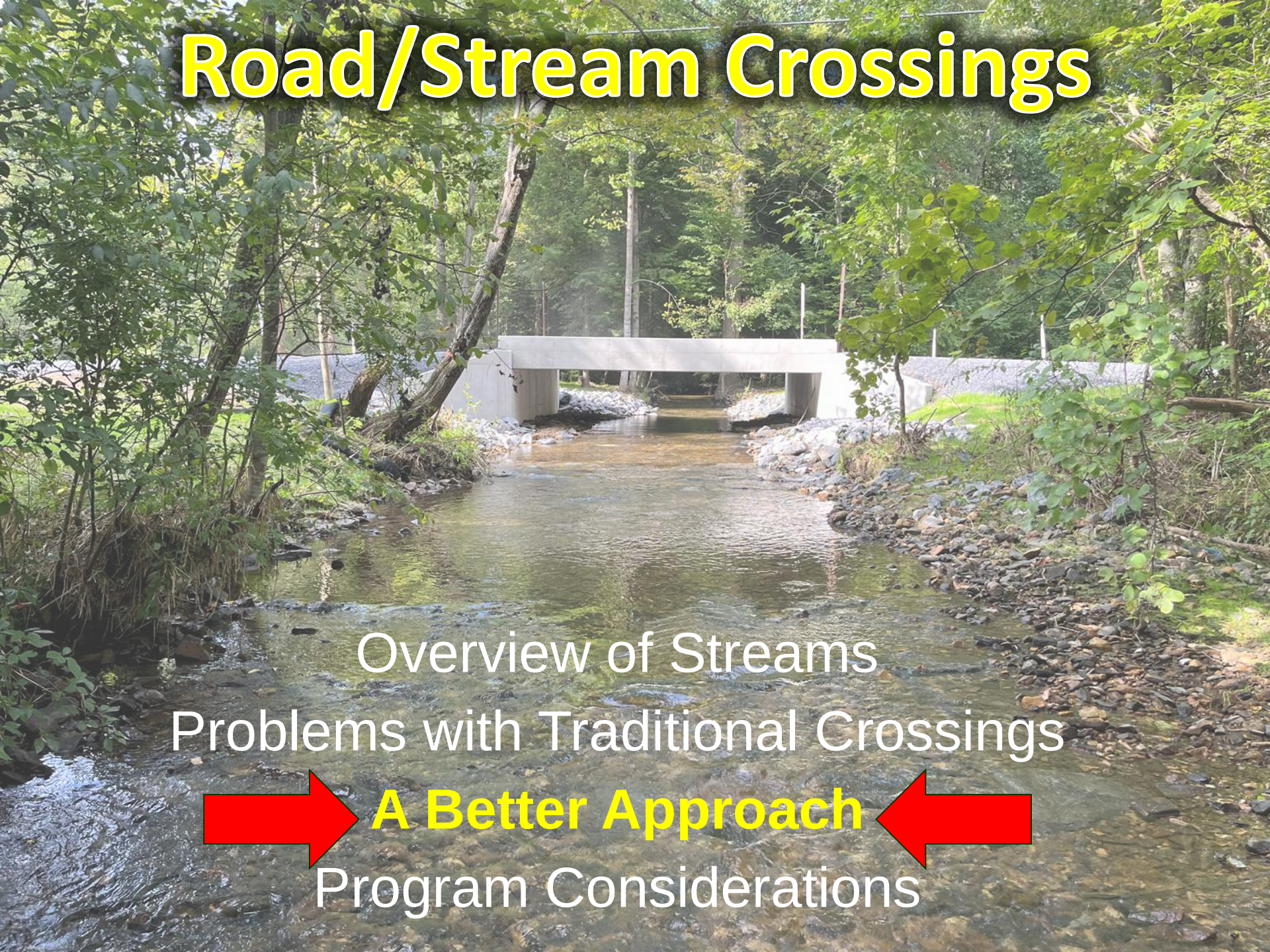
THE BIG PICTURE…

Trying to save money on stream crossings results in:

- Undersized pipes
- Poor pipe alignment
- Pipes too short
- Ends too close to the road
- Increased risk and maintenance
- Issues and headaches that cost you **time** and **money**

DGLVR Program provides funding and technical support for **Better Stream Crossings**

