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

Ditch Outlets

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
Road Surface

Ditch Outlets

Introduction

Traditional Road Maintenance Practices

Environmentally Sensitive Maintenance Practices

What are ditch outlets?.....

Crosspipe: A pipe placed under the roadway to outlet water from the upslope road ditch.

Crosspipe:

Culvert

Sluice Pipe

Crossdrain

Tiles

Turnout: An opening in the downslope road ditch to outlet drainage away from the road area.

Turnout:
Bleeders
Cutouts

This section deals with DRAINAGE, not streams.

Drainage Culvert

Stream Culvert

Objectives

- Encourage stable, low maintenance outlets
- Minimize drainage impacts on streams and surrounding land uses

Drainage culverts vary by size and material

Pipe Sizing:

- **More crosspipes = less flow in each pipe**

- **Generally, use 15” – 18” smooth bore plastic crosspipes (for drainage, not streams!).**
  - Self-cleaning.
  - Sturdier than single walled plastic pipe.

Ditch Outlets

Introduction

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Environmentally Sensitive Maintenance Practices

1. **Poor Outlet Location**
2. Improper Pipe Installation
3. Installing Pipes Too Deep
4. Turnouts Too Narrow
5. Disconnected Turnouts

Ditch Outlets: Traditional Practices

Poor Outlet Location

Ditch Outlets: Traditional Practices

Poor Outlet Location

Avoid discharging water directly to streams and wetlands when possible!

Why it is Done:

- Ditch outlets are typically at the lowest point of the road near streams
- Uncooperative landowners
- Entrenched road and berms limit outlet options

Problems:

- Bank erosion
- Pipe failure due to unsupported outlet
- Potential problems for landowners
- **Water and sediment discharge** directly into stream (illegal)

Ditch Outlets: Traditional Practices

Poor Outlet Location

Avoid outletting turnout on top of pipe!

- Erosion around pipe outlet
- Pipe failure
- Doubles water volume & erosion

1. Poor Outlet Location

2. **Improper Pipe Installation**

- No headwalls and endwalls
- Inlet too far off road
- Inlet too close to road
- Outlet extends too far
- Drop inlets
- Poor pipe alignment
- Inadequate compaction or cover

Ditch Outlets: Traditional Practices

Improper Pipe Installation

Ditch Outlets: Traditional Practices

Improper Pipe Installation

Inlet to close to road

- Narrows cartway

Ditch Outlets: Traditional Practices

Improper Pipe Installation

Avoid Drop Inlets on Unpaved Roads

- Road elevation changes over time
- Road material will clog grate
- Will clog or be bypassed

Ditch Outlets: Traditional Practices

Improper Pipe Installation

Ditch Outlets: Traditional Practices

Improper Pipe Installation

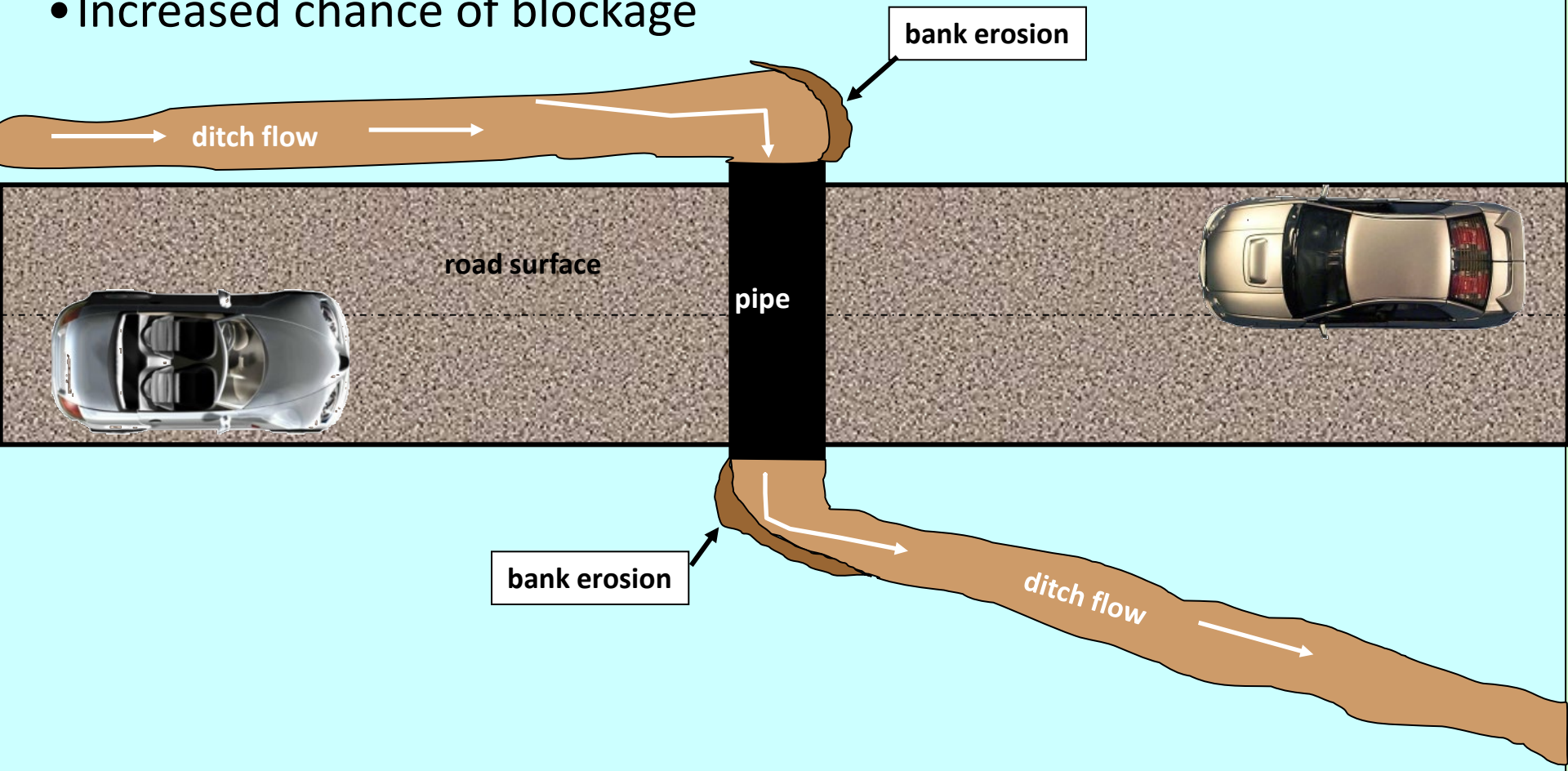
Improper fill or compaction:

Settling and heaving

Improper Pipe Installation

Placing pipe at 90 degree angle across road

- Inlet / outlet erosion
- Lower flow capacity
- Increased chance of blockage



Ditch Outlets: Traditional Practices

Improper Pipe Installation

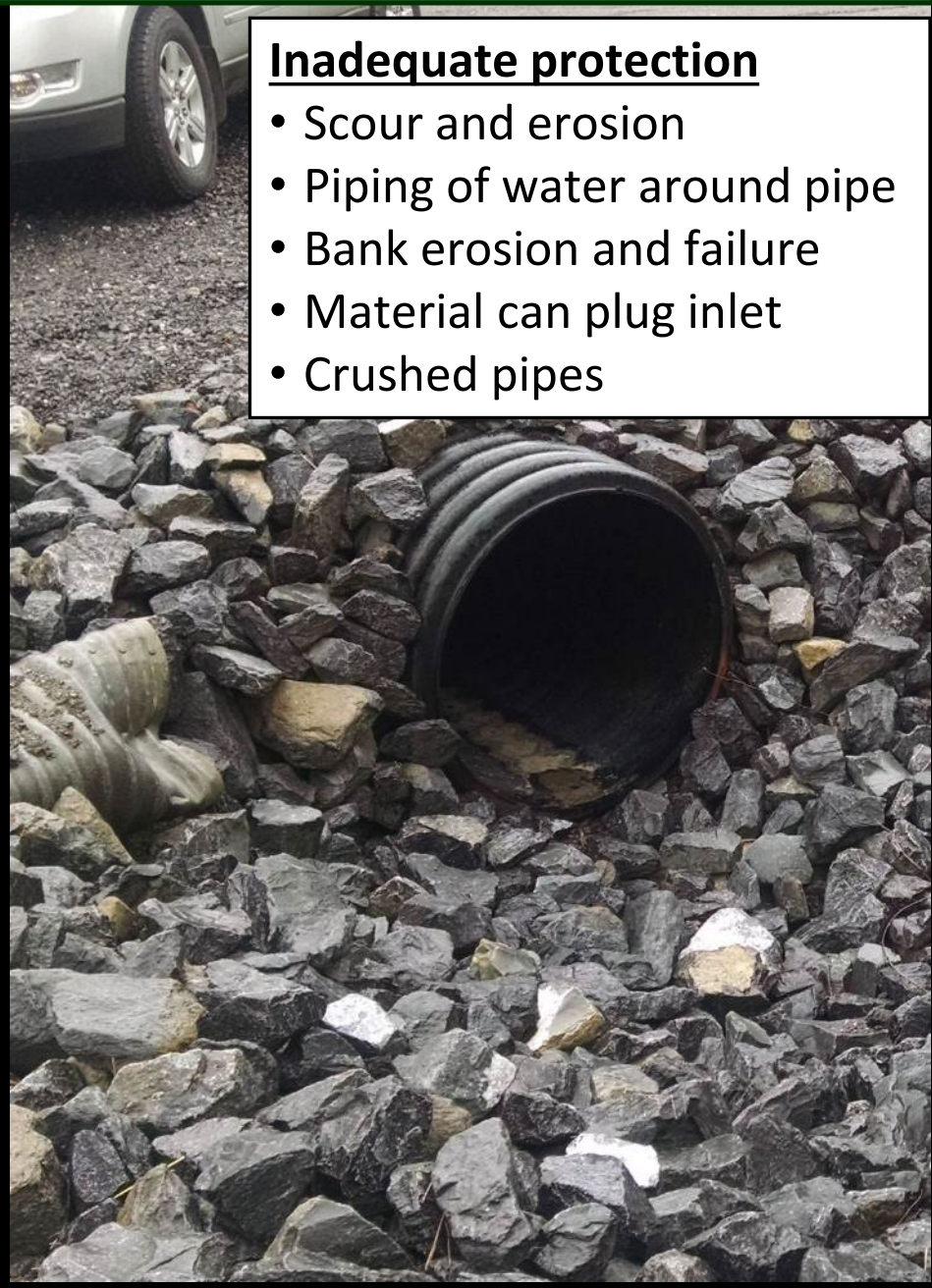
Pipes extend to far: Potential pipe failure at joints

Ditch Outlets: Traditional Practices

Improper Pipe Installation

Inadequate protection

- Scour and erosion
- Piping of water around pipe
- Bank erosion and failure
- Material can plug inlet
- Crushed pipes



Ditch Outlets: Traditional Practices

Improper Pipe Installation

Poor or inadequate cover

- Pipe failure

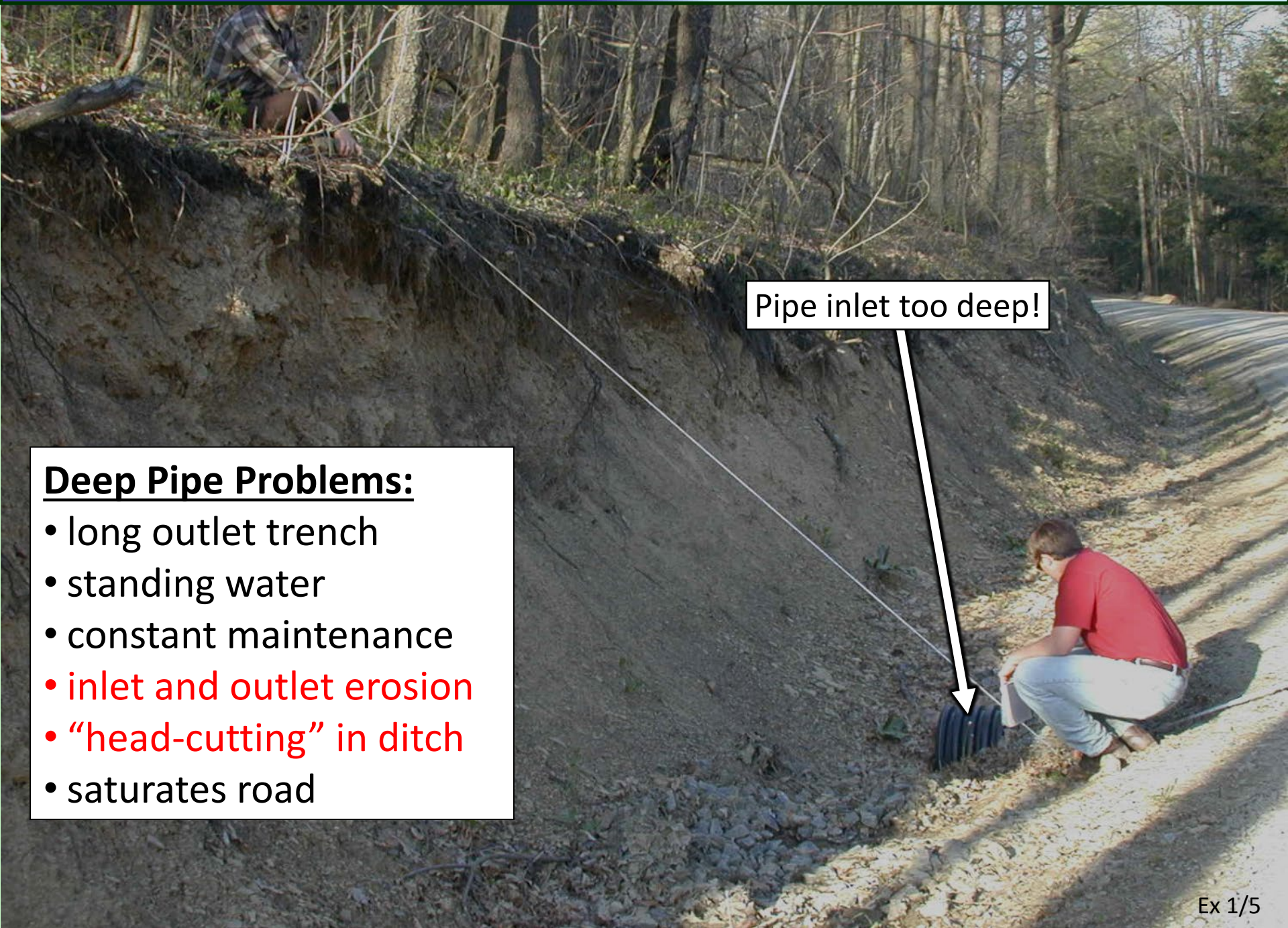
1. Poor Outlet Location
2. Improper Pipe Installation
3. **Installing Pipes Too Deep**
4. Turnouts Too Narrow
5. Disconnected Turnouts

