DOs and DO NOTs of Subgrade Maintenance

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Why are we here?

- Improve Safety
- Improve quality of the track structure
- Reduce re-work
- Review examples of real life problems
- Exchange stories and experiences

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SAFETY

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Today's Program

1. Subgrade Maintenance
2. Trench Drain Construction

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Presentation Outline

- Soft Track
- Ballast Pockets
- Drainage
- Culverts
- Construction Practices
- Over Steepened Slopes
- Riprap
- Record Keeping

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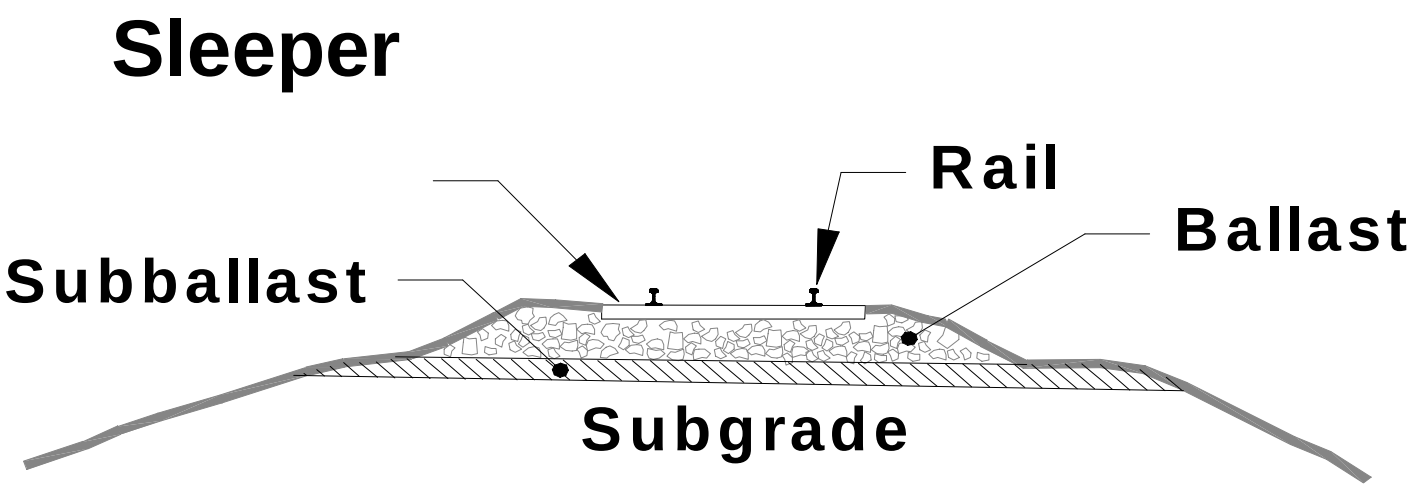
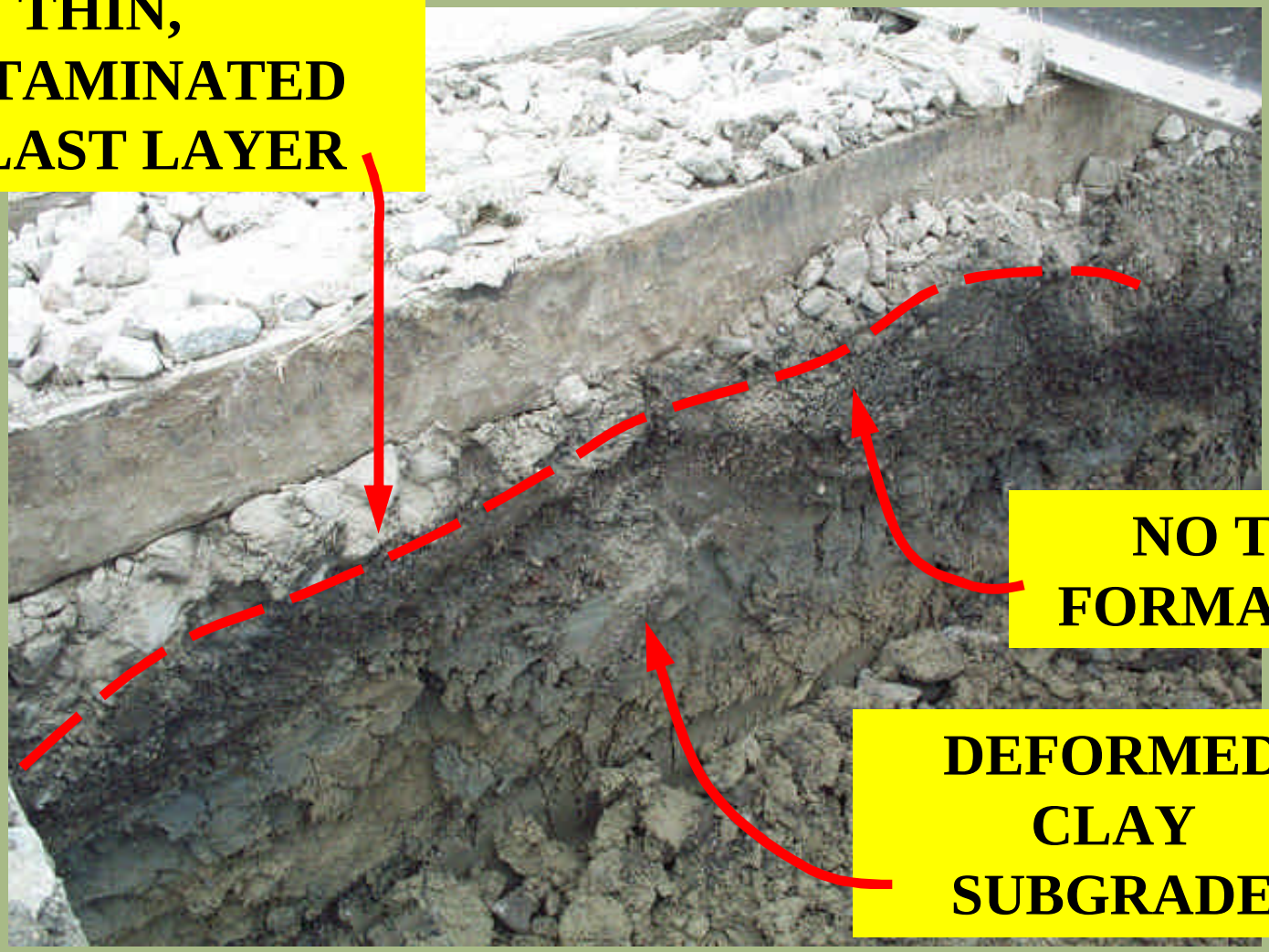
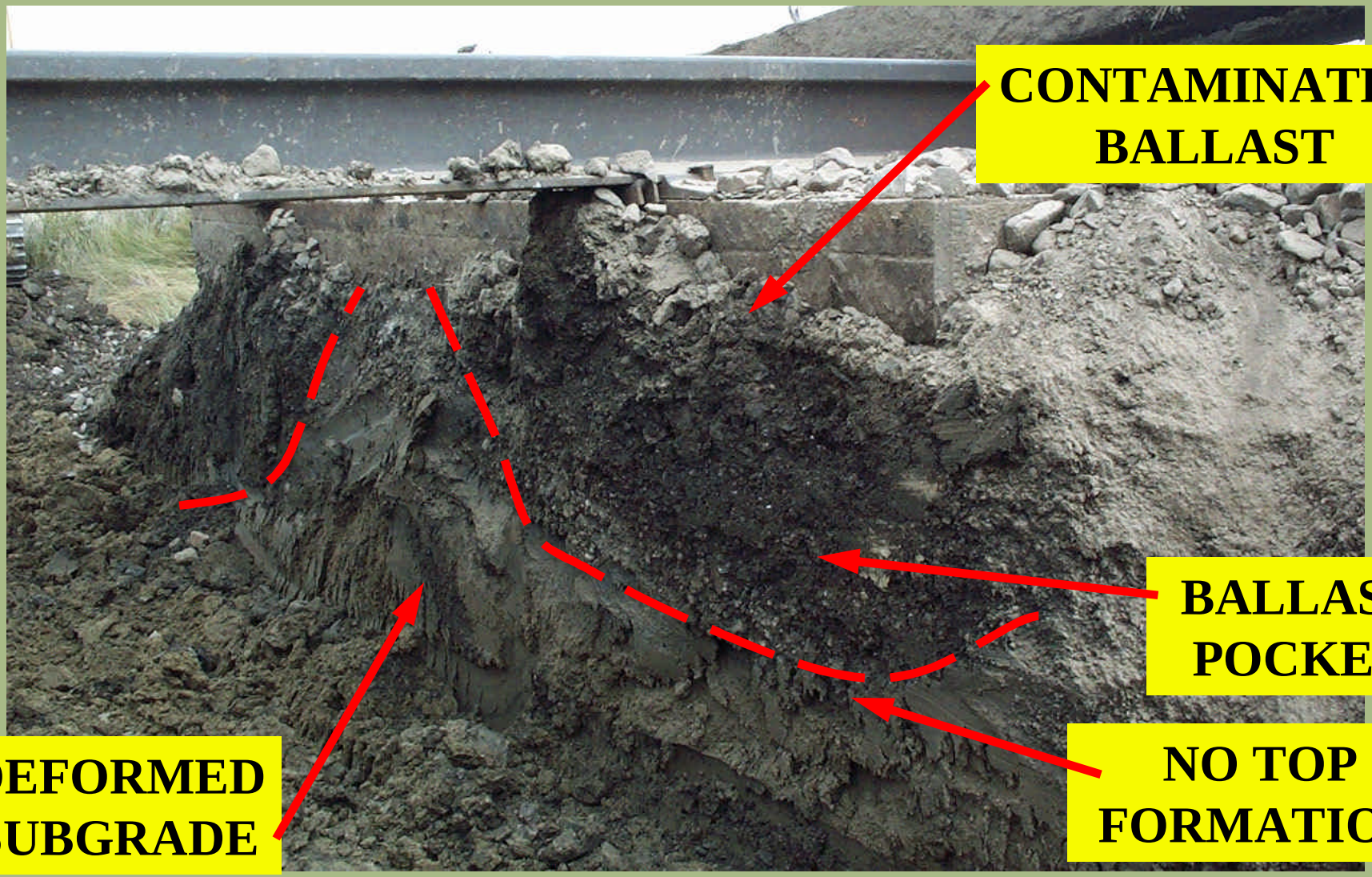
Idealized Track Section