Road/Stream Crossings



Overview of Streams

Problems with Traditional Crossings

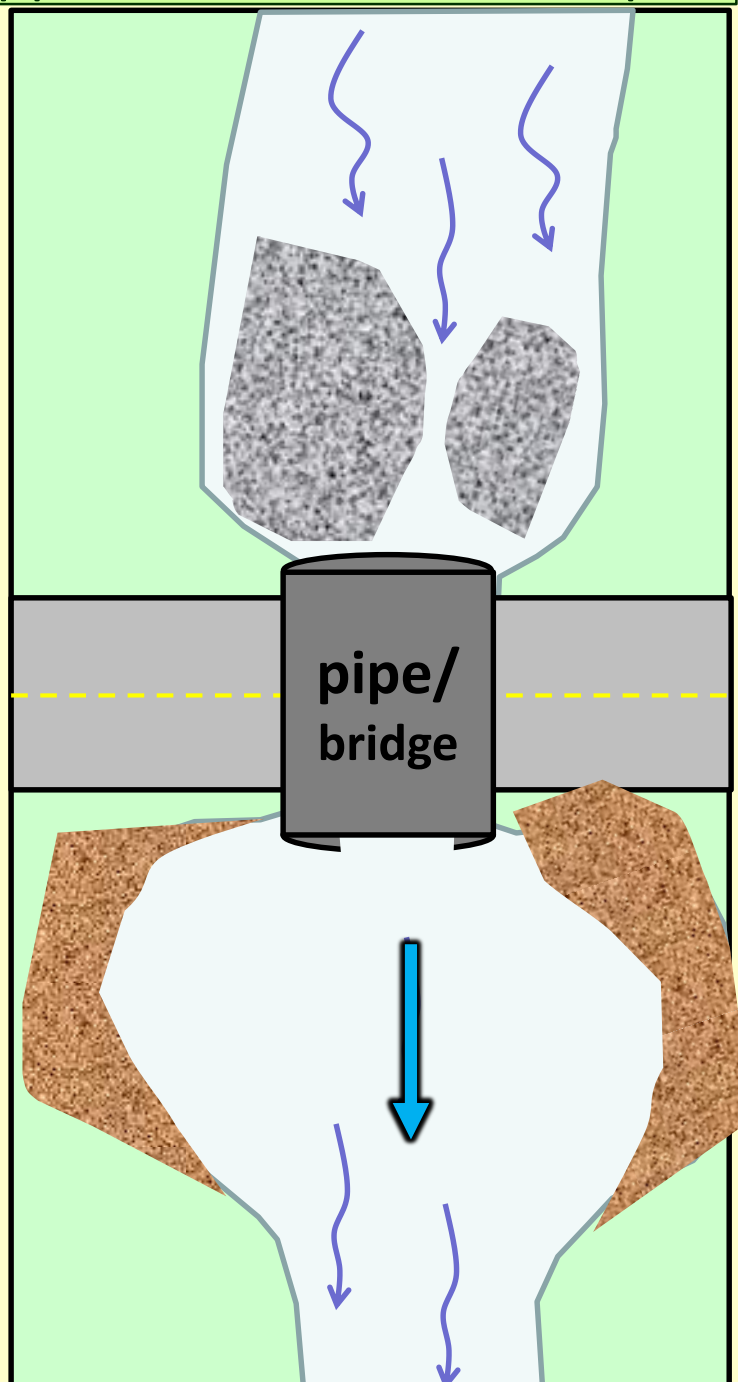
A Better Approach

Program Considerations

A Better Approach – Undersized Pipes

Remember undersized pipe issues

- Gravel bar formation upstream
- Erosion downstream



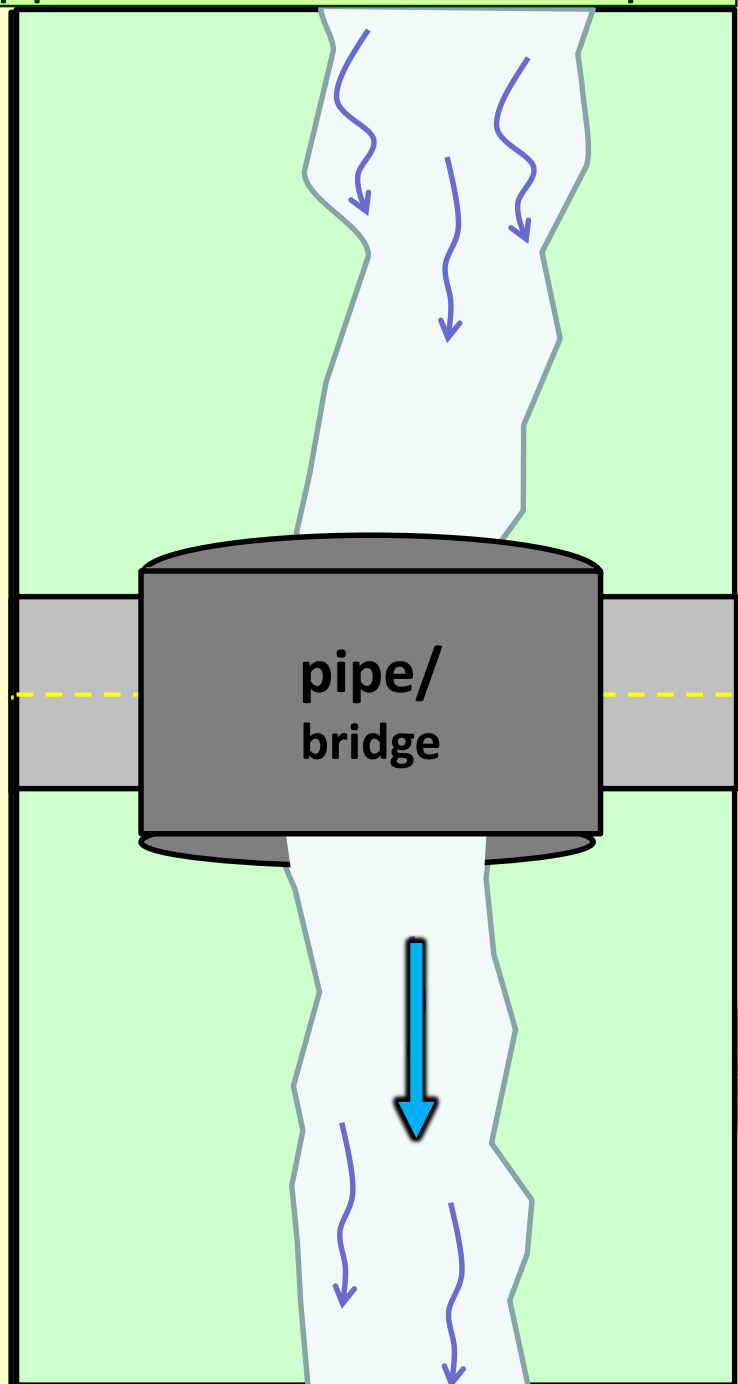
Remember undersized pipe issues

- Gravel bar formation upstream
- Erosion downstream

A New Approach…

"Build the stream like the road isn't even there"

Requires larger structure and additional considerations



A Better Approach:

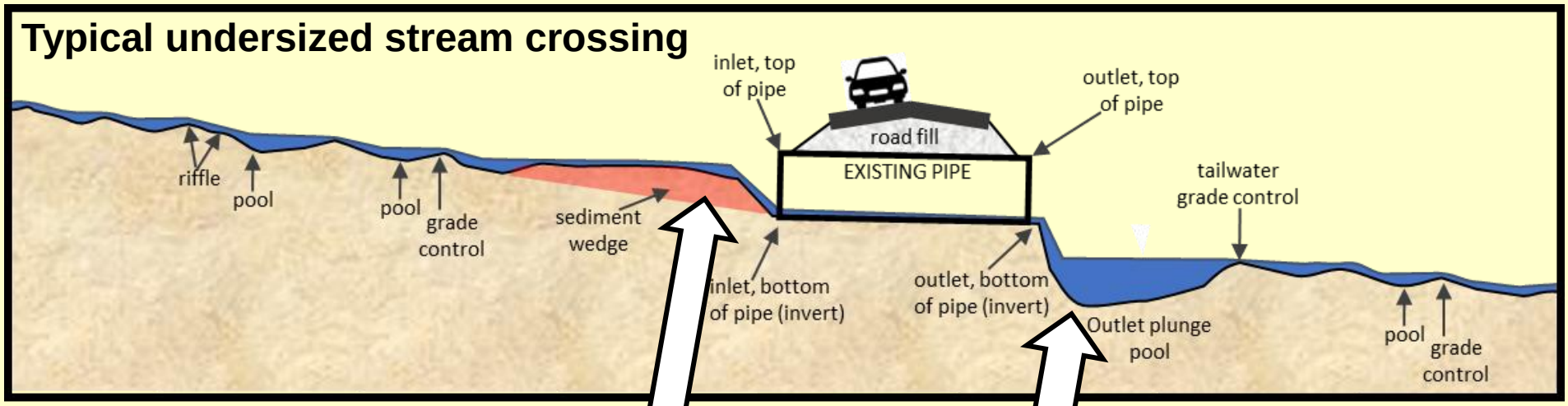
"Build the stream like the road isn't even there"

Better for Environment

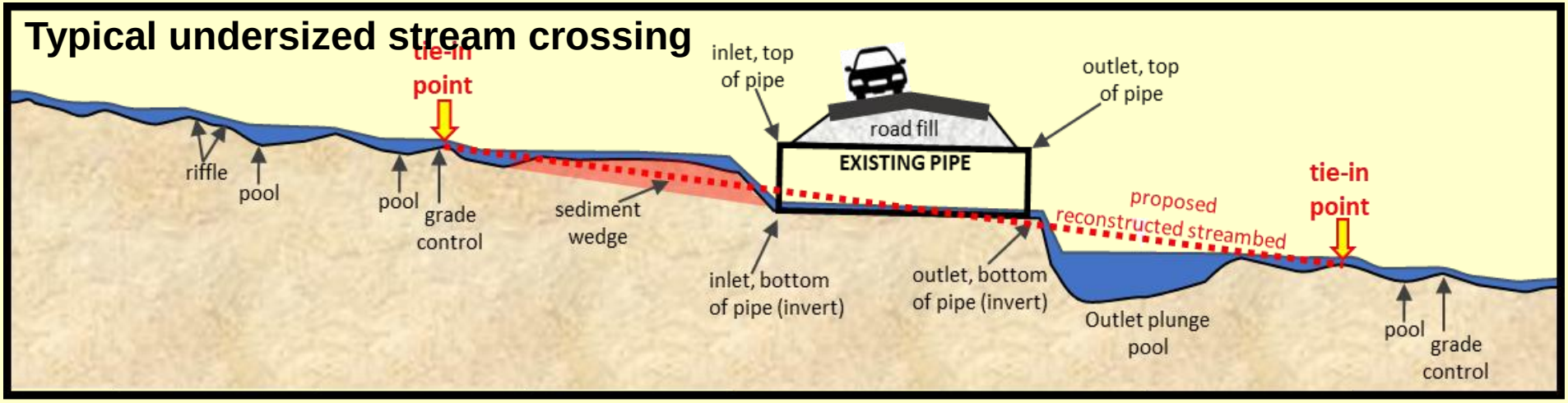
- Less erosion
- Passage for aquatic life

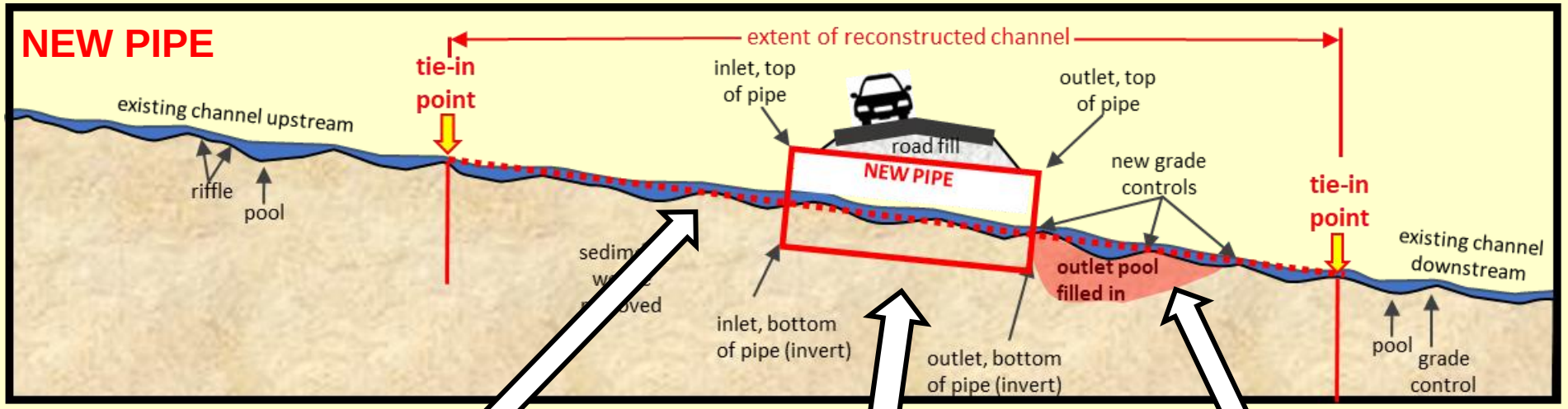
Better for YOU

- Less maintenance
- Less clogging and washout potential
- Longer structure life


Typical undersized stream crossing
inlet, top of pipe
outlet, top of pipe
road fill
EXISTING PIPE
riffle
pool
pool
grade control
sediment wedge
tailwater grade control
inlet, bottom of pipe (invert)
outlet, bottom of pipe (invert)
Outlet plunge pool
pool
grade control