Why Pipes are Placed too Deep:

- Pipe depth based off road surface elevation
- “More is better” philosophy for pipe cover
- Use of excessive pipe cover to account for improper installations

Ditch Outlets: Traditional Practices

Pipes to Deep



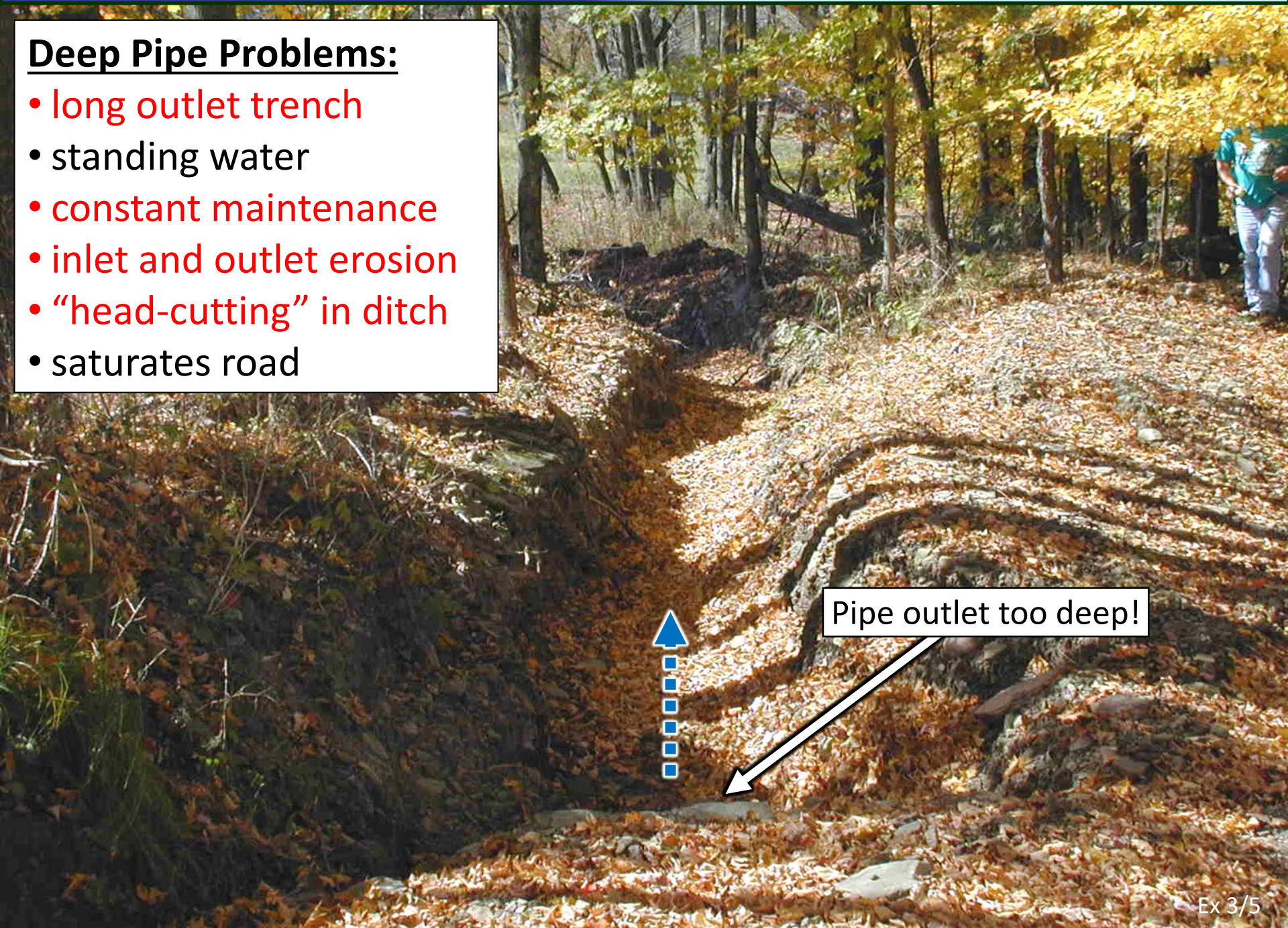
Deep Pipe Problems:

- long outlet trench
- standing water
- constant maintenance
- inlet and outlet erosion
- “head-cutting” in ditch
- saturates road

Ditch Outlets: Traditional Practices

Pipes to Deep

Ex 2/5


Deep Pipe Problems:
• long outlet trench
• standing water
• constant maintenance
• inlet and outlet erosion
• “head-cutting” in ditch
• saturates road
Pipe outlet too deep!

Ditch Outlets: Traditional Practices

Pipes to Deep

Deep Pipe Problems:

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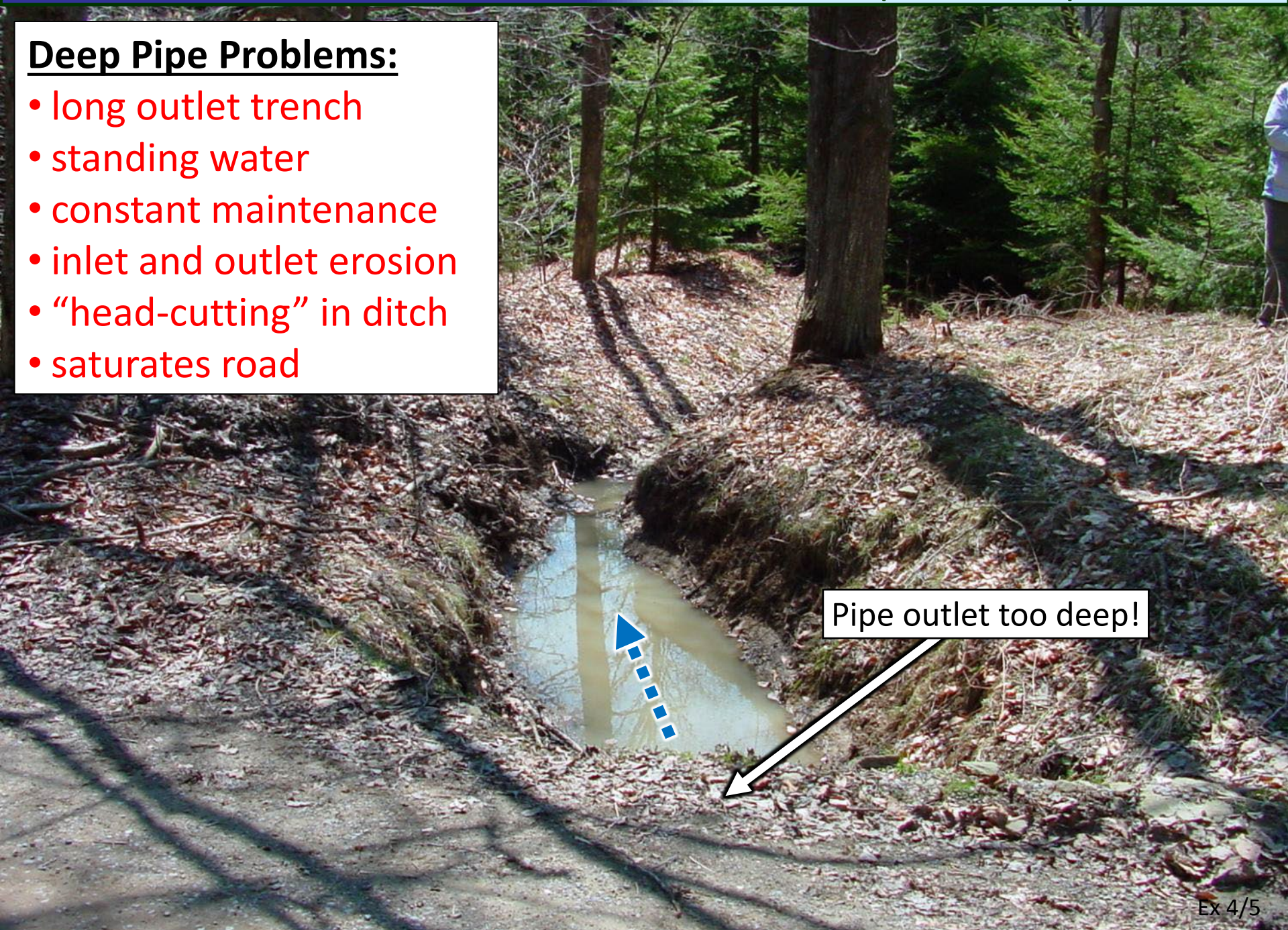
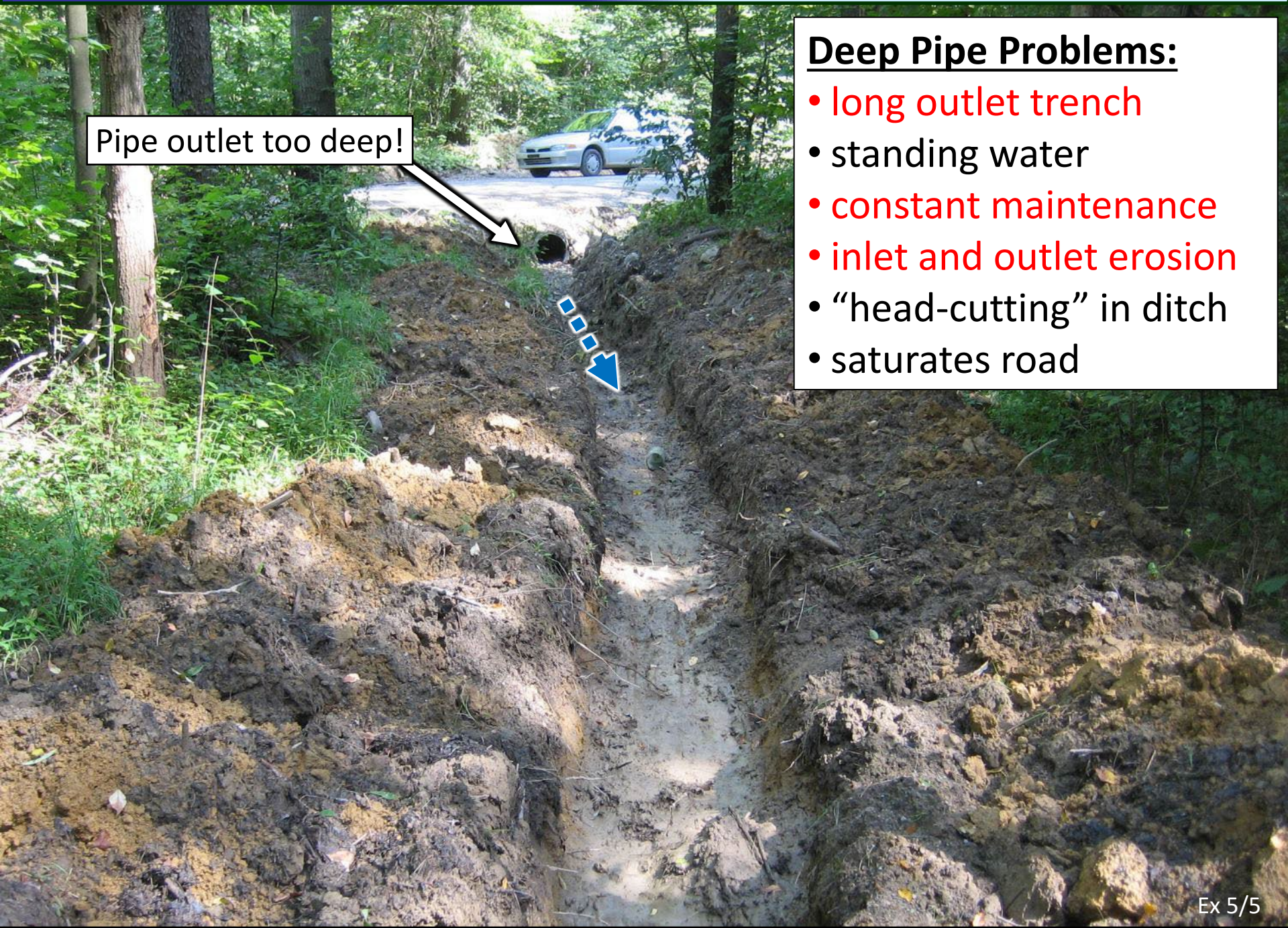


Ditch Outlets: Traditional Practices

Pipes to Deep



Deep Pipe Problems:

- long outlet trench
- standing water
- constant maintenance
- inlet and outlet erosion
- “head-cutting” in ditch
- saturates road

1. Poor Outlet Location
2. Improper Pipe Installation
3. Installing Pipes Too Deep
4. **Turnouts Too Narrow**
5. Disconnected Turnouts

Turnouts to Narrow

Problems:

- Constricts flow
- More outlet erosion
- More maintenance

1. Poor Outlet Location
2. Improper Pipe Installation
3. Installing Pipes Too Deep
4. Turnouts Too Narrow
5. **Disconnected Turnouts**