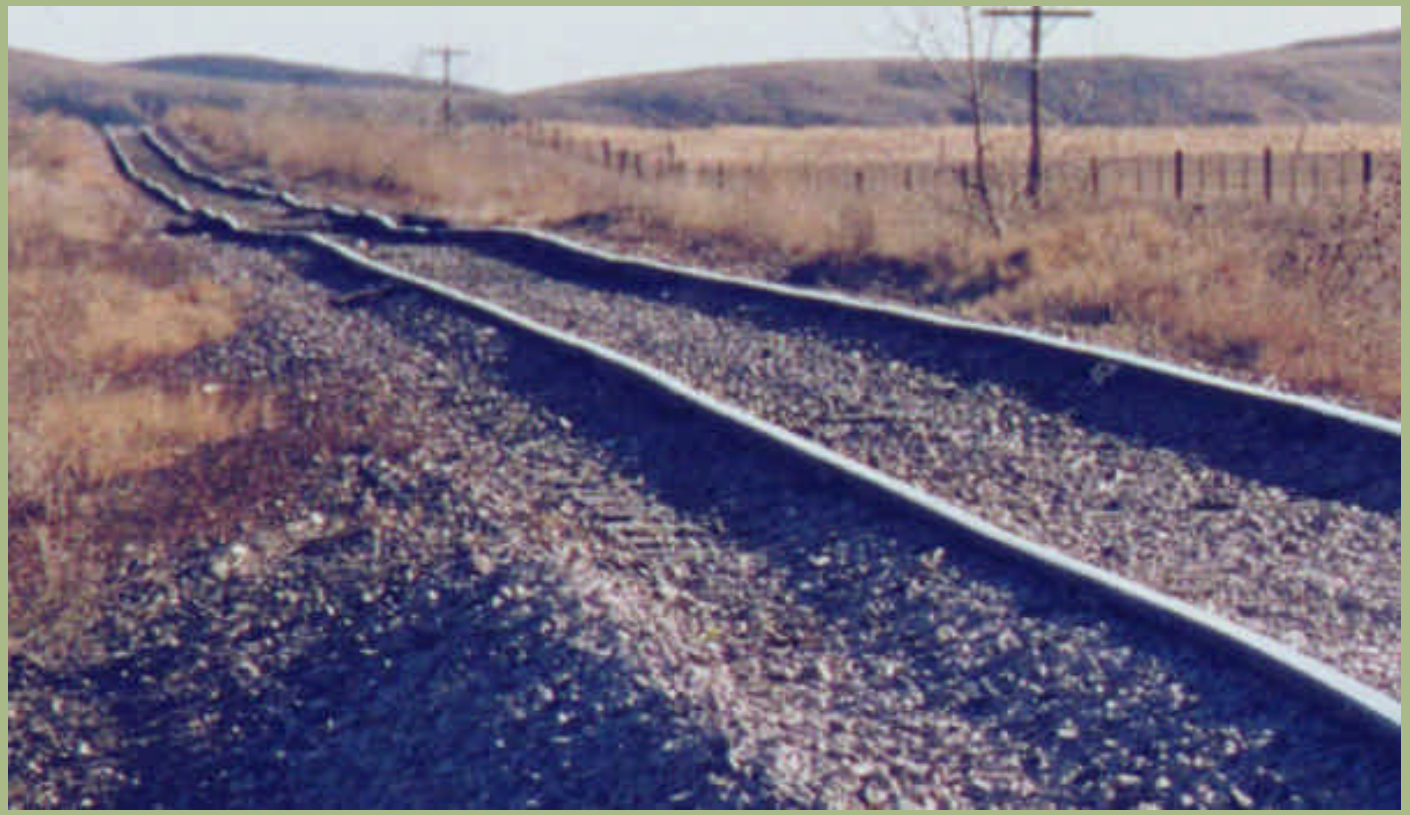
Less Than Ideal Track Section



Another Less than Ideal Track Section



What is “Soft Track” ?



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What is “Soft Track” ?

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What is “Soft Track” ?

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What is “Soft Track” ?

- **Ballast failure and pumping track**
- **Top Formation failure**
- **Shallow subgrade failures**
- **Rigid layer “mud” pumping**
- **Embankment failure**
- **Landslides**

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Contributors to “Soft Track”

- Water
- Weak Subgrade Soil
- Overstressed Soil
- Fouled Ballast
- Poor Initial Construction
- Poor Maintenance Practices
- Over Loaded and Over Steepened Slopes

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Water is a Major Contributor to Soft Track

… and the key to reducing the occurrence of soft track is … …

DRAINAGE

DRAINAGE

DRAINAGE

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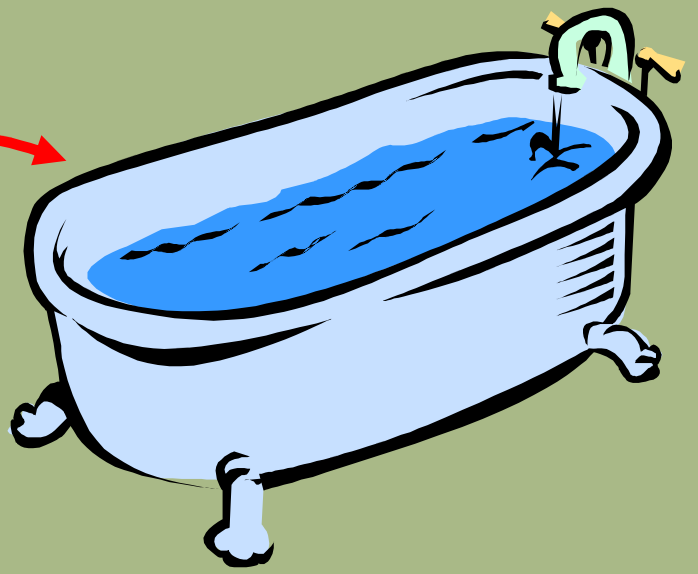
The Ballast Pocket

… Water trapped in a ballast pocket is a major contributor to many soft track situations …