Road-Stream Crossings — A Better Approach

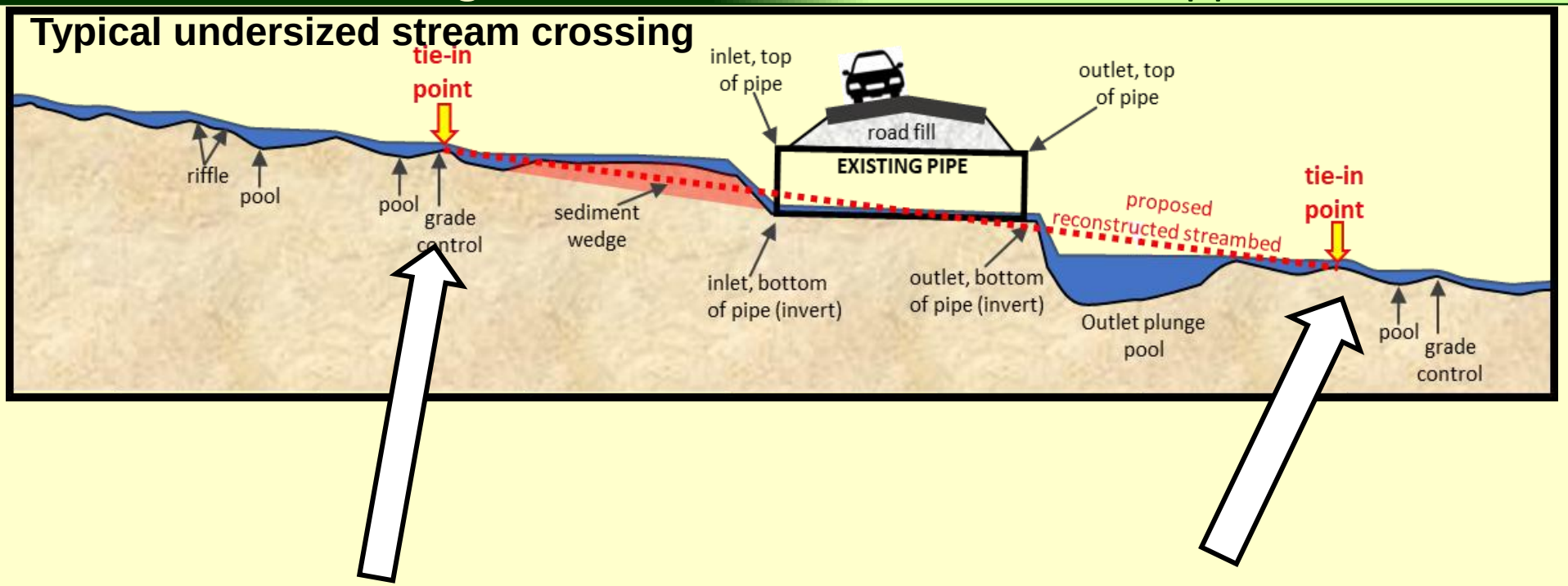




- **Sediment wedge removed**
- **Streambed reconstructed**

- **Larger pipe installed**
- **Sufficient material in pipe**

- **Scour hole filled in**
- **Streambed/banks reconstructed**

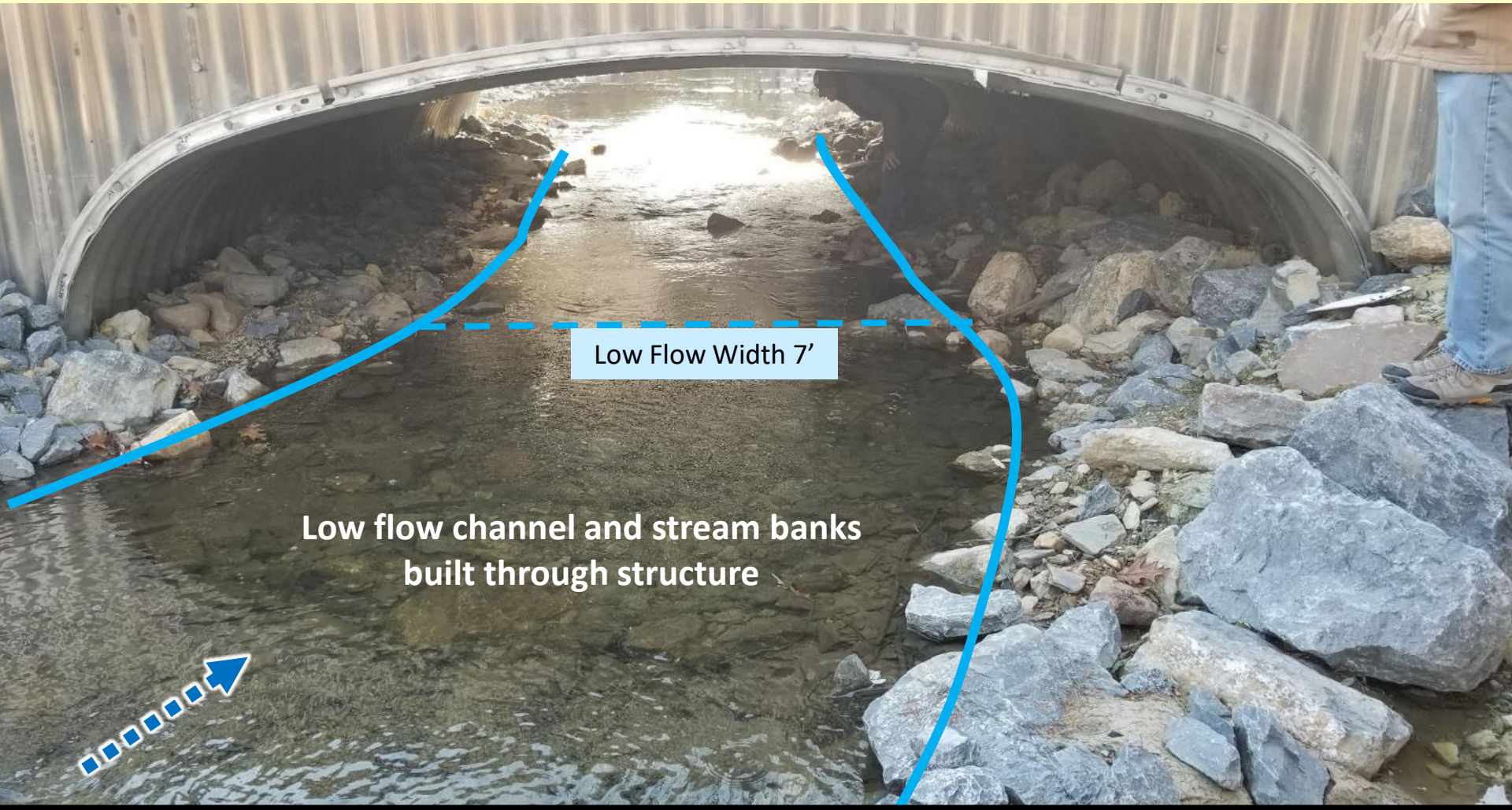


This often requires upstream and downstream channel work

Design will attempt to make features the same upstream, downstream, and through the structure

- Channel Shape
- Channel Composition
- Channel Slope
- Channel Structure (pools, riffles)
- Low Flow channel and bank margins

A Better Approach: "Build the stream like the road isn't even there"