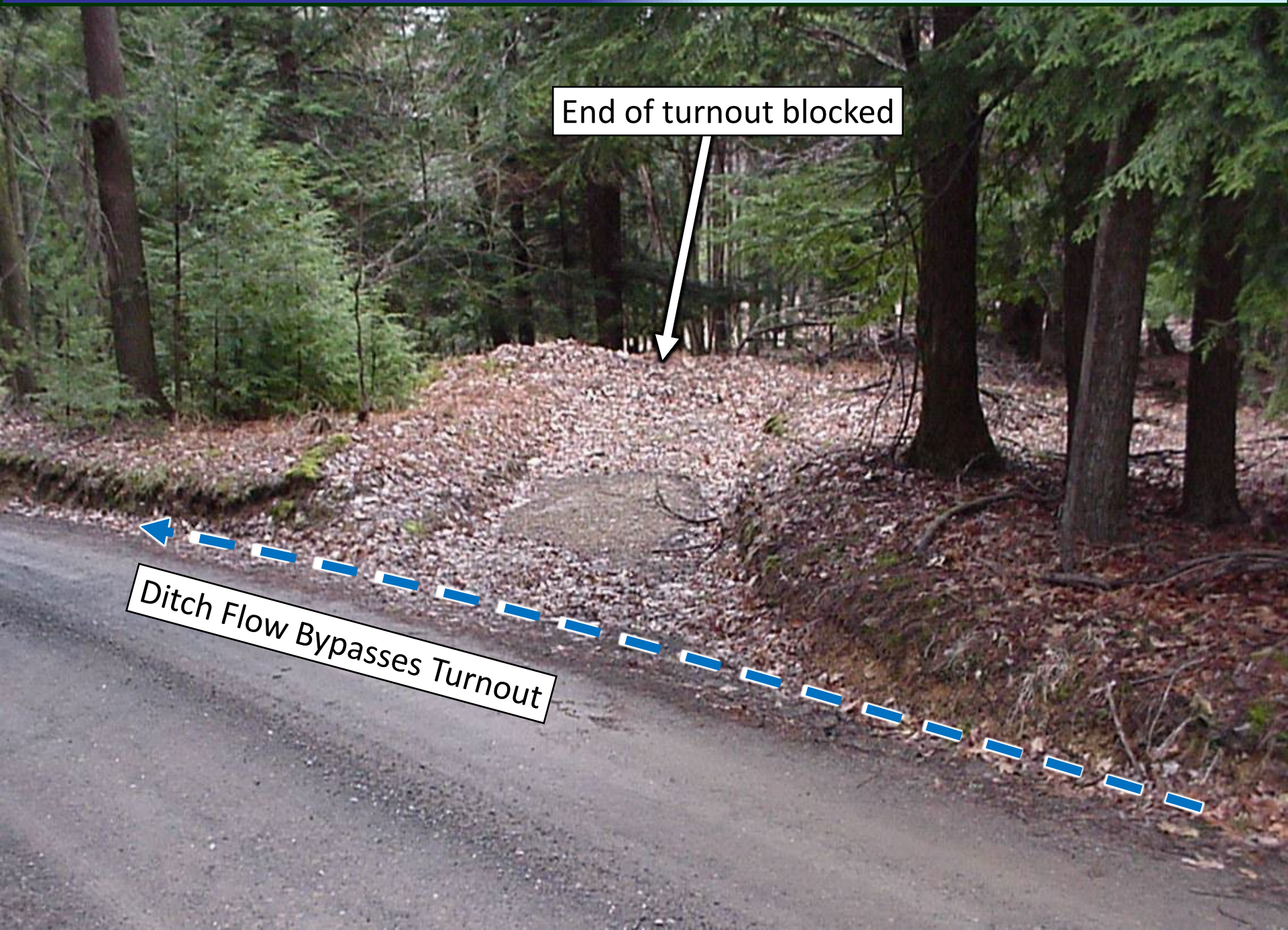
What is a Disconnected Turnout?

A turnout that does not carry water:

- Turnouts higher than road
- Turnouts going uphill
- Turnouts filling with material
- End of turnout is clogged

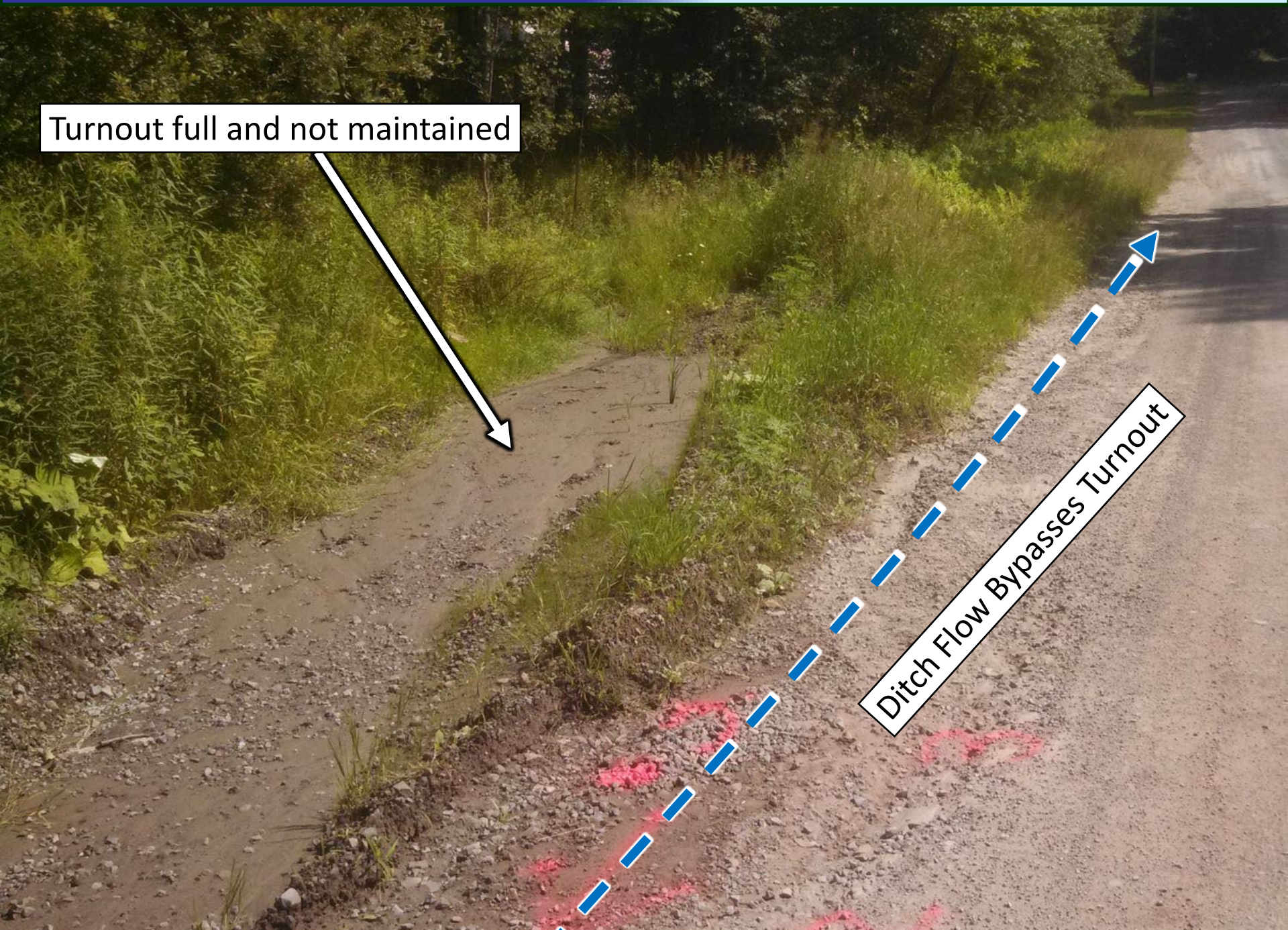
Ditch Outlets: Traditional Practices

Disconnected Turnouts



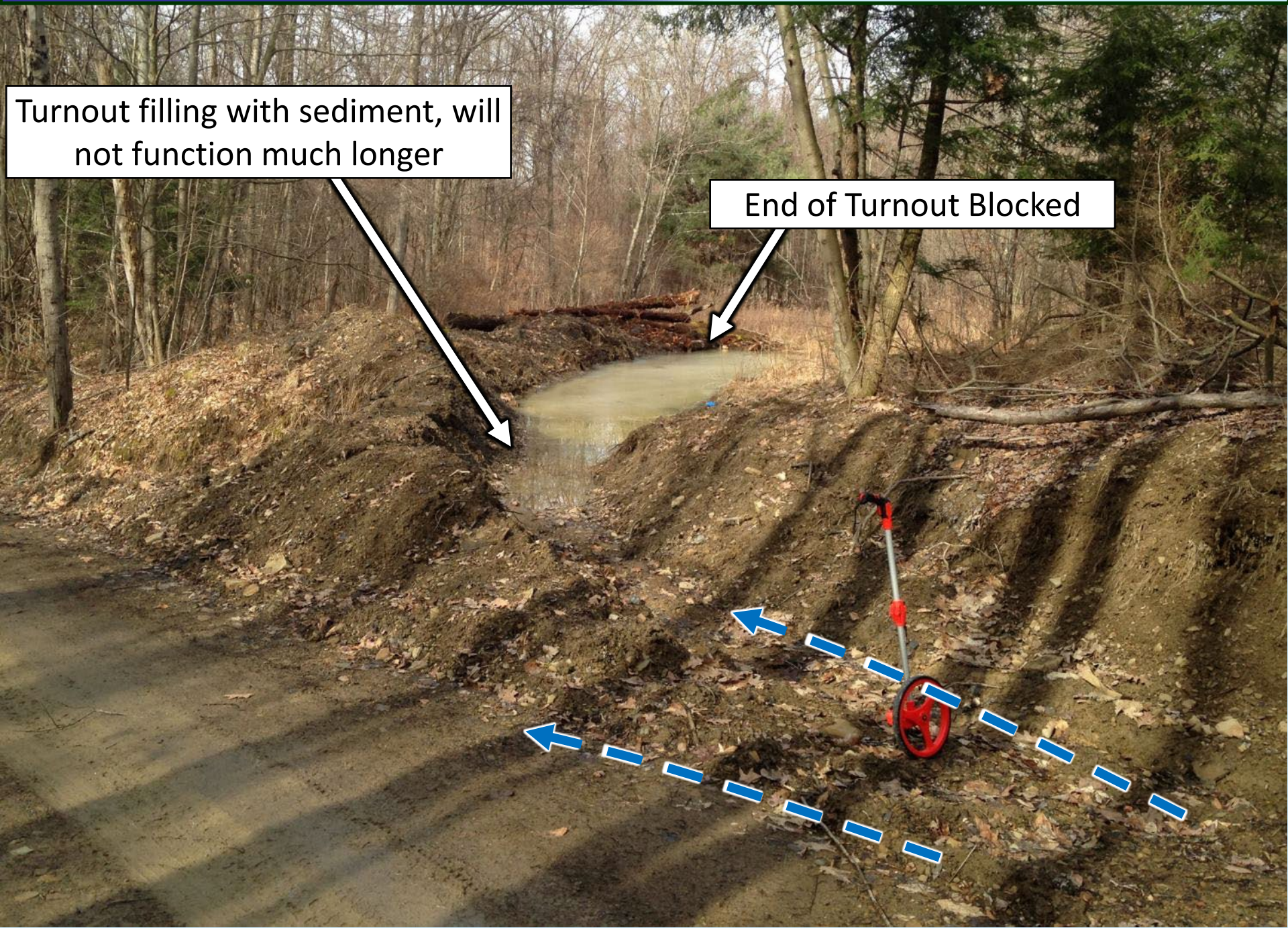
Ditch Outlets: Traditional Practices

Disconnected Turnouts



Ditch Outlets: Traditional Practices

Disconnected Turnouts



Ditch Outlets

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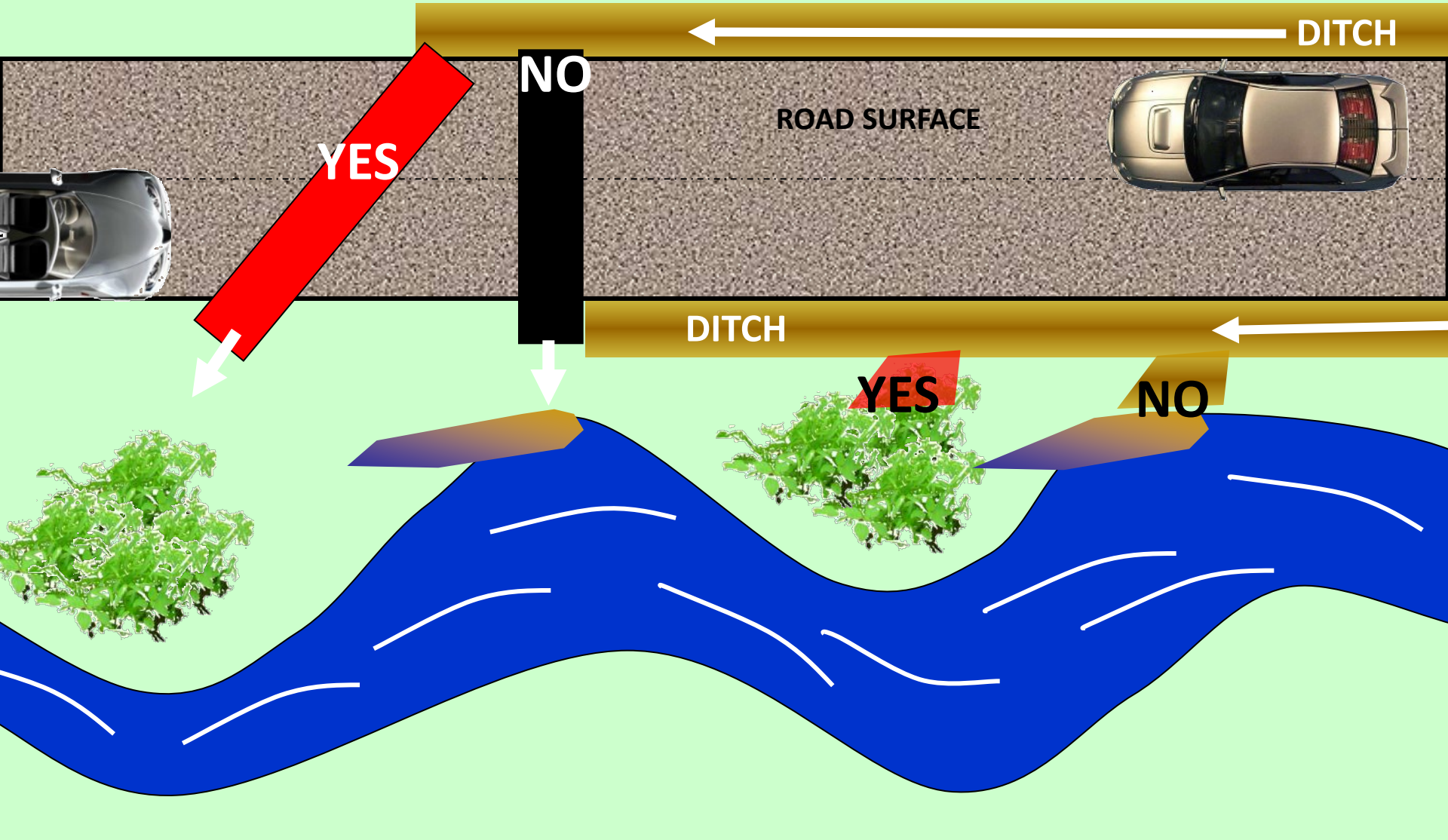
Traditional Road Maintenance Practices