Ballast Pocket



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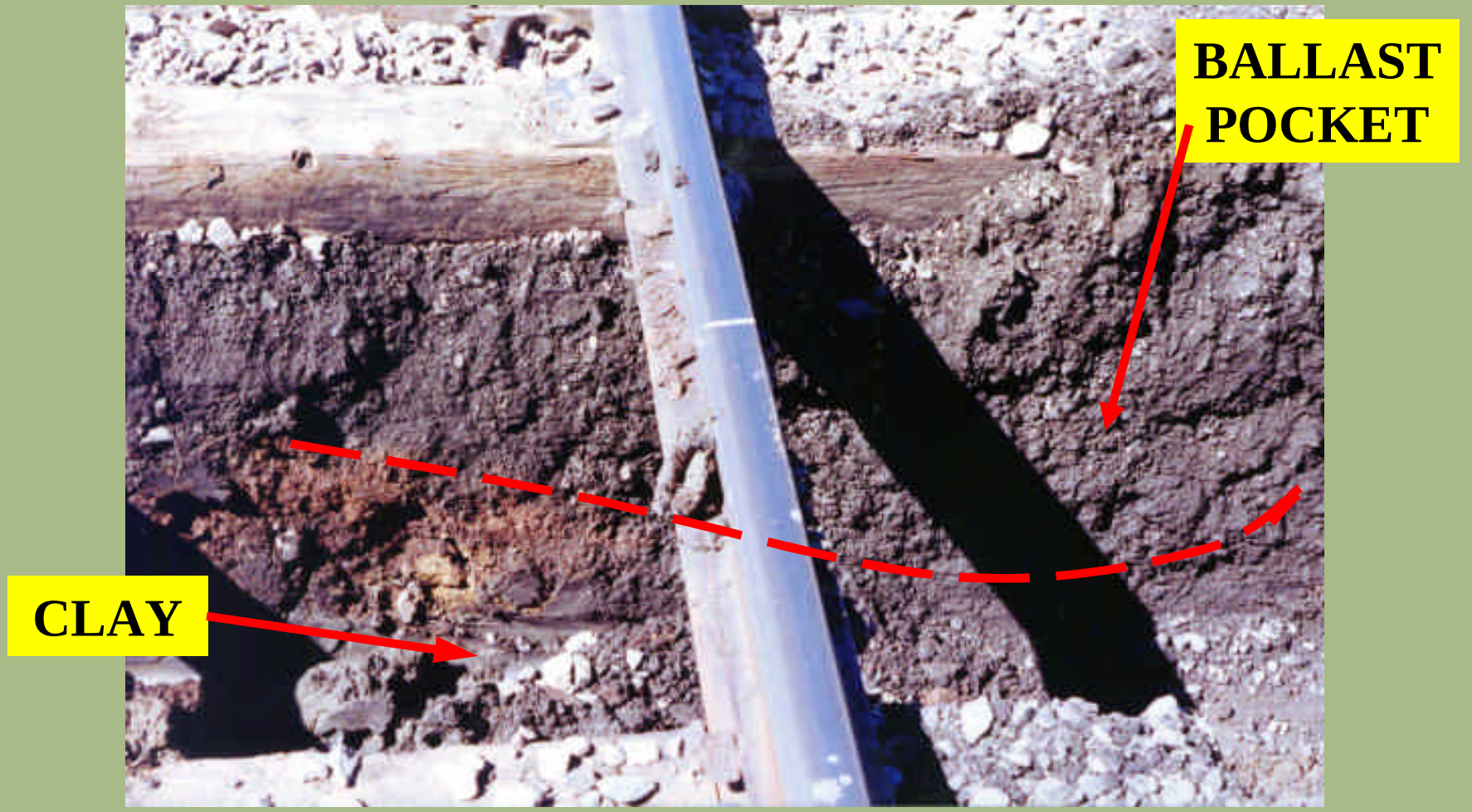