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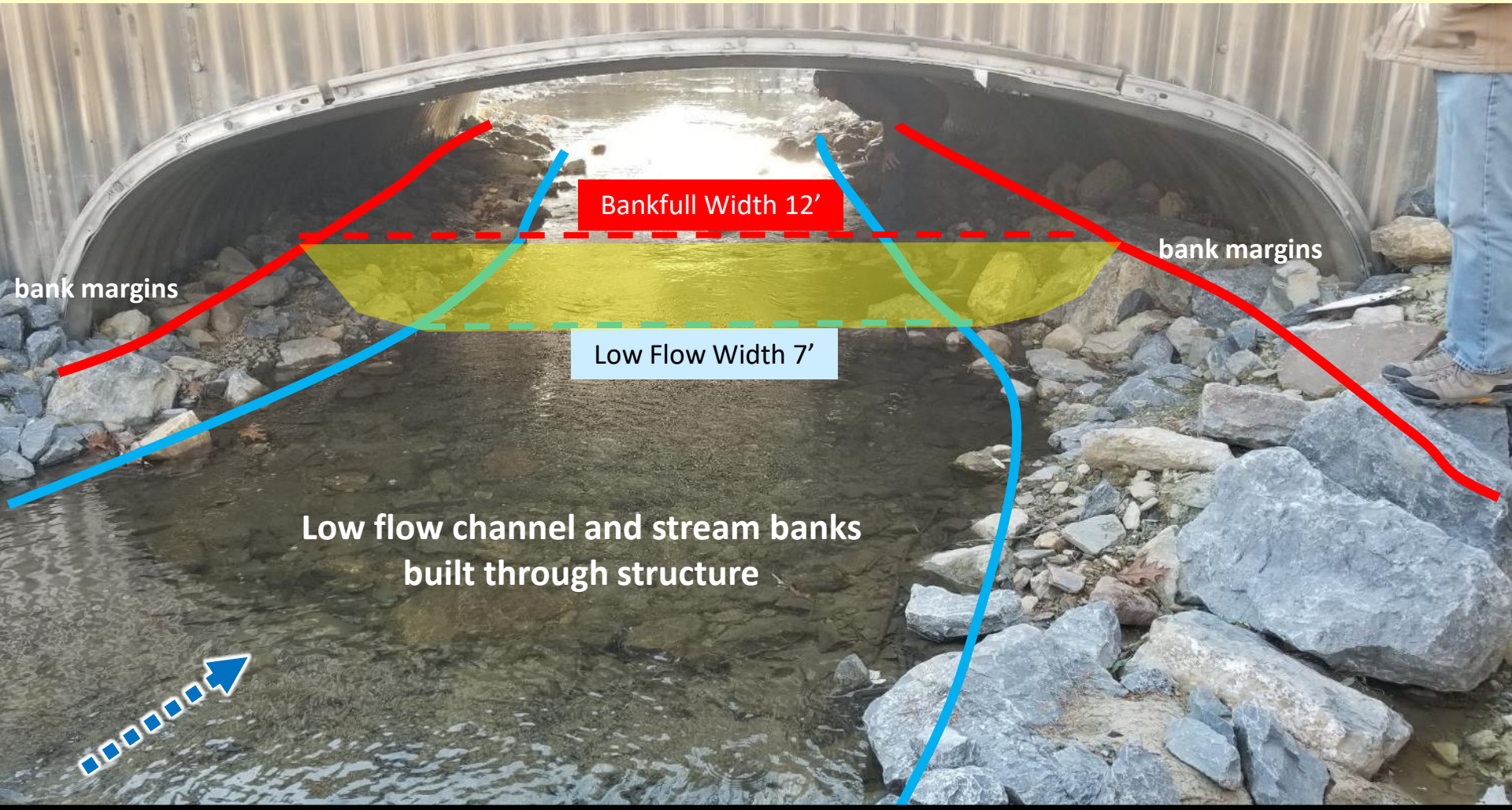
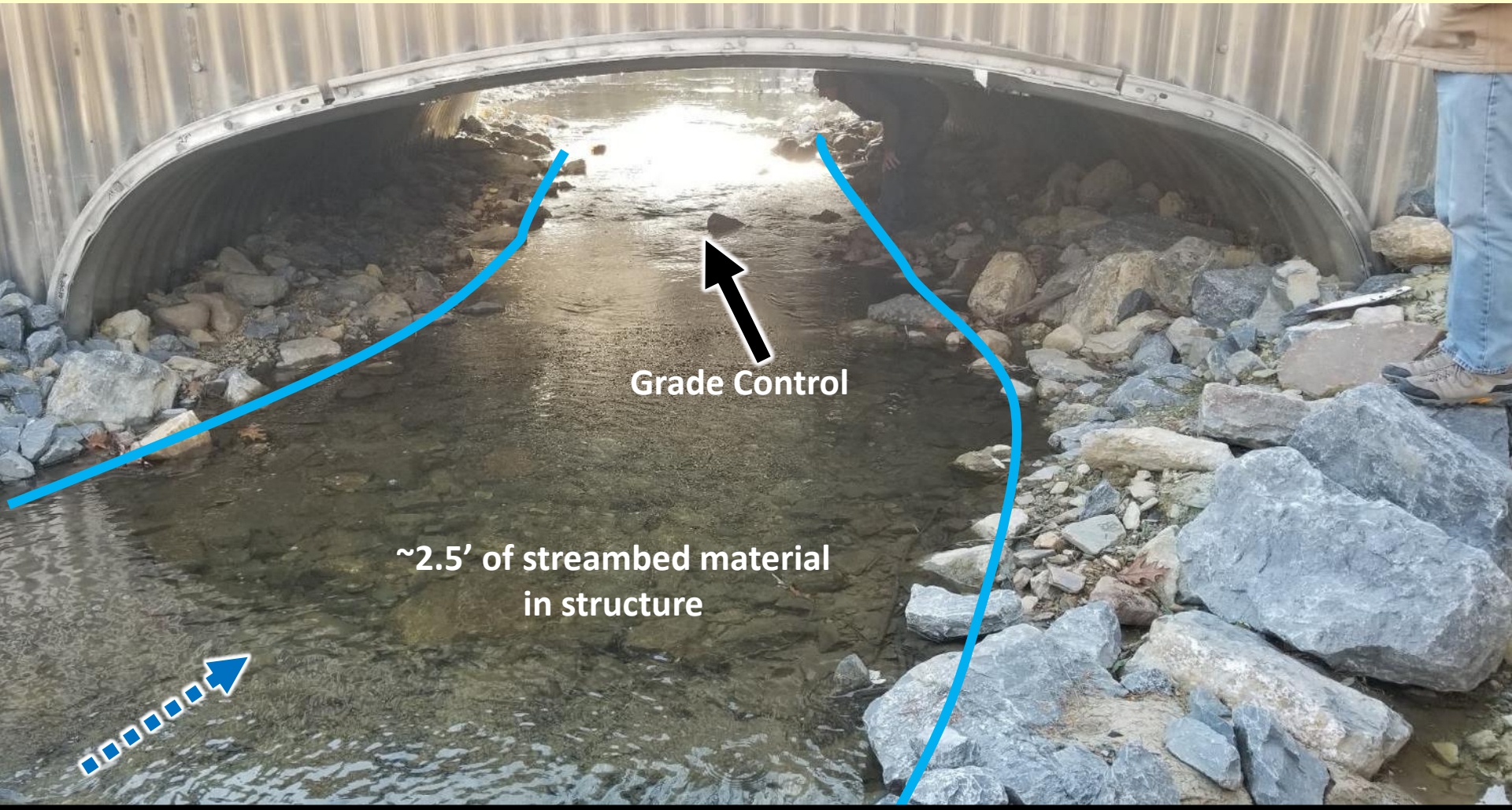


A Better Approach: "Build the stream like the road isn't even there"

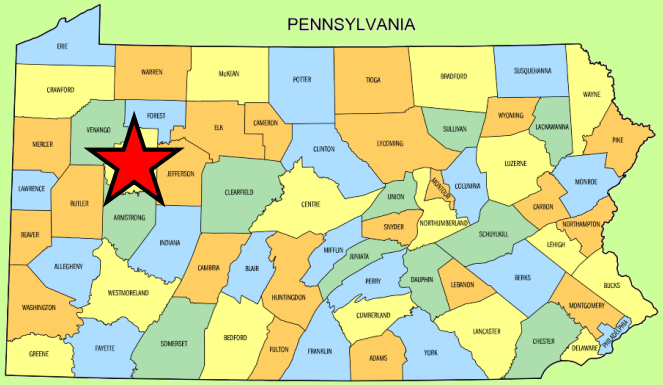


Example DGLVR Replacement Projects

- Clarion: 55’ Spread footing Bridge
- Union: 22’ Concrete Box Culvert
- Huntingdon: 15’ Arch Culvert Time Lapse
- Elk: 18’ Bottomless Arch Pipe