Environmentally Sensitive Maintenance Practices

1. **Selecting a Good Outlet Location**
2. Creating Low Maintenance Turnouts
3. Proper Pipe Alignment
4. Proper Pipe Installation
5. Shallow Pipe Installation
6. “Through-the-Bank” Pipes
7. French Mattresses

Avoid discharging pipes directly to stream, Discharge into vegetated buffer when possible



Ditch Outlets: ESMPs

Good Outlet Locations

Benefits:

- Keeps road out of stream
- Vegetative filters provide outlet protection
- In many cases, it is ILLEGAL to discharge water directly into the stream

Considerations:

- May require more and/or longer crosspipes
- Landowner issues concerning outlets

Ditch Outlets: ESMPs

Good Outlet Locations

Outlet turnouts and crosspipes separately when possible

1. Selecting a Good Outlet Location
2. **Creating Low Maintenance Turnouts**
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Low-Maintenance Turnouts

Properties of effective turnouts:

- Wide level turnouts better
- Turnouts must have fall
- Shallow turnout elevation
- Turnouts should be vegetated
- Ensure water does not return to road

Low-Maintenance Turnouts

Effective Turnouts:

- Wide and flat
- Must have fall
- Shallow elevation
- Vegetated
- Direct water away

Low-Maintenance Turnouts

Effective Turnouts:

- Wide and flat
- Must have fall
- Shallow elevation
- Vegetated
- Direct water away

Benefits:

- Less erosion
- Less maintenance
- Promotes infiltration

Considerations:

- Requires more initial effort (but reduces future maintenance effort)
- Landowner interactions

Benefits:

- Keeps road drainage out of stream
- Reduces erosion around pipes
- Reduces flow volumes at outlets
- Encouraged infiltration

Considerations:

- Possible landowner interactions

1. Selecting a Good Outlet Location
2. Creating Low Maintenance Turnouts
3. **Proper Pipe Alignment**
4. Proper Pipe Installation
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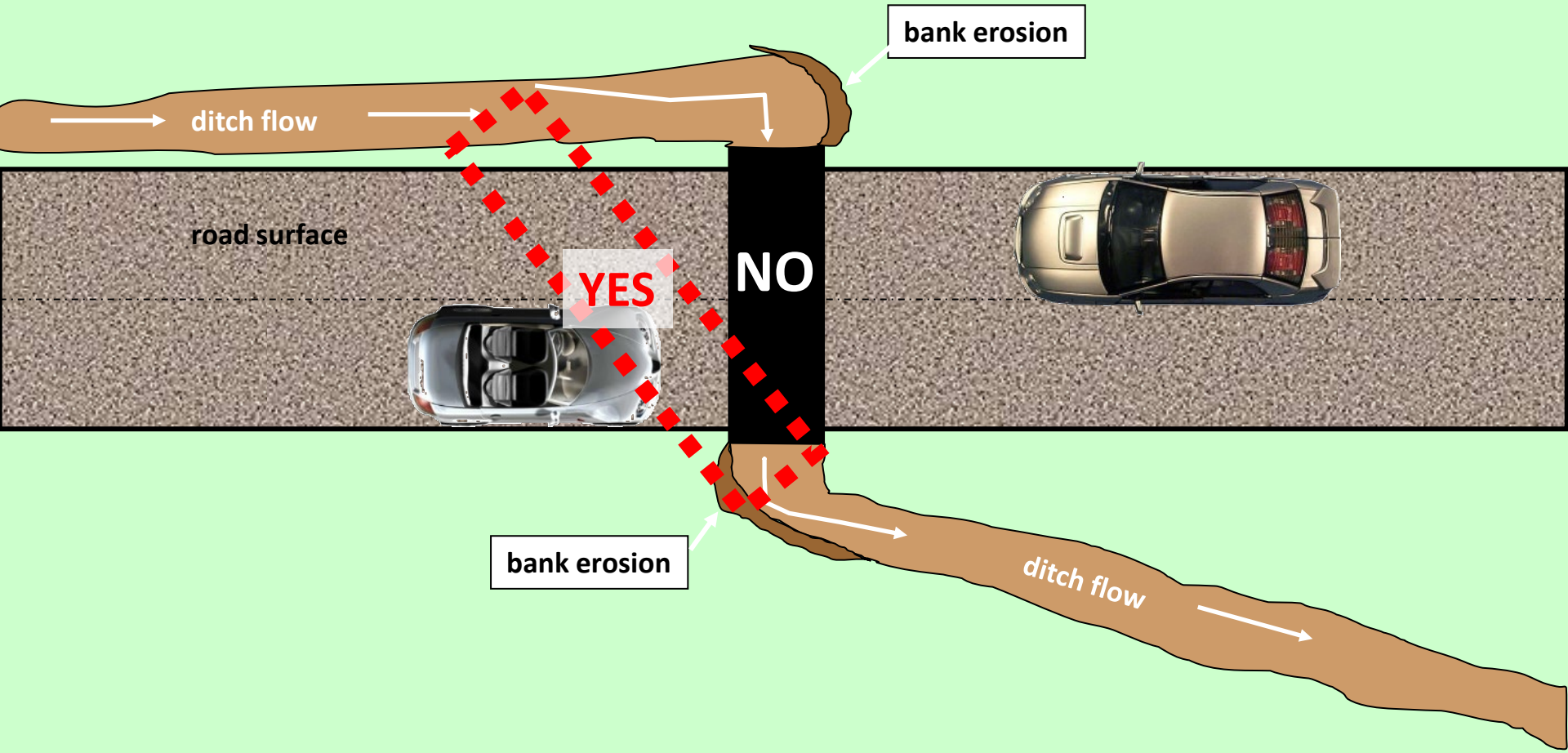
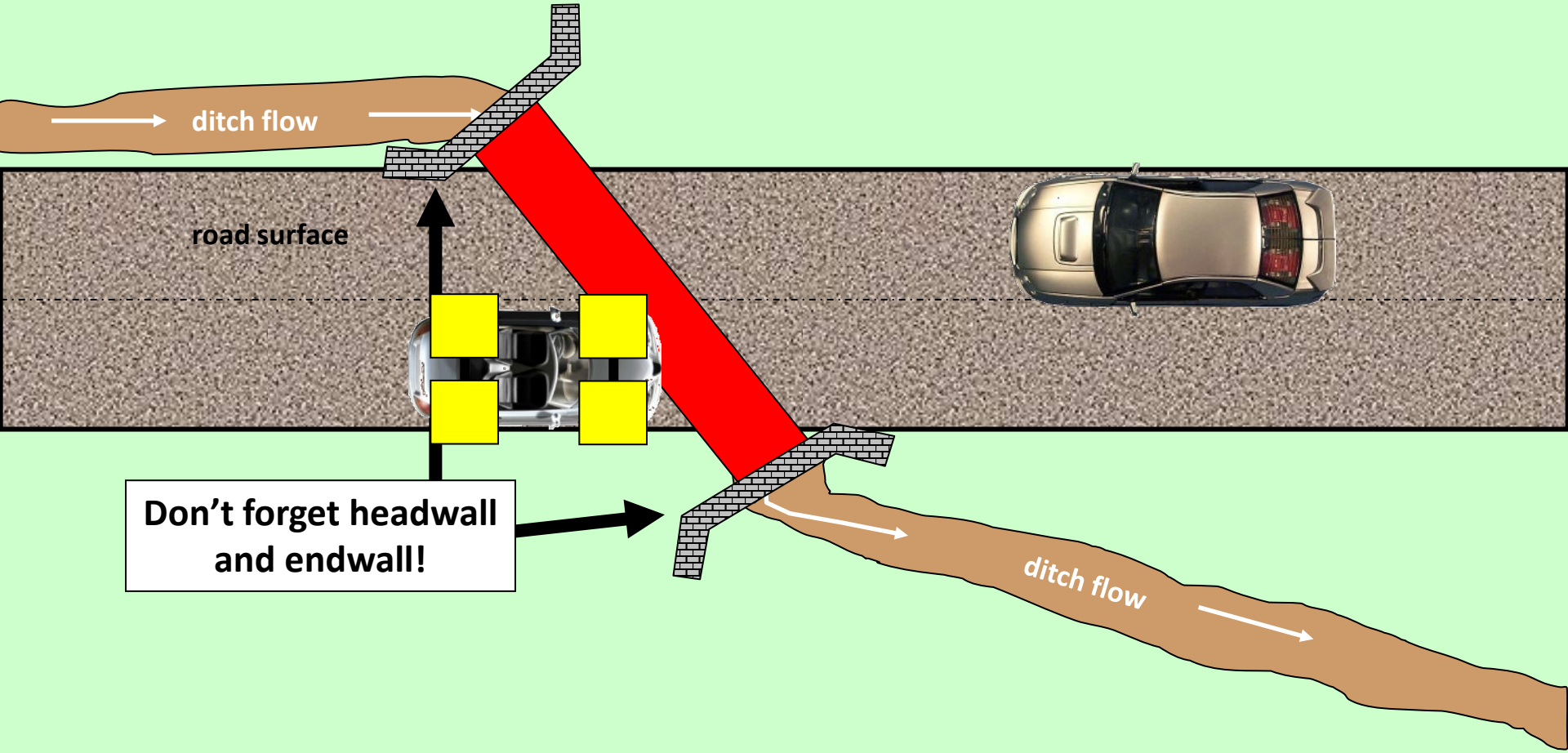
Install pipes in direction of flow



Ditch Outlets: ESMPs

Proper Pipe Alignment



Proper Pipe Alignment

Benefits:

- Less erosion at inlet and outlet
- Pipe will carry more water
- Reduces effect of traffic load
- Allows more flexibility of inlet and outlet placement

Considerations:

- Requires longer pipe

1. Selecting a Good Outlet Location
2. Creating Low Maintenance Turnouts
3. Proper Pipe Alignment
4. **Proper Pipe Installation**

1. **Excavate Pipe Trench**
2. Place Pipe in Trench
3. Fill and Compaction
4. Inlet & Outlet Protection

Excavate Pipe Trench

Excavate Pipe Trench:

- Wide enough for compaction on both sides
- Typically pipe width +16” for jumping jack.

Ditch Outlets: Pipe Installation

Excavate Pipe Trench

Equipment:

- Backhoe, trackhoe
- Compaction equipment

Excavate Pipe Trench

Trench Depth:

- Inlet in existing ditchline if possible
- Outlet even on natural ground if possible

Lots More to come on this in "Shallow Crosspipe Installations"

Potter

Excavate Pipe Trench

Trench Fall:

- Minimum 2% slope (1/4 inch per foot)
- Use level to determine slope

Too little slope = deposition in pipe

Too much slope = more velocity and deeper outlet elevation

1. Selecting a Good Outlet Location
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Place Pipe in Trench

Pipe bedding?