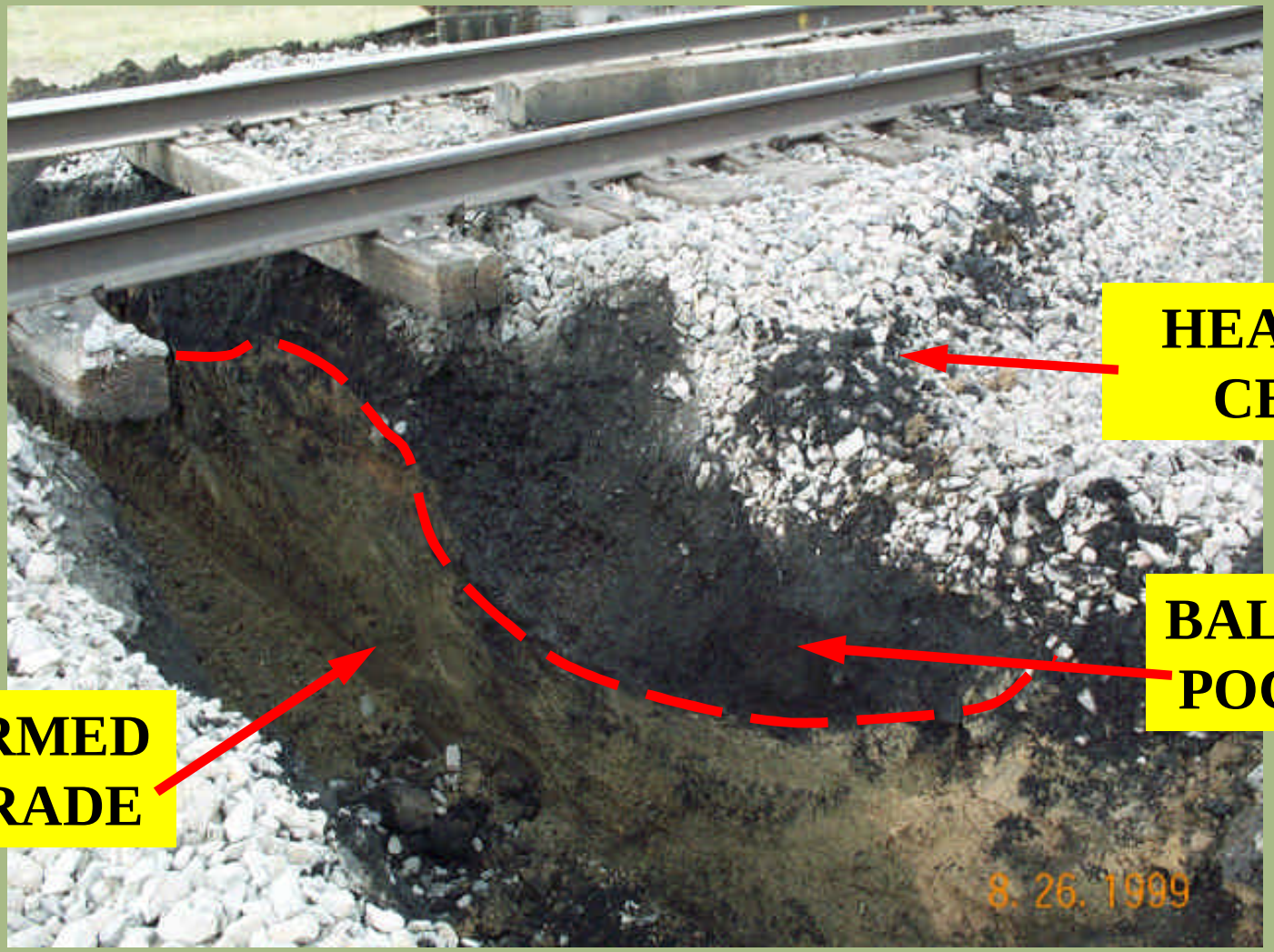
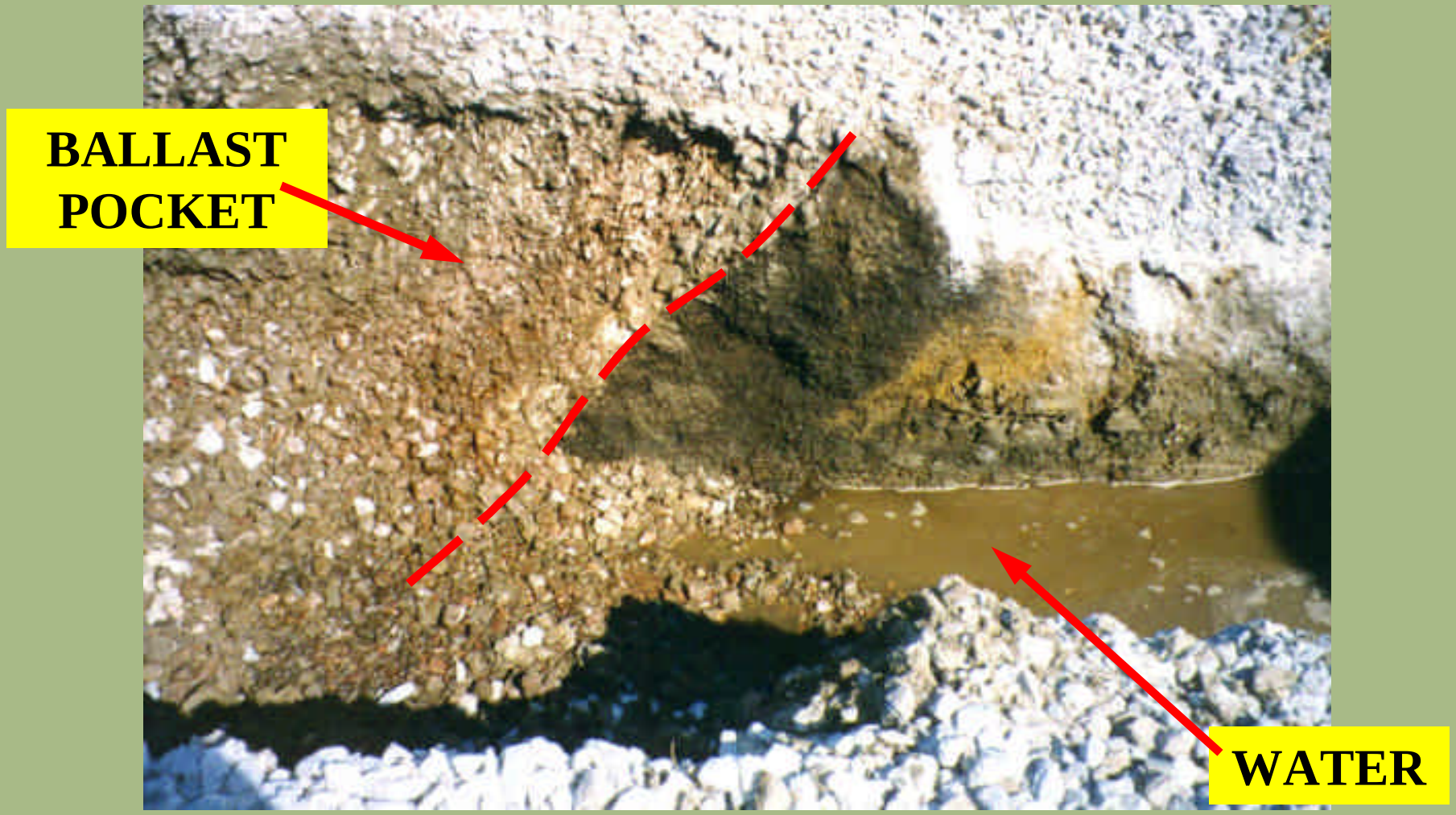
Ballast Pocket Exposed in Trench below Track