Project Walkthrough: Clarion County, Gowdy Road

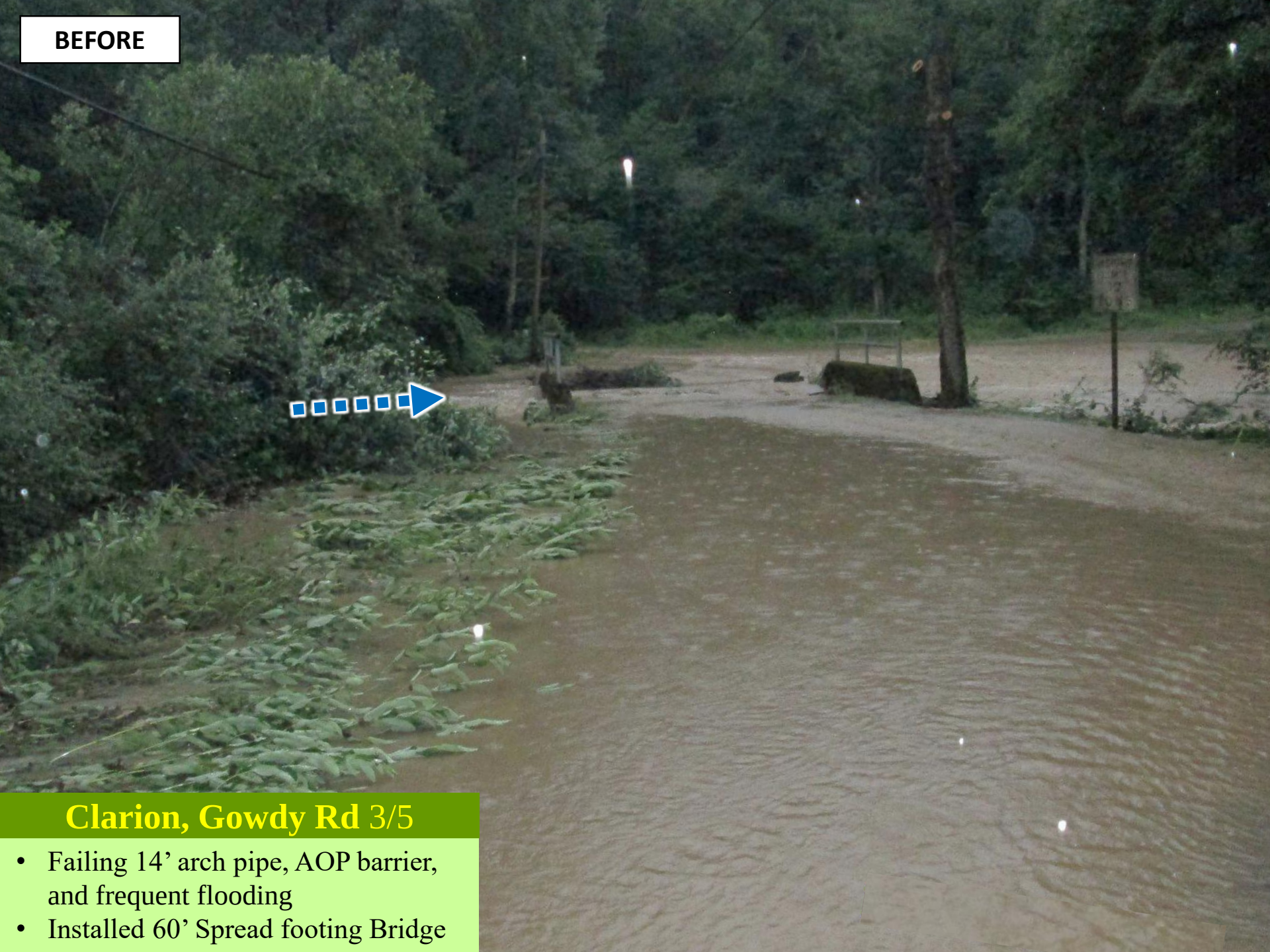
- **2022: $284K Grant, $30K in-kind**
- Failing 14’ arch pipe, AOP barrier, and frequent flooding
- Installed 60’ Spread footing Bridge



BEFORE

Clarion, Gowdy Rd 2/5

- Failing 14’ arch pipe, AOP barrier, and frequent flooding
- Installed 60’ Spread footing Bridge



Clarion, Gowdy Rd 3/5

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Clarion, Gowdy Rd 4/5

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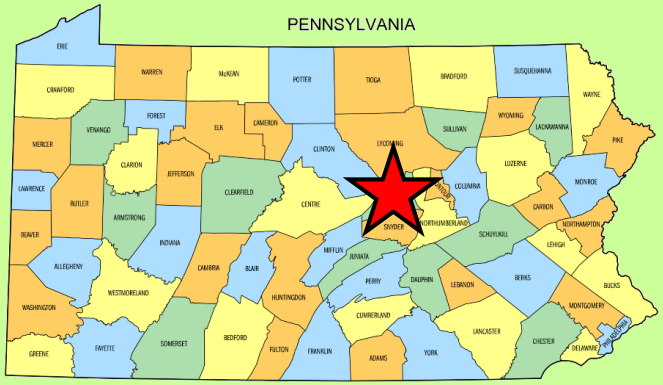
Clarion, Gowdy Rd 5/5

- Failing 14’ arch pipe, AOP barrier, and frequent flooding
- Installed 60’ Spread footing Bridge

Project Walkthrough: Union County, Polly Pine Road

- **2024: $160K Grant, $86K in-kind**
- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert with 5 grade controls



Union, Polly Pine Rd 2/8

- Twin 4’ pipes in 15’ channel
- Frequent clogging and flooding
- Installed 22’ concrete box culvert

Union, Polly Pine Rd 3/8

- Twin 4’ pipes in 15’ channel
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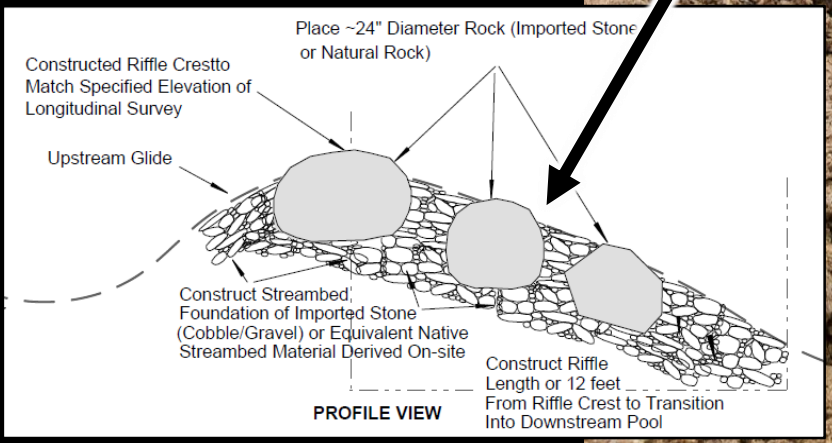
DURING

Placement of grade controls

Grade Control



Union, Polly Pine Rd 4/8

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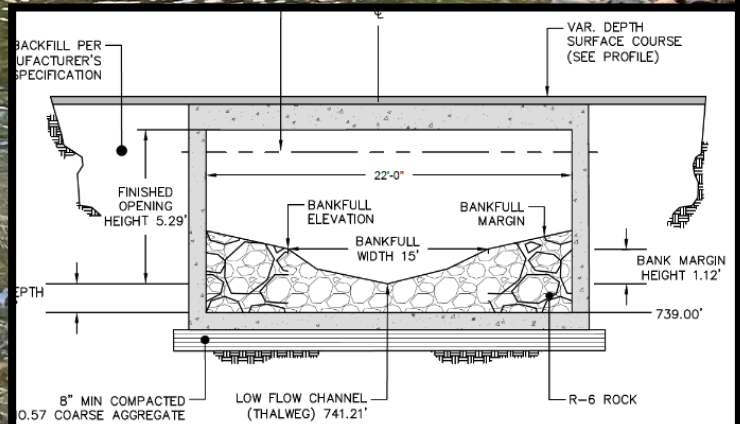
BEFORE

AFTER

Grade Control



Union, Polly Pine Rd 5/8

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Hurricane Debbie, ~7” of rain, 3 weeks post construction

Union, Polly Pine Rd 6/8

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Hurricane Debbie, ~7” of rain, 3 weeks post construction

Union, Polly Pine Rd 8/8

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- Frequent clogging and flooding
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Completed under DGLVR Stream Crossing Design and Installation Standard

VIDEO:

- Time Lapse (2:04)
- Shaver's Creek 15' arch pipe installation

PA Dirt, Gravel, and Low Volume Road Maintenance Program

Project Video: Shaver Creek Road Pipe Installation (Downstream)

Location: Shaver Creek Road, Penn State Experimental Forest, Huntingdon County, 40°39‘20.2"N, 77°55‘35.2"W
Watershed area ~840 acres

Problem: Failing 6’ squash pipe in a headwater stream with a 14’ bankfull channel. Undersized crossing had created a significant upstream sediment wedge and downstream scour hole with a ~3’ outlet drop.

Fix: A 15’ x 10’ structural plate pipe arch was assembled and installed with headwall/endwall. Streambed was re-established in the pipe and three log cross vanes were installed upstream to control the grade and return the stream to its natural condition.

Project Funding: PSU Center for Dirt and Gravel Road Studies, through PA State Conservation Commission DGLVR Program.

Time Lapse Information:

April 8-23, 2019

Image interval: 1 minute

Frame rate: 20 FPS

Funding provided by PA State Conservation Commission, Dirt, Gravel, and Low Volume Road Maintenance Program.

Video created by Penn State University Center for Dirt and Gravel Road Studies.