- If pipe trench is uneven, pipe bedding may be required

If Necessary:

- Place 2-3” of suitable bedding material in bottom of trench and level off
- Compact prior to pipe placement

Ditch Outlets: Pipe Installation

Place Pipe in Trench

Inlet:

Place inlet in ditchline if possible

- **To close**: traffic hazard
- **To Far**: bank erosion

Inlet to close to road makes traffic hazard:

Before: Inlet too close to road

After: Imported bank material

Ditch Outlets: Pipe Installation

Place Pipe in Trench

Placement:

- Place sections in trench
- Join with collars
- Check grade >1%
- Check for uniform support
- Correct any gaps or grade issues with additional bedding

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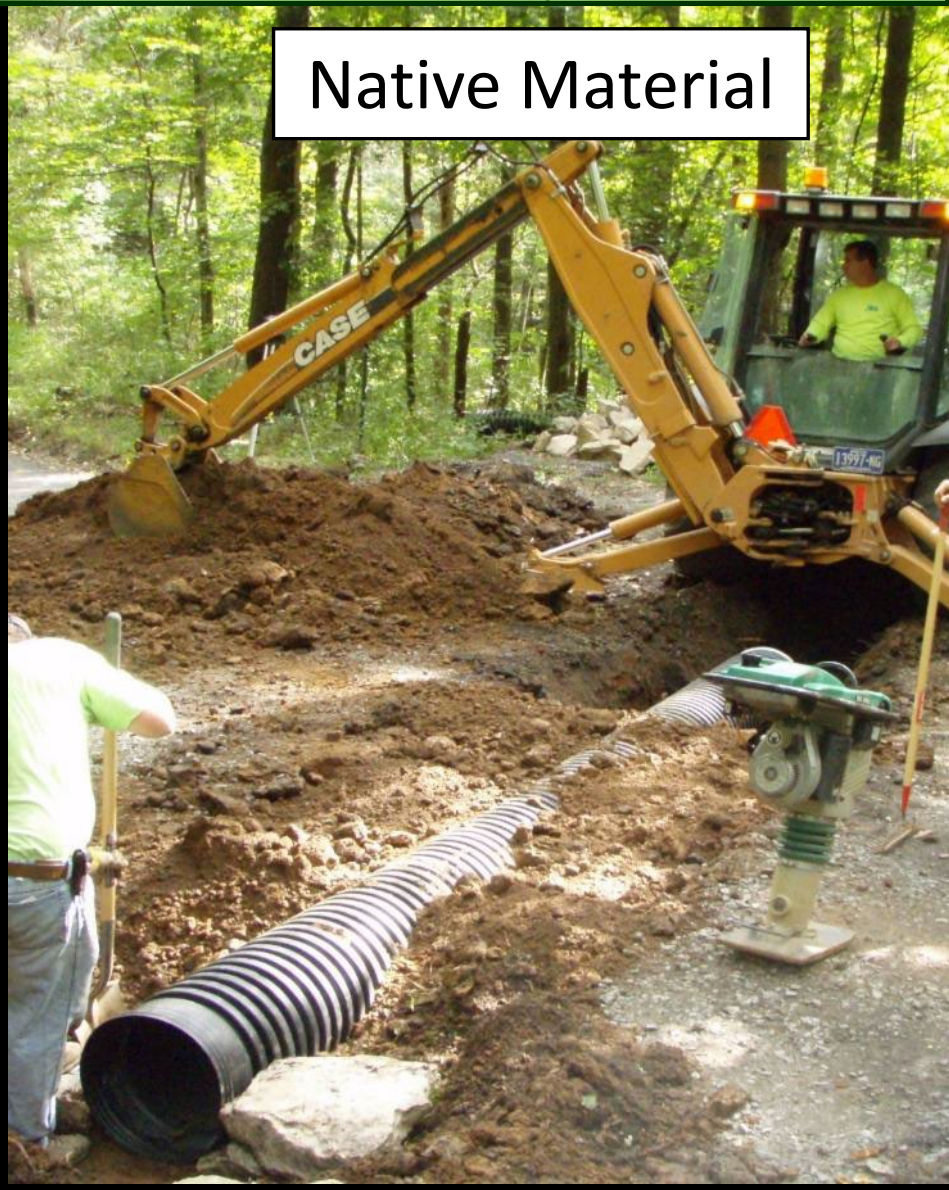
    3. **Fill and Compaction**
    4. Inlet & Outlet Protection

Ditch Outlets: Pipe Installation

Fill and Compaction



Fill and Compaction

Ideal Fill Material:

- **Use excavated material when possible**
- If excavated material is too course, fill material should be imported
- Typical fill materials include bankrun gravel, shale, and 2RC

Fill and Compaction

Fill:

- While holding pipe in place, add 8-12” of pipe fill on each side of pipe
- Place by machine, spread by hand

Potter

Fill and Compaction

Compaction:

Typically done using a "Jumping Jack"

Jumping Jack: (tamper, whacker) device that uses a rapidly vibrating foot to compact soil.

Juniata

Compaction:

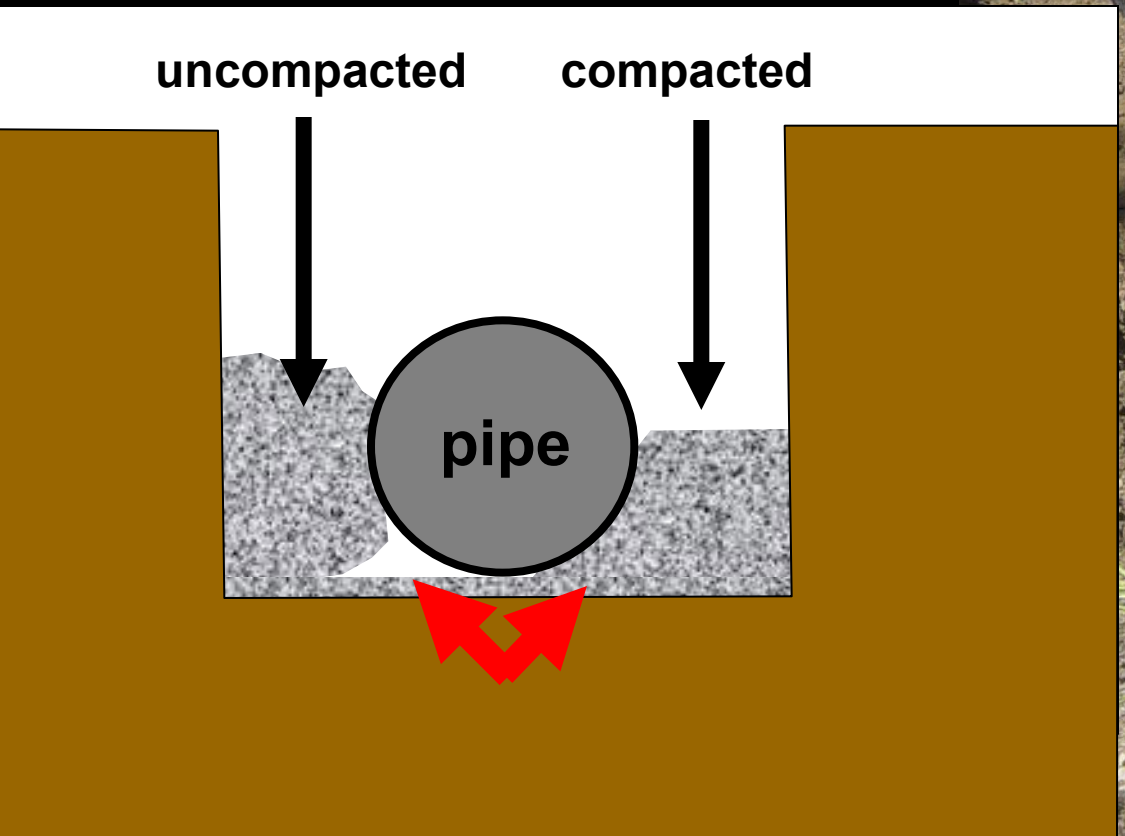
Sometimes done with a “Shaker Head”

Vibratory Plate: Hydraulic attachment that uses a vibrating foot to compact soil.

Fill and Compaction

Compact:

Compaction of first lift is crucial to support bottom of pipe!



Fill and Compaction

Compact:

- Continue to fill and compact in 8-12” lifts
- Thicker lifts will not compact properly
- Compaction is crucial to avoid pipe flex
- Use moist fill material for better compaction

Fill and Compaction

Compact:

- Continue to fill and compact in 8-12” lifts over pipe
- Insure adequate compacted cover over pipe
- Need 12”+ in most cases, not including aggregate!

Fill and Compaction

Consider Geo-grid over crosspipes:

Why: reduces the impact of traffic on the pipe

When:

- Heavy hauling
- Poor subbase
- Inadequate cover

Venango

Fill and Compaction

Consider Geo-grid over crosspipes:

Depth: Keep one foot of cover over geo-grid

Length: Geo-grid should extend at least one vehicle length on both sides of the pipe

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4. **Proper Pipe Installation**

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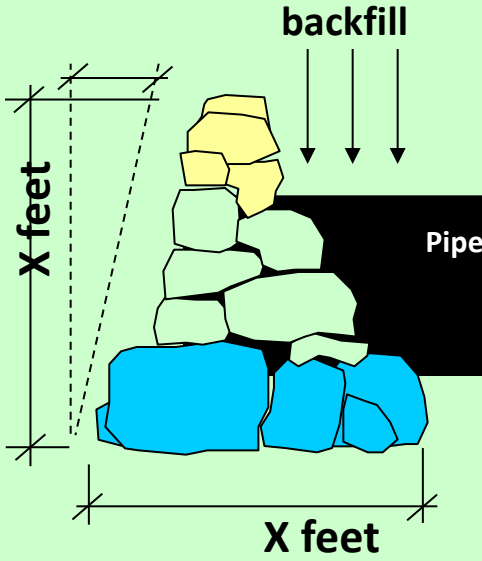
4. **Inlet & Outlet Protection**

Remember Headwalls and Endwalls from "Road Stream Interactions" Chapter:

- **Every pipe must have a headwall and endwall**
  - Increases pipe capacity
  - Prevents erosion around pipe
  - Protects and supports your road
  - Visually identifies ditch and pipe



Headwalls can be installed:

Before pipe fill

-or-

After pipe fill

Headwalls and Endwalls

Outlet Aprons:

- Use only when necessary

- Use placed natural stone where possible

Outlet Aprons:

- Use large rocks that will not move during storms
- Apron size depends on volume of water

Flared end-sections:

Simple and effective way to protect pipe outlet and spread water

“Big Chunky Rock”

Dissipate energy and support pipe when placed under outlet

Infiltration at Ditch Outlets

- Consider using basins to slow water down at ditch outlets to reduce runoff and erosion.
- Will cover this in the next chapter on "Structural Infiltration Practices"

Benefits:

- Increases pipe capacity
- Prevents erosion around pipe
- Sediment capture
- Protects and supports your road
- Visually identifies ditch and pipe

Considerations:

- Requires work, maybe even….hand work!

Ditch Outlets

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7. French Mattresses

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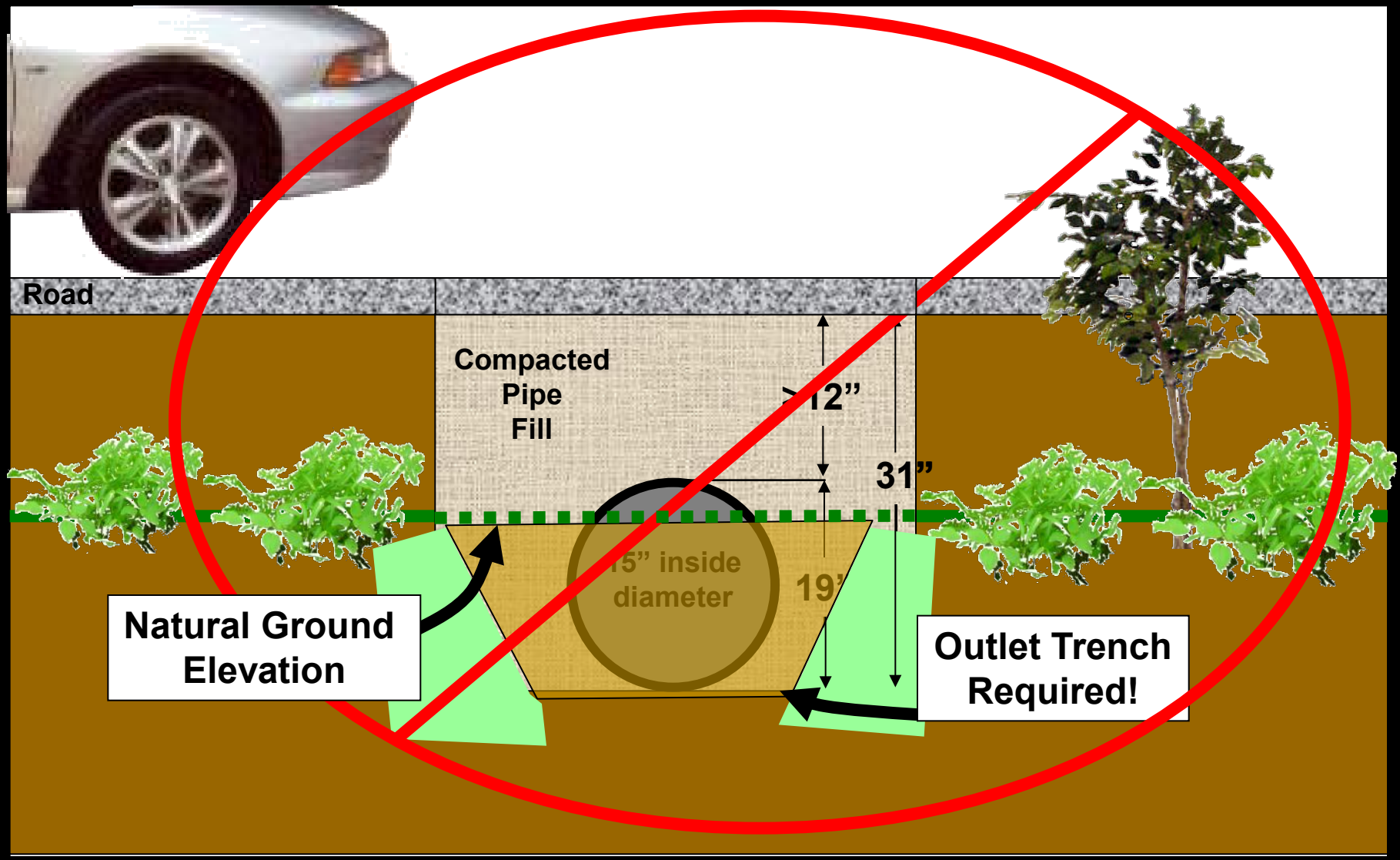
SHALLOW Crosspipes