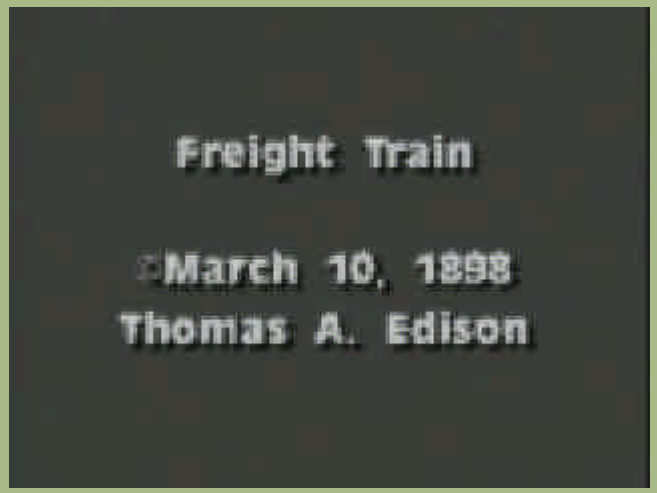


Ballast Pockets under each Rail



Water Flowing from Ballast Pocket





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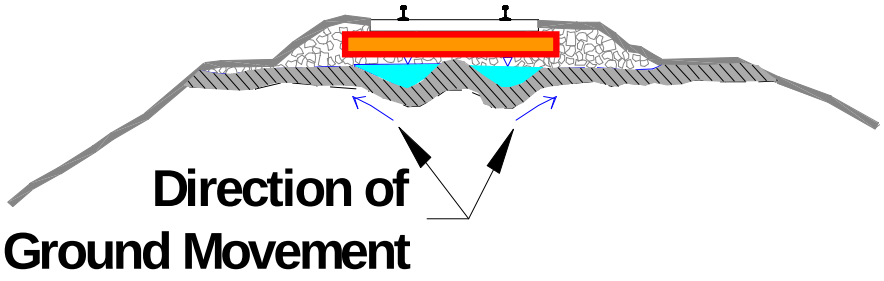
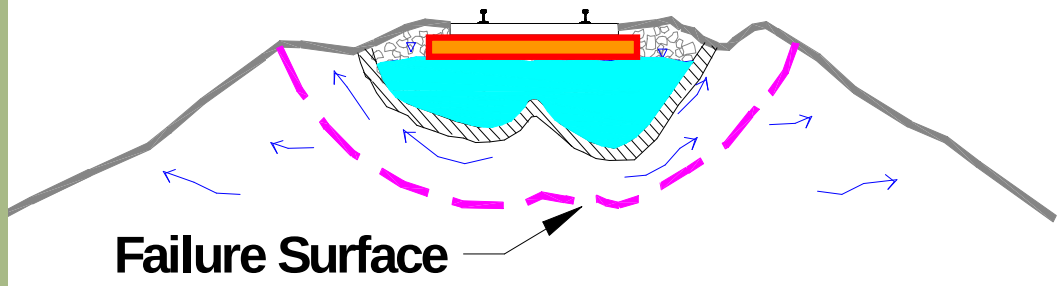
Ballast Pockets associated with Common Subgrade Failure Modes

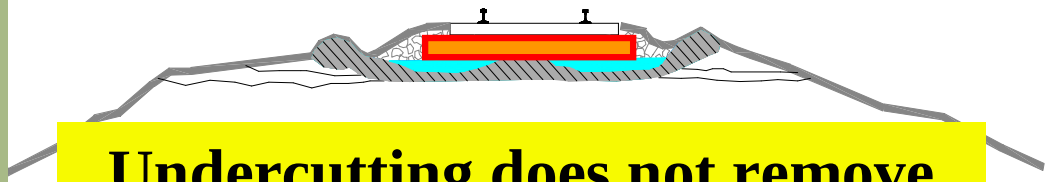


Ballast pocket development. Water trapped in depressions under rail.