Huntingdon: Shaver’s Creek Time Lapse

- Existing 6’ Squash Pipe
- 13’ Bankfull Channel
- Installed 15’ Structural Plate Arch

Road/Stream Crossings

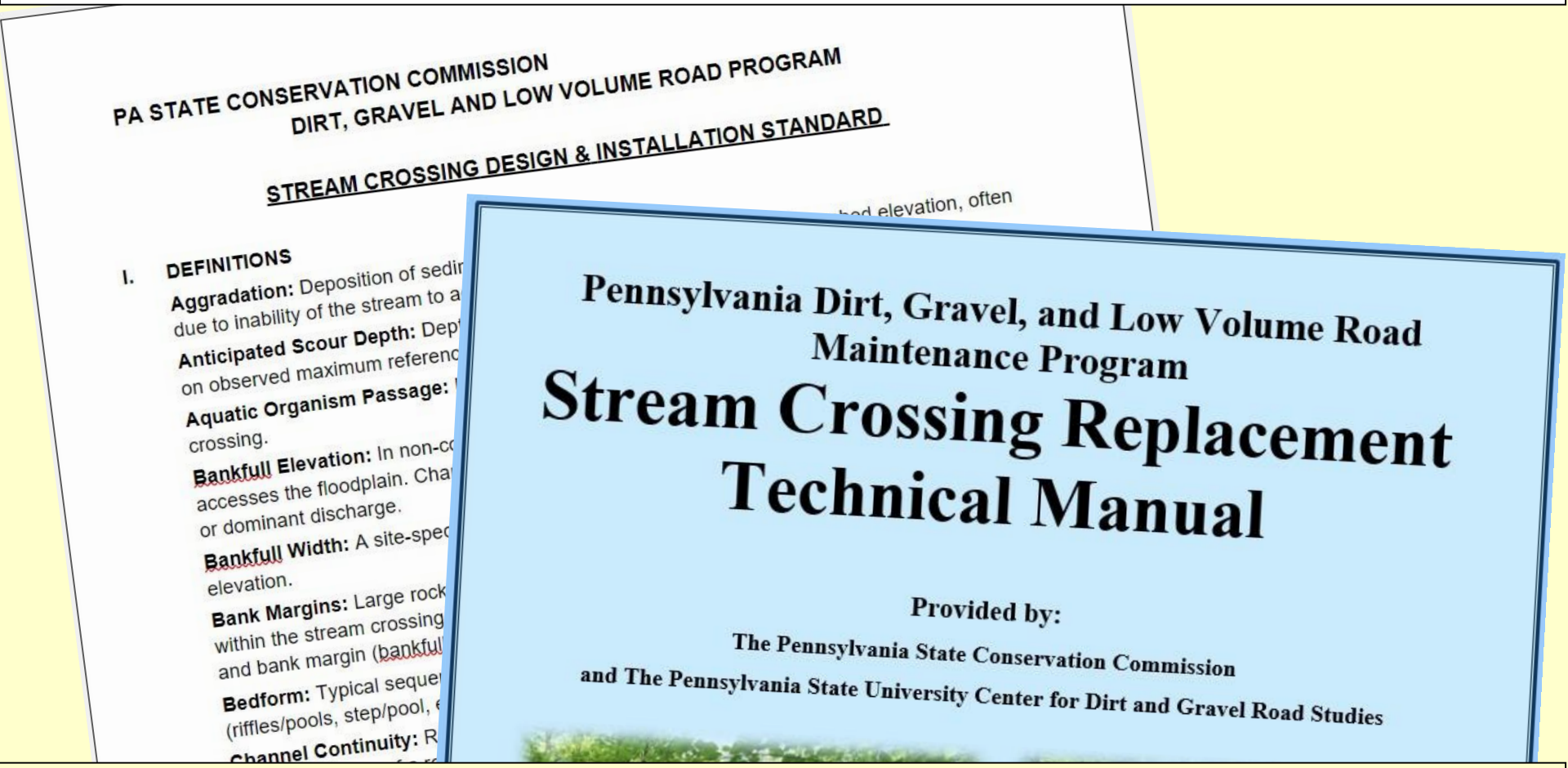
Overview of Streams

Problems with Traditional Crossings

A Better Approach

Program Considerations

How do we do this?


PA STATE CONSERVATION COMMISSION
DIRT, GRAVEL AND LOW VOLUME ROAD PROGRAM

STREAM CROSSING DESIGN & INSTALLATION STANDARD

I. DEFINITIONS

Aggradation: Deposition of sedi
due to inability of the stream to a

Anticipated Scour Depth: Dep
on observed maximum referenc

Aquatic Organism Passage:
crossing.

Bankfull Elevation: In non-c
accesses the floodplain. Cha
or dominant discharge.

Bankfull Width: A site-spec
elevation.

Bank Margins: Large rock
within the stream crossing
and bank margin (bankful

Bedform: Typical sequer
(riffles/pools, step/pool,

Channel Continuity: R

Pennsylvania Dirt, Gravel, and Low Volume Road Maintenance Program

Stream Crossing Replacement Technical Manual

Provided by:

The Pennsylvania State Conservation Commission

and The Pennsylvania State University Center for Dirt and Gravel Road Studies

Design & Installation Standard (“Rulebook”)

Technical Manual (“How-To Guide”)

Will not review in detail today

Interested? - Contact your Conservation District!

Initial considerations:

- Some CDs **do not fund** stream crossings
- Some CDs are **limited by funding availability**
- Structure to be replaced **must be undersized**
- **Some small crossings are exempt** from Standards
- **Off Right-of-Way permission is necessary** to restore stream channel upstream and downstream of the structure

Interested? - Contact your Conservation District!

Initial considerations:

- Permitting with DEP
- Channel reconstruction/re-alignment
- Timelines

Initial Site Assessment with Conservation District

- CD will help in measuring bankfull width and determining structure eligibility for replacement
- CD will fill out form to document eligibility

PA Dirt Gravel and Low Volume Road Program—Stream Crossing Eligibility Determination Form **7/2022**

Reviewer Information:

Date: _____

Reviewer(s): _____

_____

Existing Structure (circle):

round oval arch Other (Draw)

box bridge multiple

Site Information:

County _____ Township _____

Road Owning Entity _____

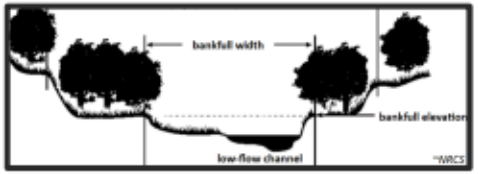
Structure Owning Entity _____

Road Name _____

Stream Name _____

Latitude _____ N Longitude _____ W

Site Notes _____



Measuring Bankfull Channel Width: Since stream conditions vary, these guidelines are flexible, and the goal is to determine bankfull width of an unaltered "reference reach" of the stream.

Where to take Measurements: Look upstream if possible, trying to find an undisturbed stretch of stream free from influences that may impact cross section (such as debris jams, floodplain obstructions, bedrock outcrops, etc.). Look downstream for measurements if prevented from going upstream. In order to get out of the "area of influence" from the structure, roughly estimate the bankfull channel width, then go at least 5 times that distance away from the structure before considering taking bankfull measurements. Additional bankfull widths should be measured so that three to five (more preferred) measurements are collected. Subsequent bankfull width measurement should be collected at least 1/2 bankfull width away from the first measurement. Note that it is important to measure bankfull where the best indicators and these locations may be much greater than ½ bankfull width apart. Avoid taking bankfull measurements at unique, unnatural, or temporary features such as log or debris jams, manmade obstructions, bedrock outcrops, hard meander bends, and braided channels. Bankfull measurements can be taken further from the structure if needed if there are no major splits in the channel. **Be flexible** when choosing where to take measurements in order to capture the most representative reaches of the stream.

Taking Bankfull Measurements: When taking a bankfull measurement, locate bankfull indicators (such as changes in bank slope, depositional

Initial Site Assessment with Conservation District

- **Automatically Eligible:**
  - Existing pipe is 4’ or less
  - Multiple pipe crossings

- **Replacement eligibility is based on environmental impacts**

<u>NOT</u> structural condition

Initial Site Assessment with Conservation District

- **Potentially Eligible**

  Larger single structures must be less than 75% of bankfull width of channel

Ex. 4’ pipe in a stream with 10’ bankfull width

- 4/10 = 40% - ELIGIBLE

- **Replacement eligibility is based on environmental impacts <u>NOT</u> structural condition**

Exemptions

Some sites may be exempt from DGLVR standard:

Very Small Channels

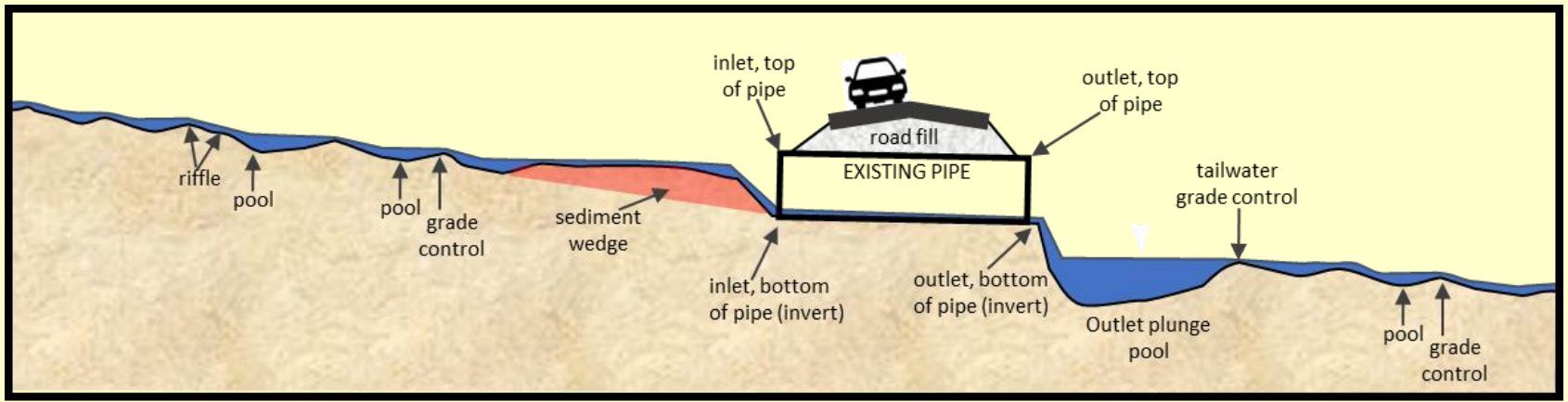
Where Connectivity is Impossible

Conservation District will help with determinations!