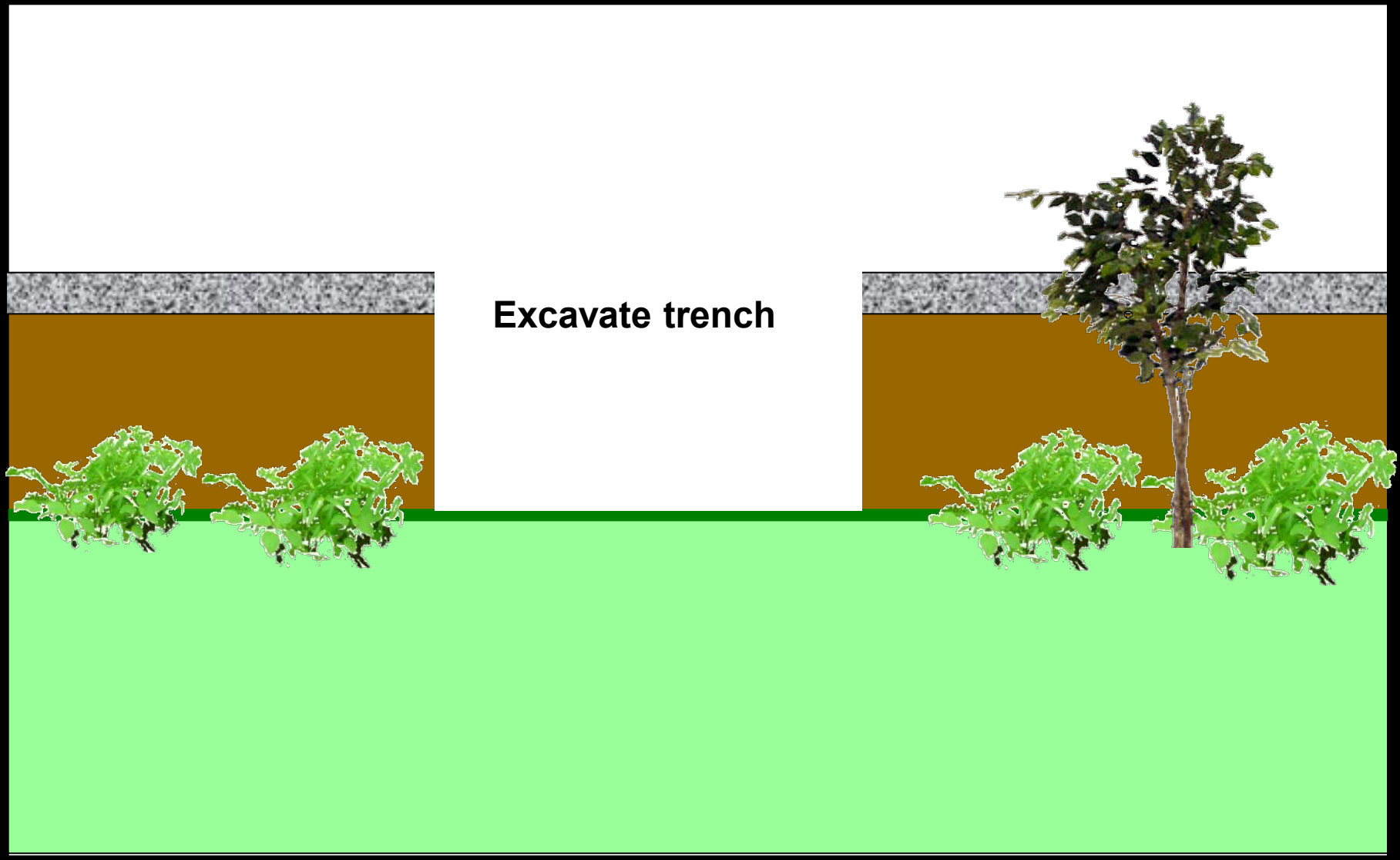
Shallow Pipe Installation: Installing a crosspipe to outlet at natural ground elevation. This typically involves a shallower trench and additional fill when compared to a traditional installation.

Traditional "Deep" Installation

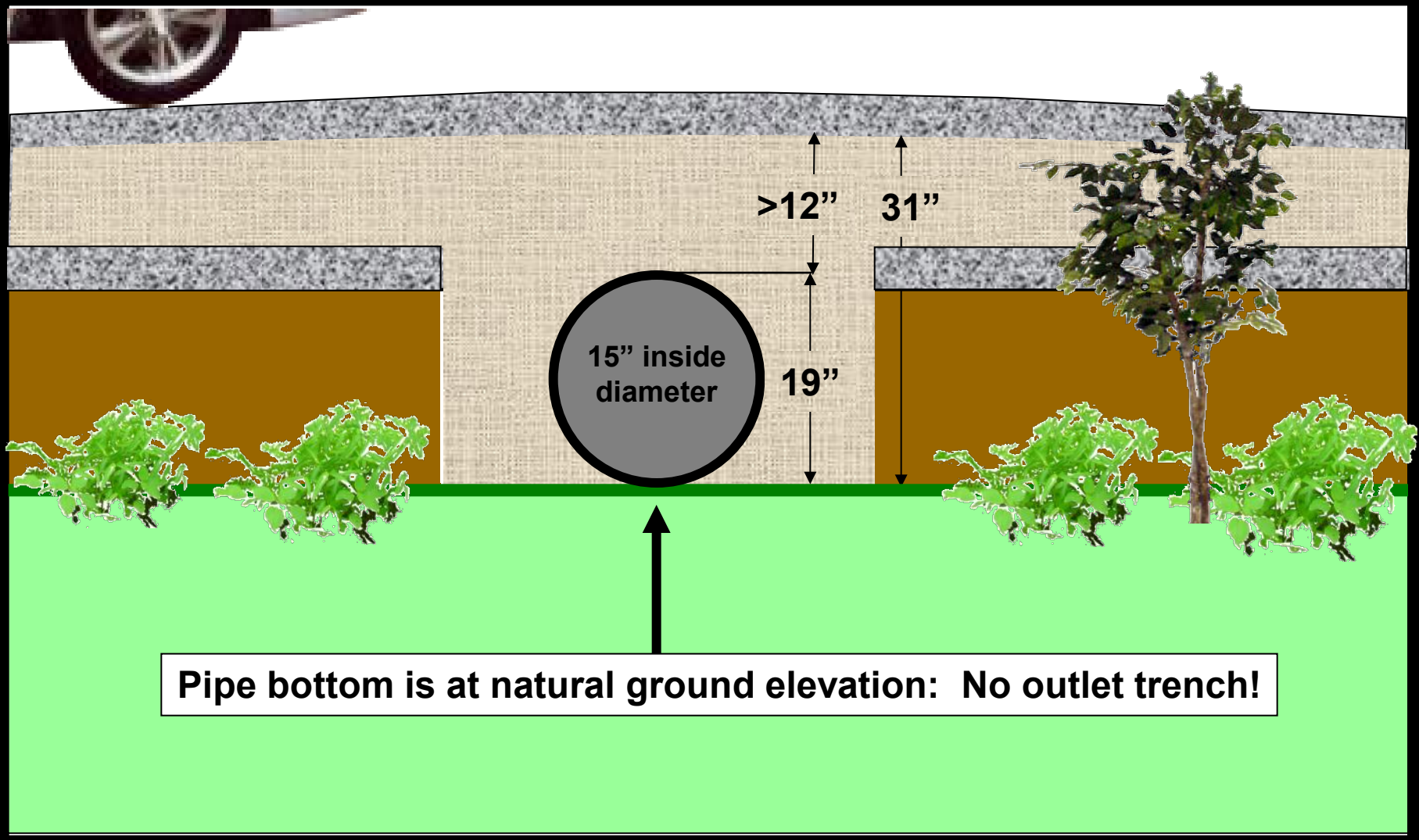


Traditional "Deep" Installation

Shallow Pipe Installation



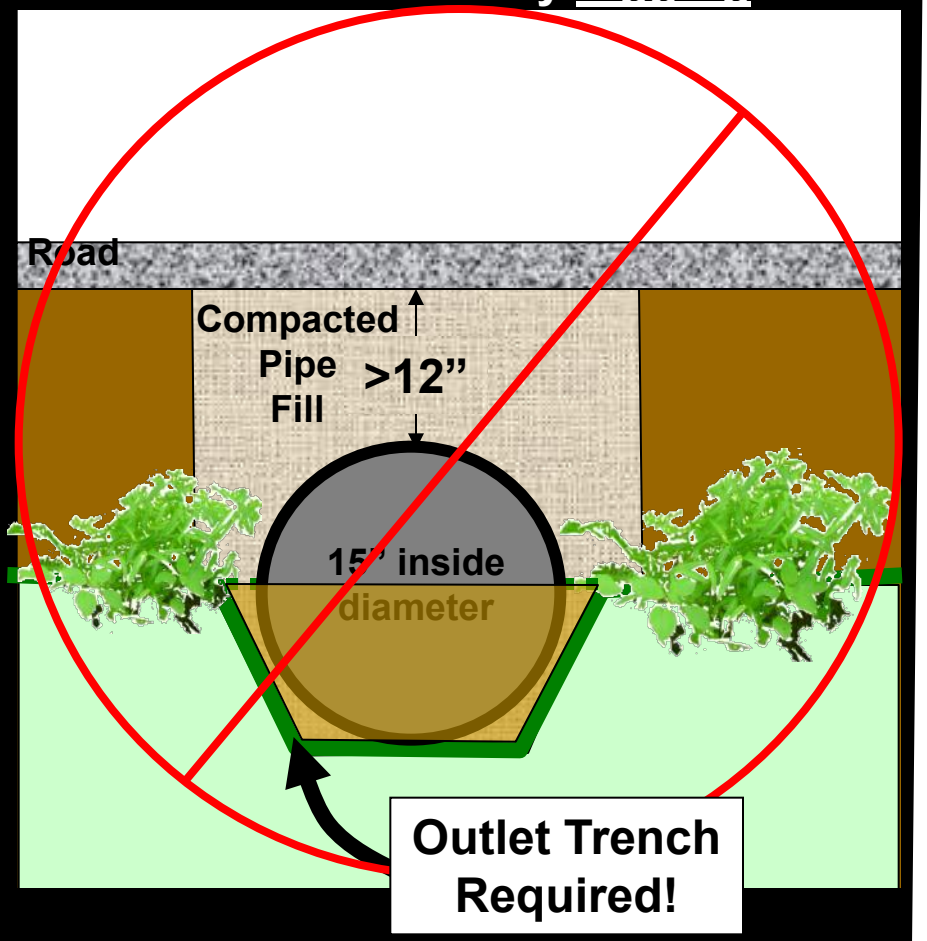
Shallow Pipe Installation



SHALLOW Crosspipes

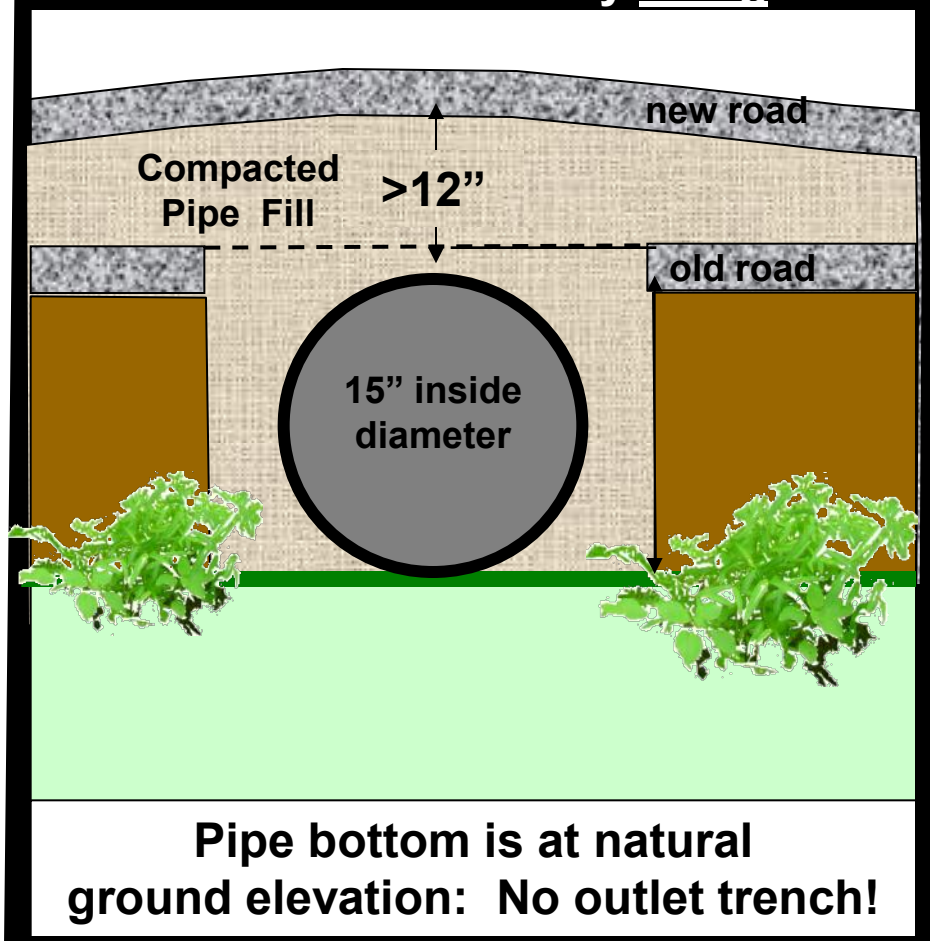
Traditional

Cover obtained by digging



Shallow

Cover obtained by filling



Ditch Outlets: ESMPs

SHALLOW Crosspipes

Cover obtained by digging

Cover obtained by filling

SHALLOW Crosspipes

Why Shallow Pipes?

Outlet water to natural ground instead of into a hole!

- Reduce maintenance
- Encourage infiltration and recharge
- Reduce problems associated with deep pipes

SHALLOW Crosspipes

The Bottom Line:

Don’t use road surface elevation to determine pipe elevation!

Use ground elevation at outlet to determine pipe elevation!

Ditch Outlets

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7. French Mattresses

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Through-the-Bank Pipes

“Through-the-Bank” Pipes: A pipe placed through the down-slope road bank to carry ditch drainage through the bank and away from the road.

When to use a "through-the-bank" pipe

- To "punch a hole" through a bank on the downnhill side of the road to outlet water
- To outlet water from entrenched roads as an alternative to costly road fill
- More acceptable than erosive turnout to some landowners.