Bearing failure

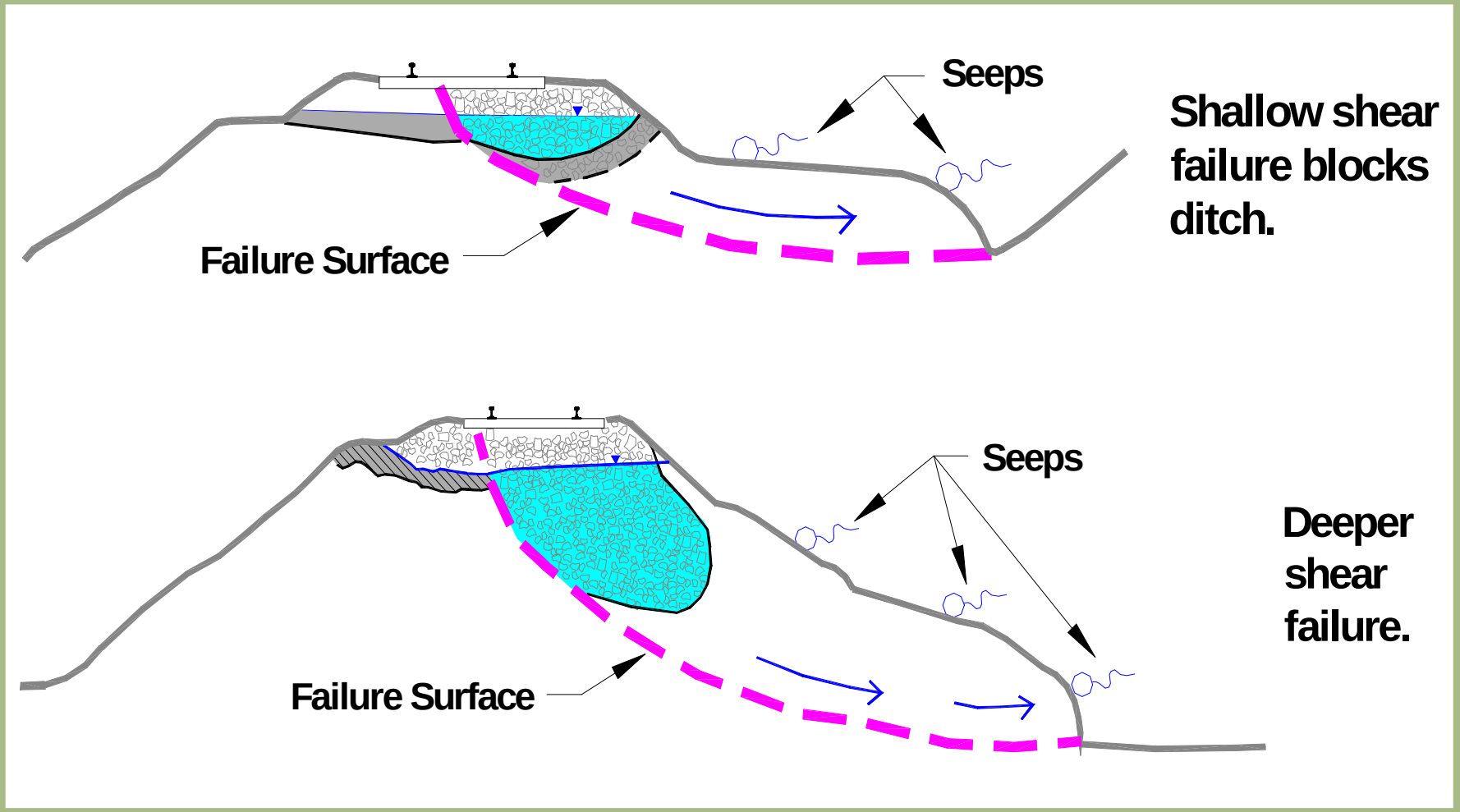
Water saturated track structure.



Top Formation squeeze, minimal subgrade deformation.

Undercutting does not remove or drain the ballast pocket

Ballast Pockets associated with Common Subgrade Failure Modes



Presentation Outline

- Soft Track
- Ballast Pockets
- **Drainage**
- Culverts
- Over Steepened Slopes
- Construction Practices
- Riprap
- Record Keeping

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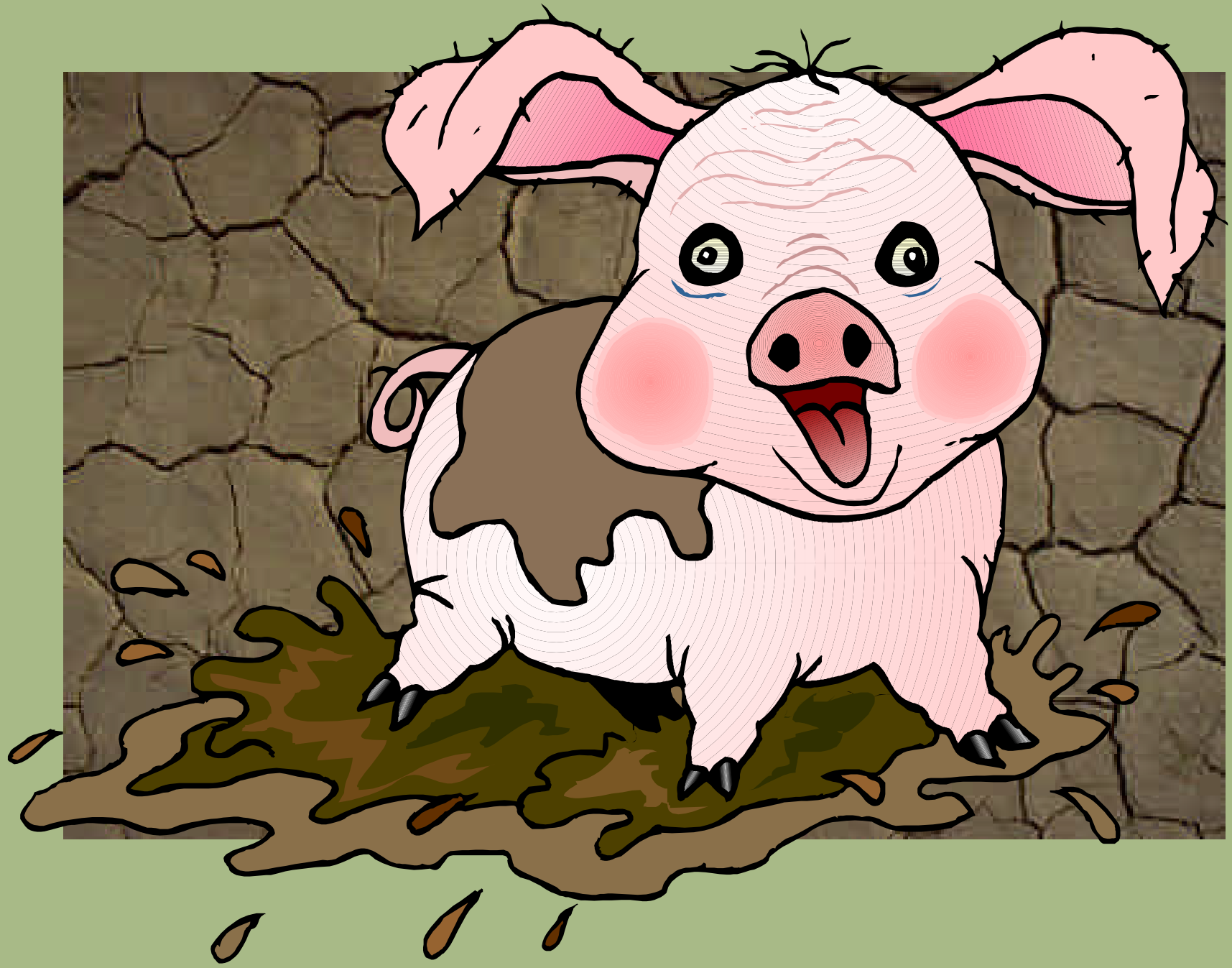
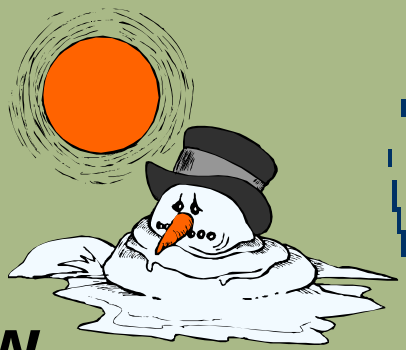