After initial site assessment…

Site Survey: Survey done by CD

- Guides project estimates and budgets
- Informs structure selection and channel reconstruction

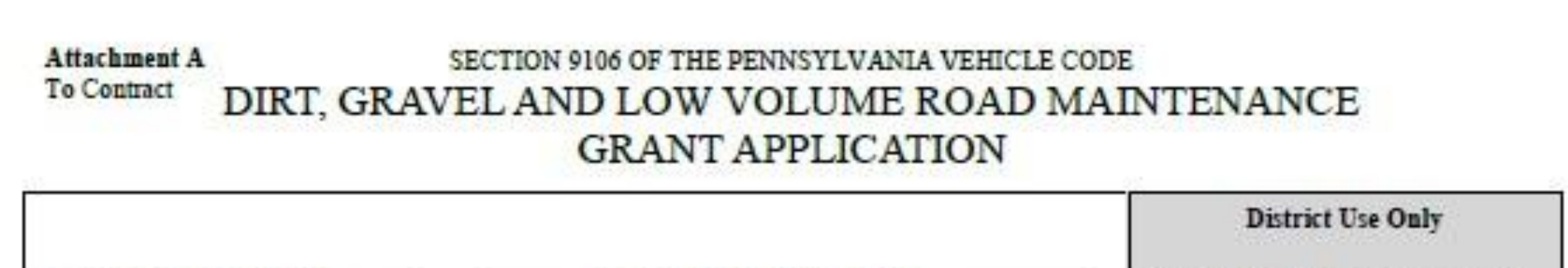


Application Considerations

After survey, use info and work with CD to figure out:

- Approximate structure type and size
- Length of streambed reconstruction needed
- Amount and type of materials needed
- Solutions for other drainage issues on road
- Who will complete the project? (Twp or Contractor)

Purpose is to get the best possible cost estimates for your grant application



Attachment A
To Contract

SECTION 9106 OF THE PENNSYLVANIA VEHICLE CODE

DIRT, GRAVEL AND LOW VOLUME ROAD MAINTENANCE
GRANT APPLICATION

District Use Only

You're funded! What's next?

Time to hire an Engineer to…

- **Select an appropriate structure** for the replacement
- **Design stream channel restoration**
- **Apply for permits** on applicant's behalf
- **Be available** for major aspects of construction

Structure sizing and selection: CD & Engineer

- Engineer will select a structure to pass 100-year storm at 80% capacity
- New structures will be significantly larger than existing structures (minimum of 125% of bankfull)

Permitting: CD & Engineer

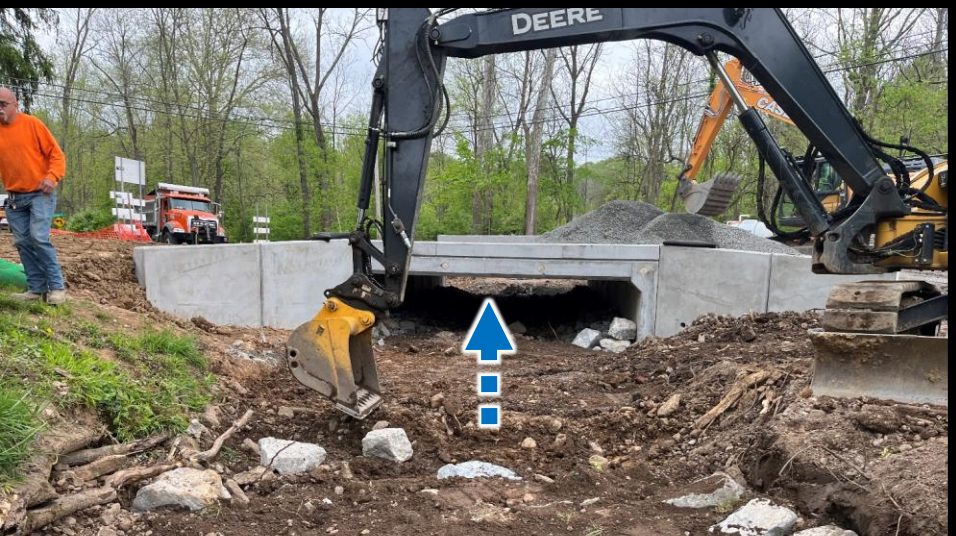
All Standard Permit Requirements Apply

- No additional DGLVR permit requirements
- CD to ensure plans are consistent with DGLVR Standard
- Engineer will submit final plans to DEP

- **GP7:** Small Crossings
- **GP11:** Medium to Large Crossings
- **Joint Permit:** Large crossings w significant channel work

Stream Restoration: CD & Engineer

Requires more channel design, work, and reconstruction



Final Considerations

YES, upfront costs will be higher

But remember, look at long term costs:

- **DGLVR will pay** for the structure, design, and installation.
- **Think long term.** Studies suggest cost savings over the 75–100-year structure life.
  - Less maintenance
  - Longer lifespan
  - Less chance of extreme failure / washout

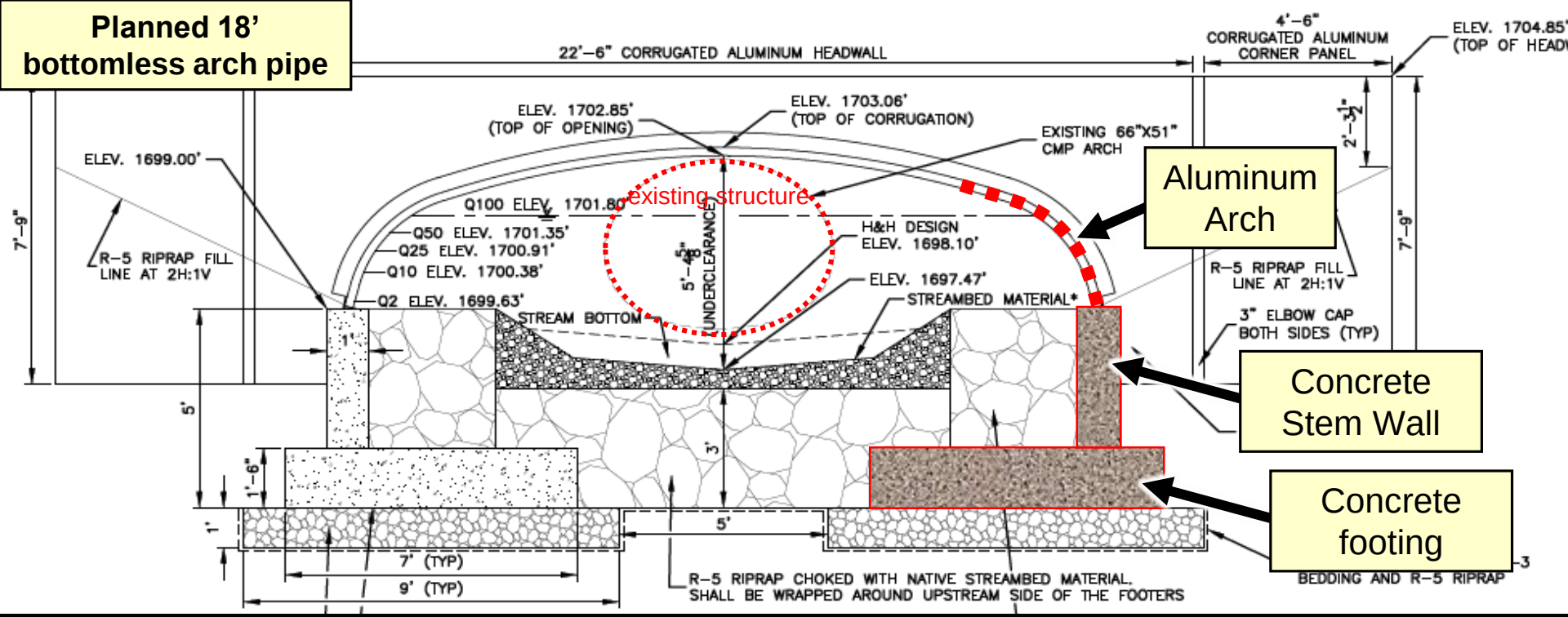
Project Walkthrough: Elk County, Gardner Hill Road