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Ditch Outlets: ESMPs

Through-the-Bank Pipes

Centre County, Big Hollow Rd, 1/6

Ditch Outlets: ESMPs

Through-the-Bank Pipes

Centre County, Big Hollow Rd, 2/6


Excavating through the bank
CASE
Centre County, Big Hollow Rd, 3/6

Ditch Outlets: ESMPs

Through-the-Bank Pipes

Centre County, Big Hollow Rd, 4/6

Ditch Outlets: ESMPs

Through-the-Bank Pipes

Centre County, Big Hollow Rd, 5/6

Ditch Outlets: ESMPs

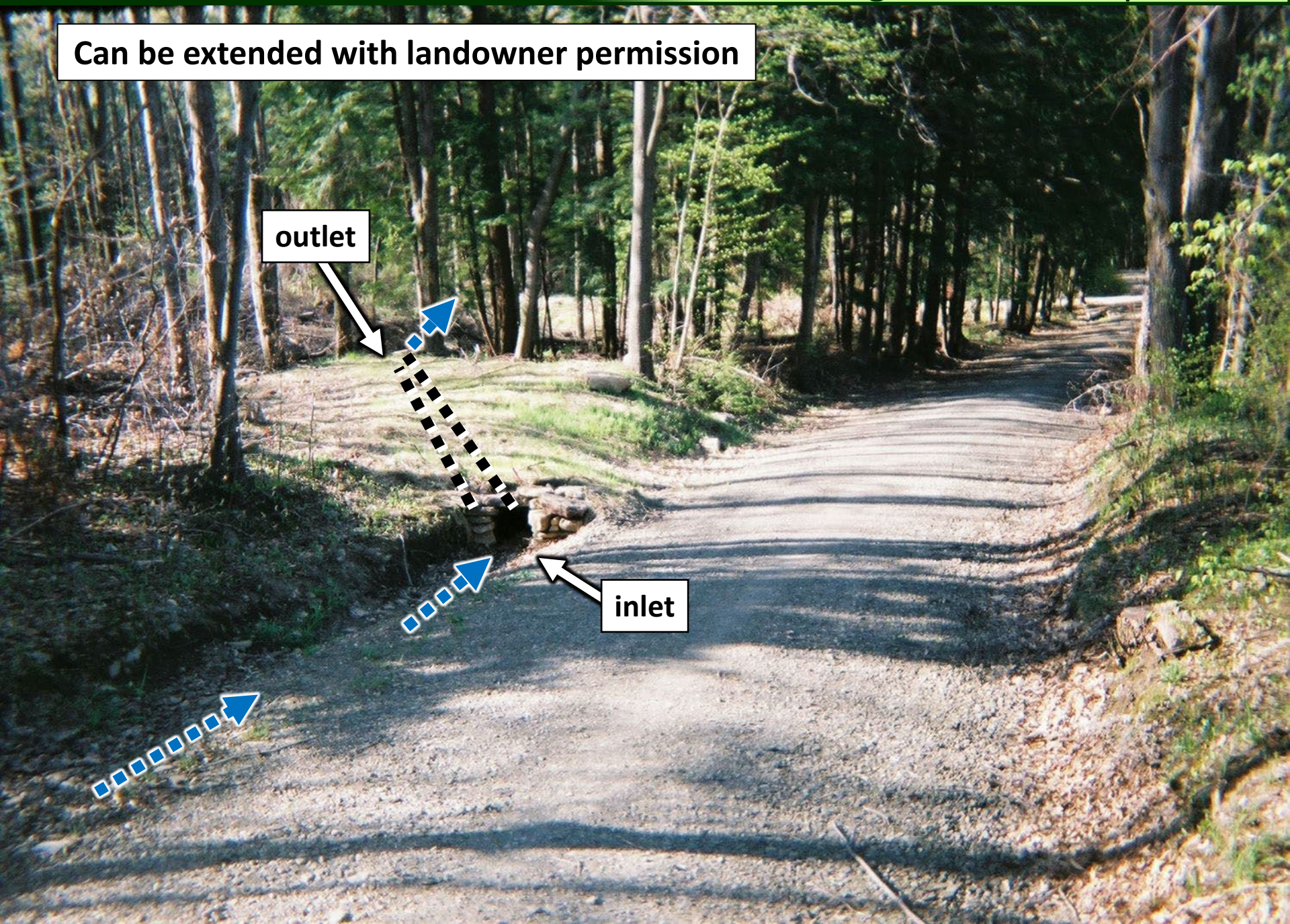
Through-the-Bank Pipes

- Plug Ditch
- Backfill
- Compact
- Headwall
- Seed/Mulch

Centre County, Big Hollow Rd, 1/6

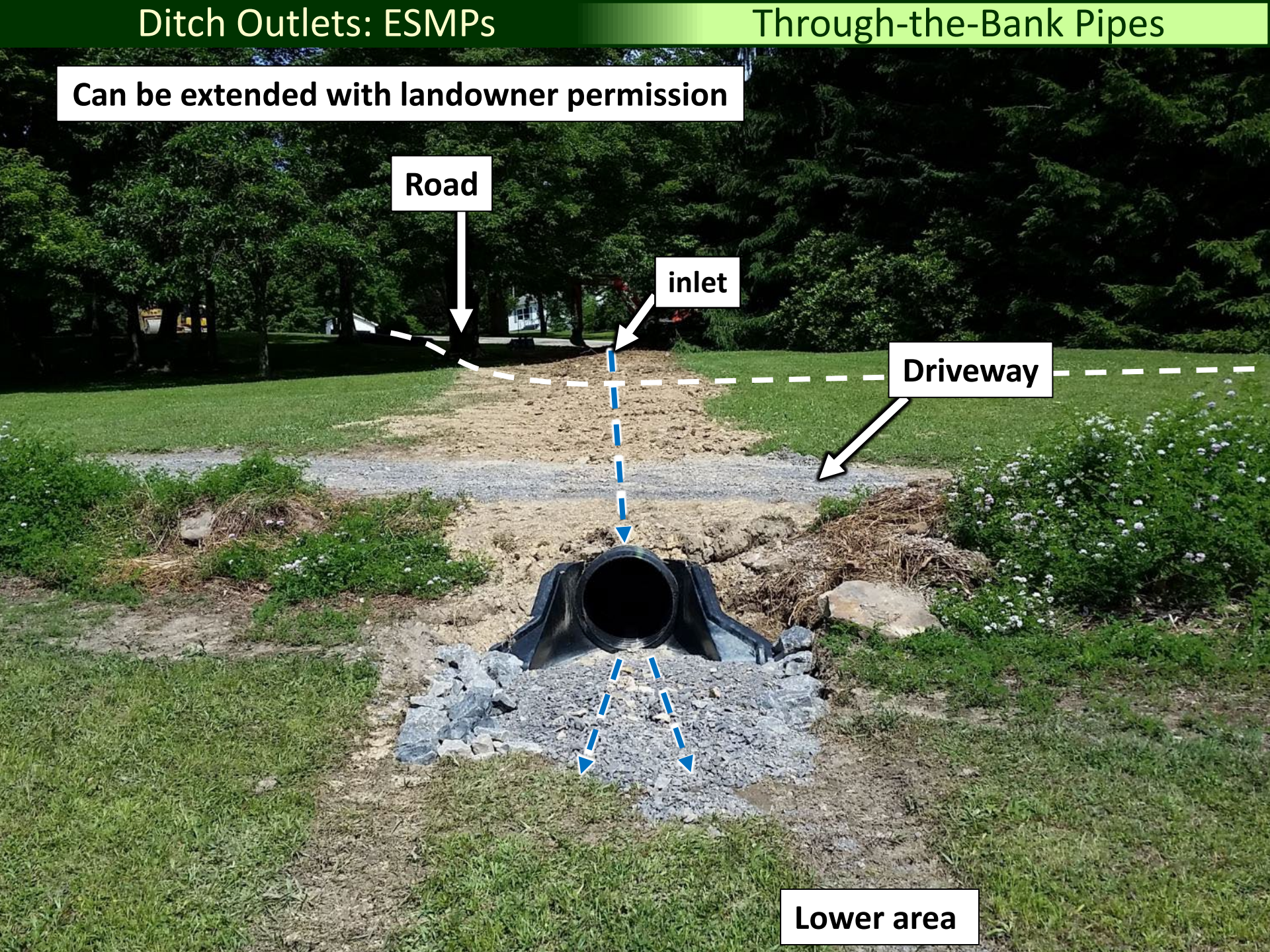
Ditch Outlets: ESMPs

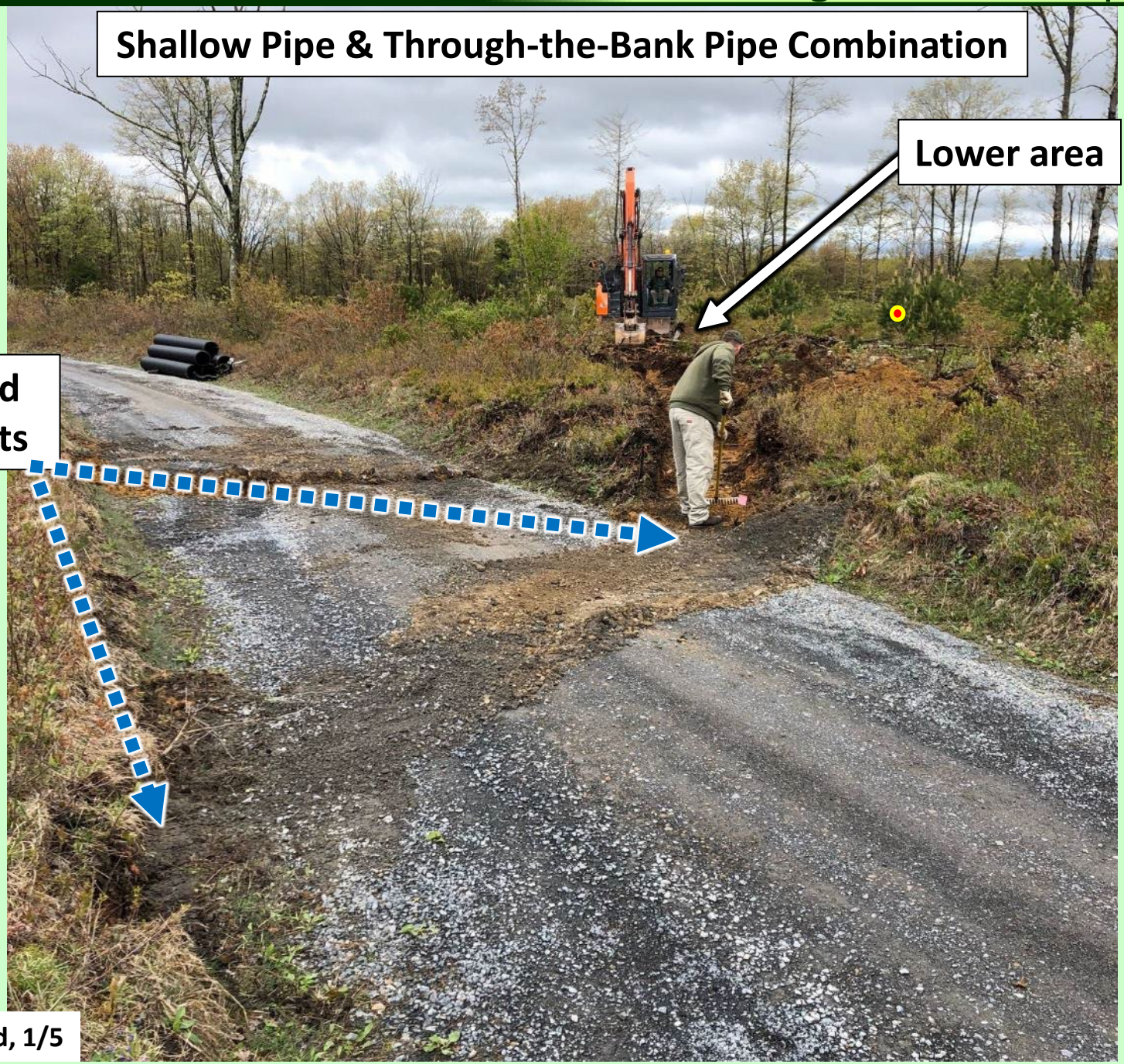
Through-the-Bank Pipes



Ditch Outlets: ESMPs

Through-the-Bank Pipes





Greenland Rd, 1/5

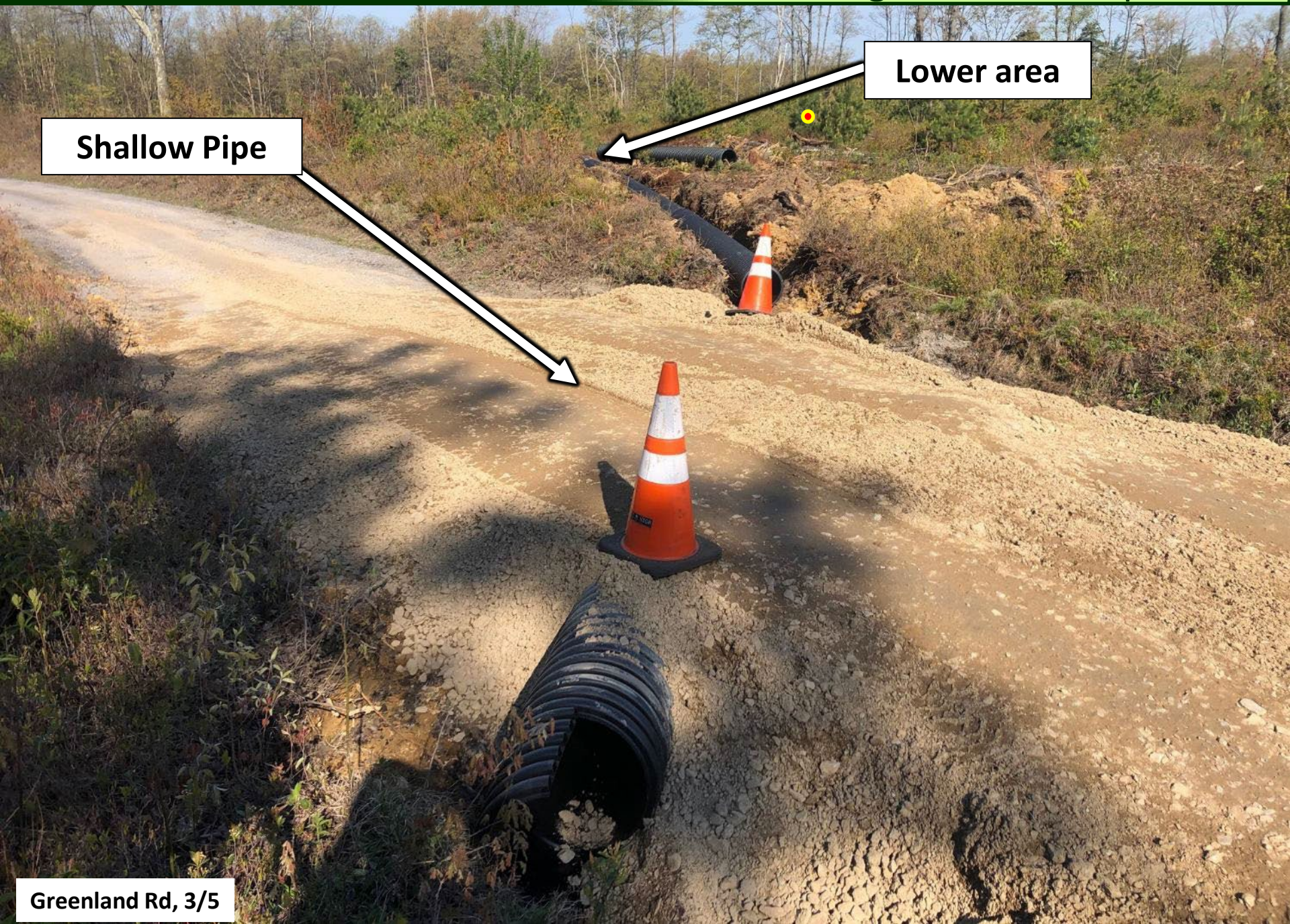
Ditch Outlets: ESMPs

Through-the-Bank Pipes

Greenland Rd, 2/5

Ditch Outlets: ESMPs

Through-the-Bank Pipes



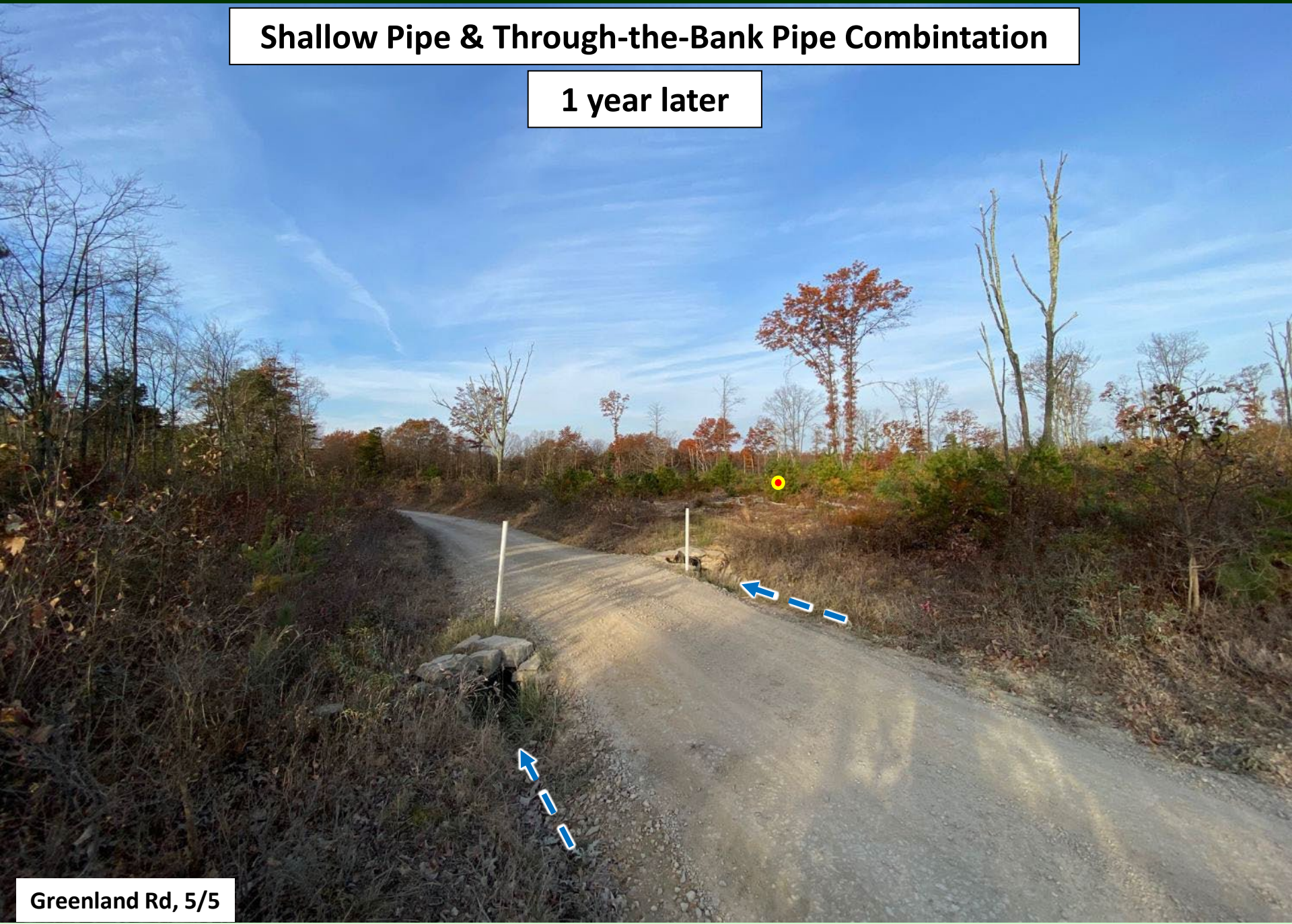
Greenland Rd, 3/5

Ditch Outlets: ESMPs

Through-the-Bank Pipes

Greenland Rd, 4/5

Shallow Pipe & Through-the-Bank Pipe Combintation



Benefits:

- Provide outlet for water when:
  - entrenched road / berm limits outlets
  - a turnout would cause excessive earth disturbance
- Can often be done within right-of-way
- Minimal long-term maintenance

Considerations:

- Creates concentrated outflow of water
- Possible landowner concerns

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Ditch Outlets

1. Selecting a Good Outlet Location
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7. **French Mattresses**

Covered in “Base”

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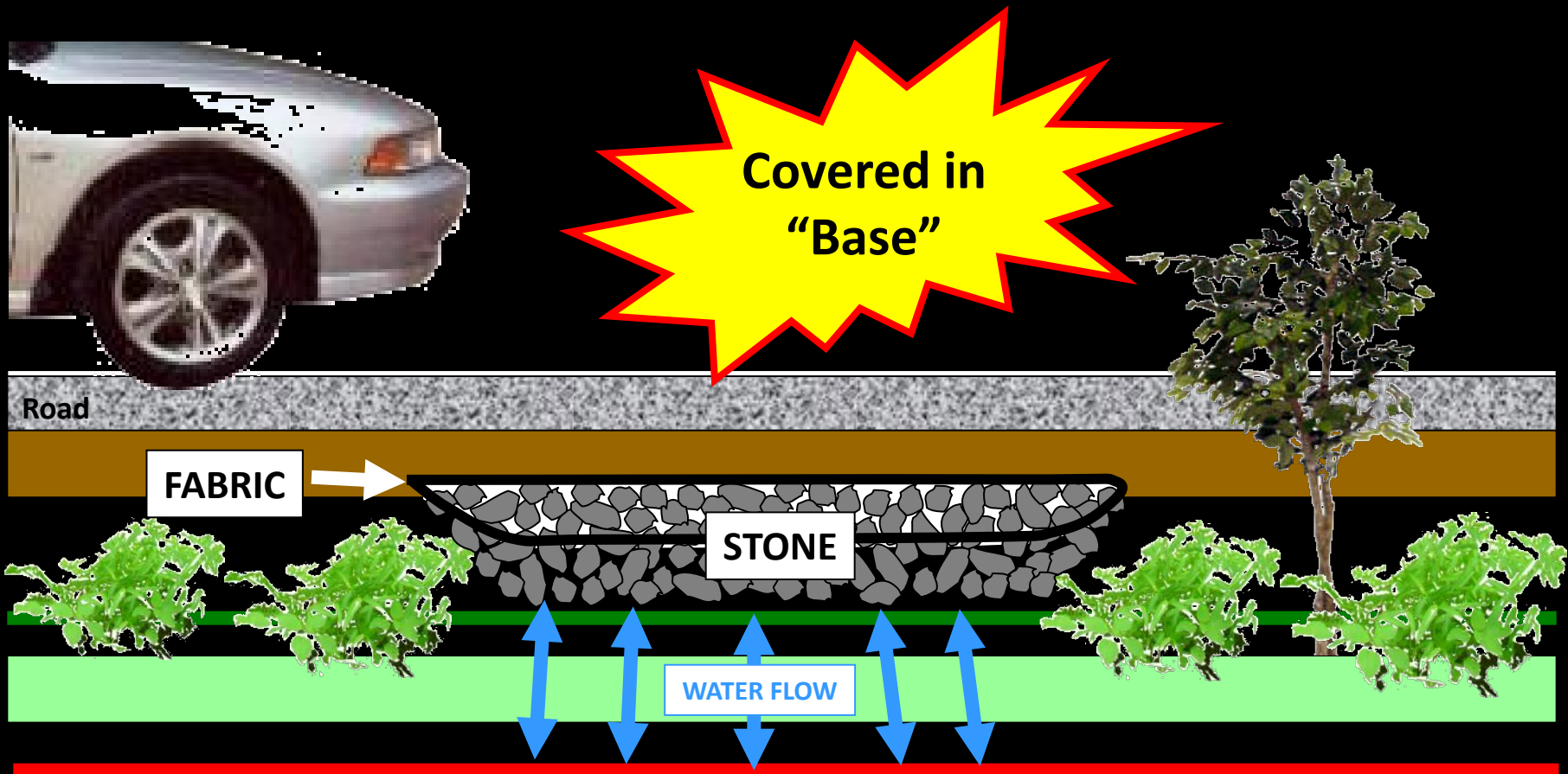
French Mattresses



French Mattress: A drainage structure under a road consisting of coarse rock wrapped in fabric through which water can freely pass.

When to use a French Mattress

- To reconnect wetland hydrology divided by road
- Flat/Level ditches that are saturated
- Very effective in:
  - sloped and lowland wetlands
  - areas with wet banks
  - areas with saturated road base
  - floodplains

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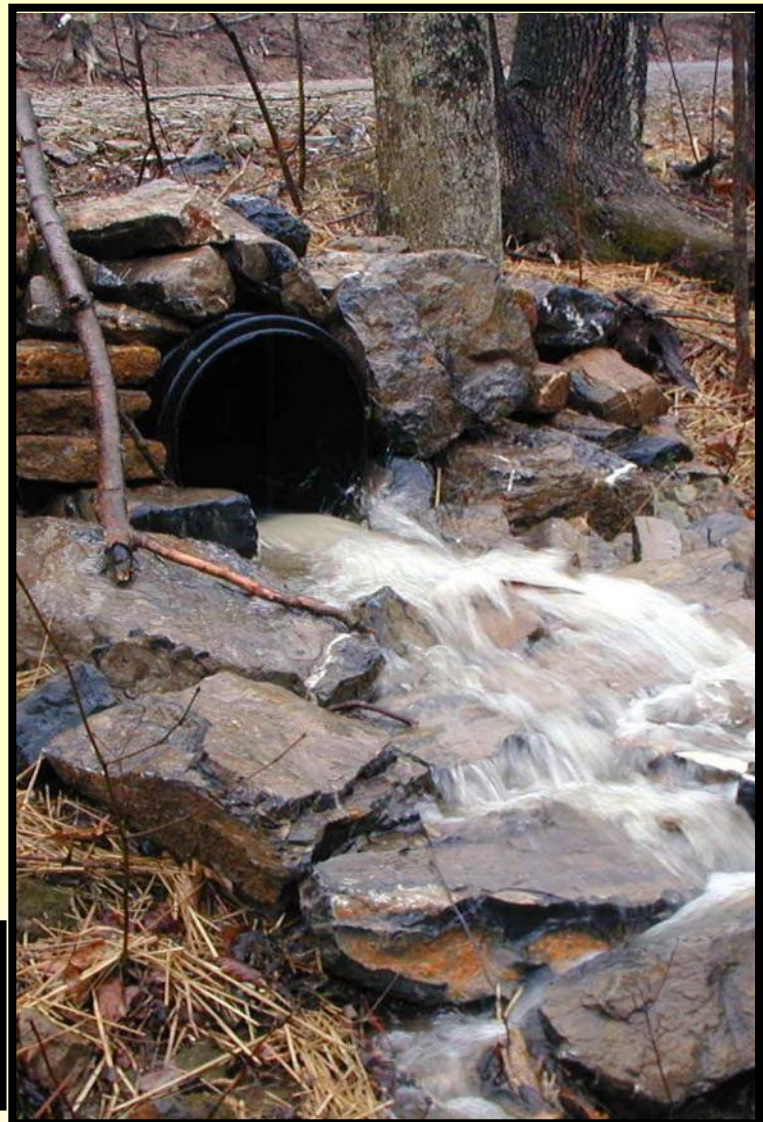
Ditch Outlets

ADDITIONAL RESOURCES:

- Your Conservation District
- Your Municipal Engineer
- www.dirtandgravelroads.org



next chapter:
Structural Infiltration