- **2024: $130K Grant, $45K in-kind**
- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Elk, Gardner Hill 2/10

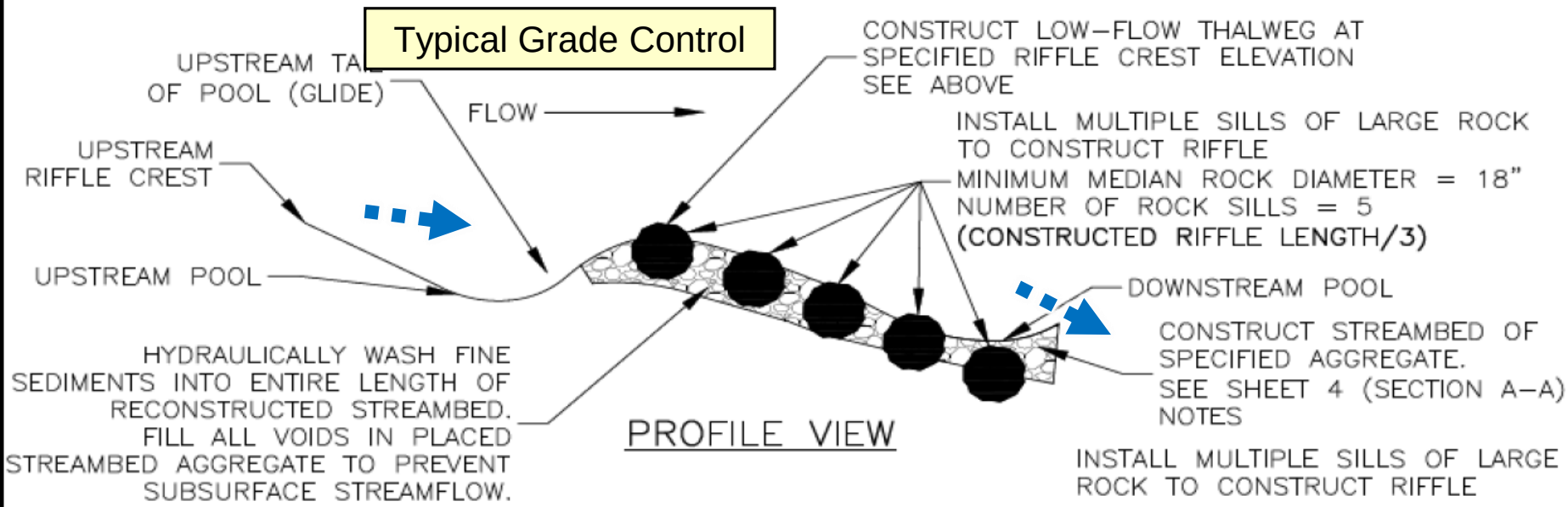
- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Planned 18' bottomless arch pipe

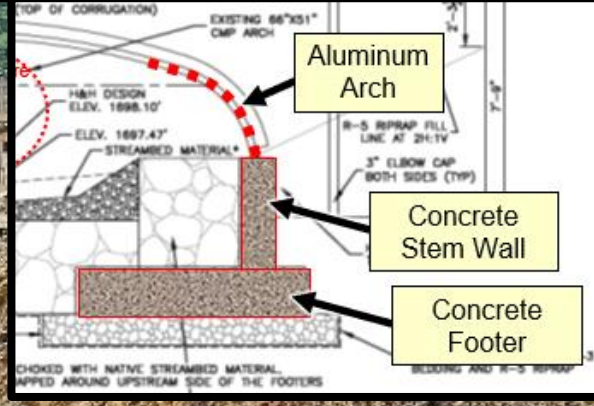


NOTE: FOR THIS PROJECT, CONSTRUCTED RIFFLE LENGTH (UPSTREAM TO DOWNSTREAM) IS 15.8'

Typical Grade Control



DURING



Rebar for stem wall

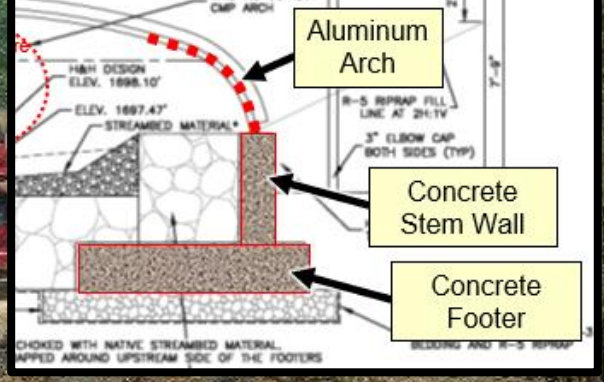
Left footing pad

Right footing

Elk, Gardner Hill 4/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

DURING



Rebar for stem wall

stem wall

Left footing

Right footing

Elk, Gardner Hill 5/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
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DURING
Stem walls allow streambed construction before installing top
stem wall
stem wall
Setting Grade Control Rocks
Bobcat
E45

Stem walls allow streambed construction before installing top

Easier than building the streambed with top on!

stem wall

stem wall

Setting Grade Control Rocks

Elk, Gardner Hill 7/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Elk, Gardner Hill 8/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Elk, Gardner Hill 9/10

- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

AFTER

Grade Control Rocks

Elk, Gardner Hill 10/10

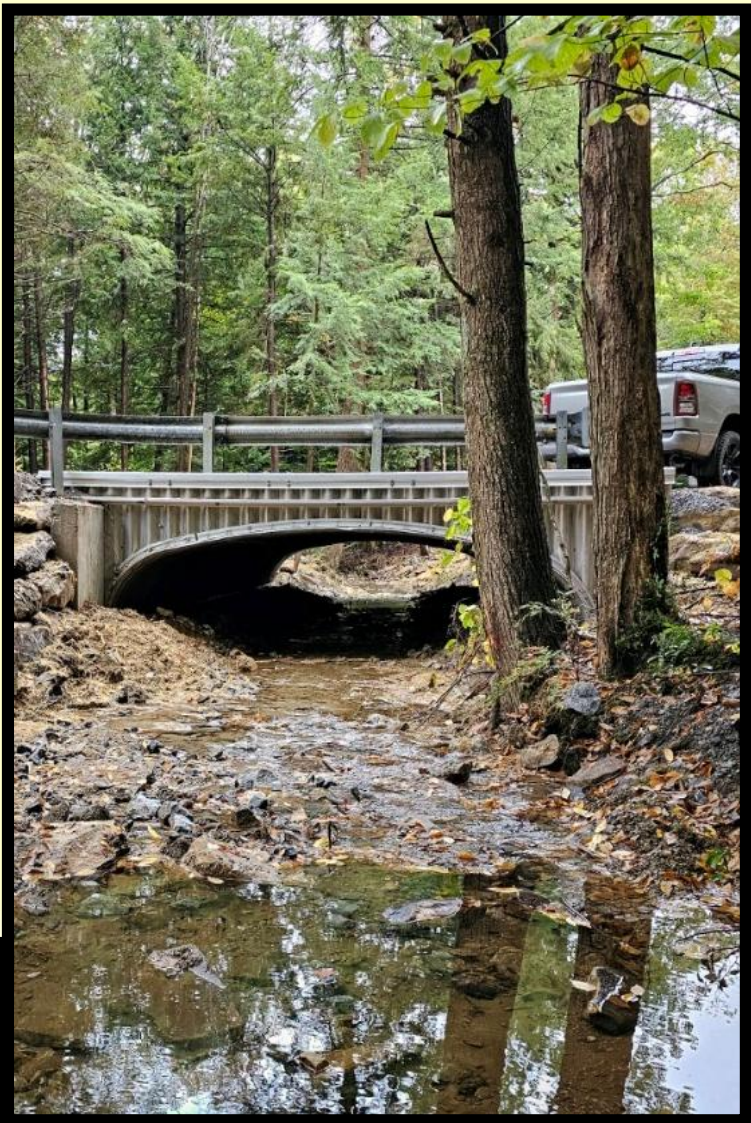
- 4’ pipe in 12’ channel caused outlet drop and AOP barrier in trout stream
- Installed18’ bottomless arch pipe on poured concrete footings

Completed under DGLVR Stream Crossing Design and Installation Standard

Stream Crossing Replacements

ADDITIONAL RESOURCES:

- Your Conservation District
- Your Municipal Engineer
- www.dirtandgravelroads.org
  - DGLVR Documents
    - Policy
    - Standard
    - Technical Manual



next chapter:
Stream Stabilization