Sources of Water



- Rain or snow
- Surface water infiltration
- Water within the track structure
- Groundwater

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Proper Surface Drainage

… is probably the least expensive and most easily implemented measure for preventing soft track problems or improving performance of soft track areas …

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Indicators of Poor Drainage

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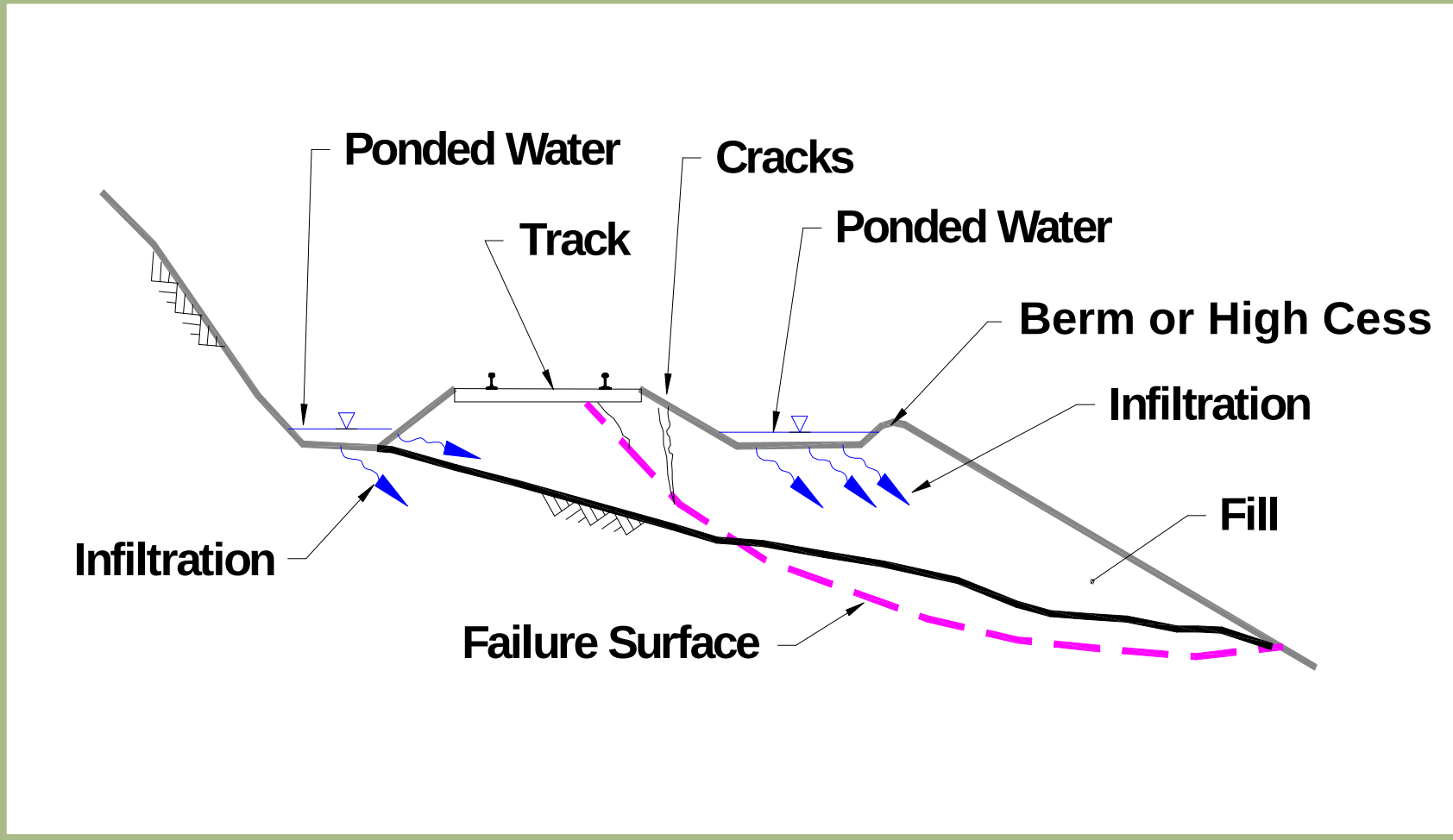
Wet Ground near or on the Embankment

Ponded Water Adjacent to Track

Cattails on Slope above Track

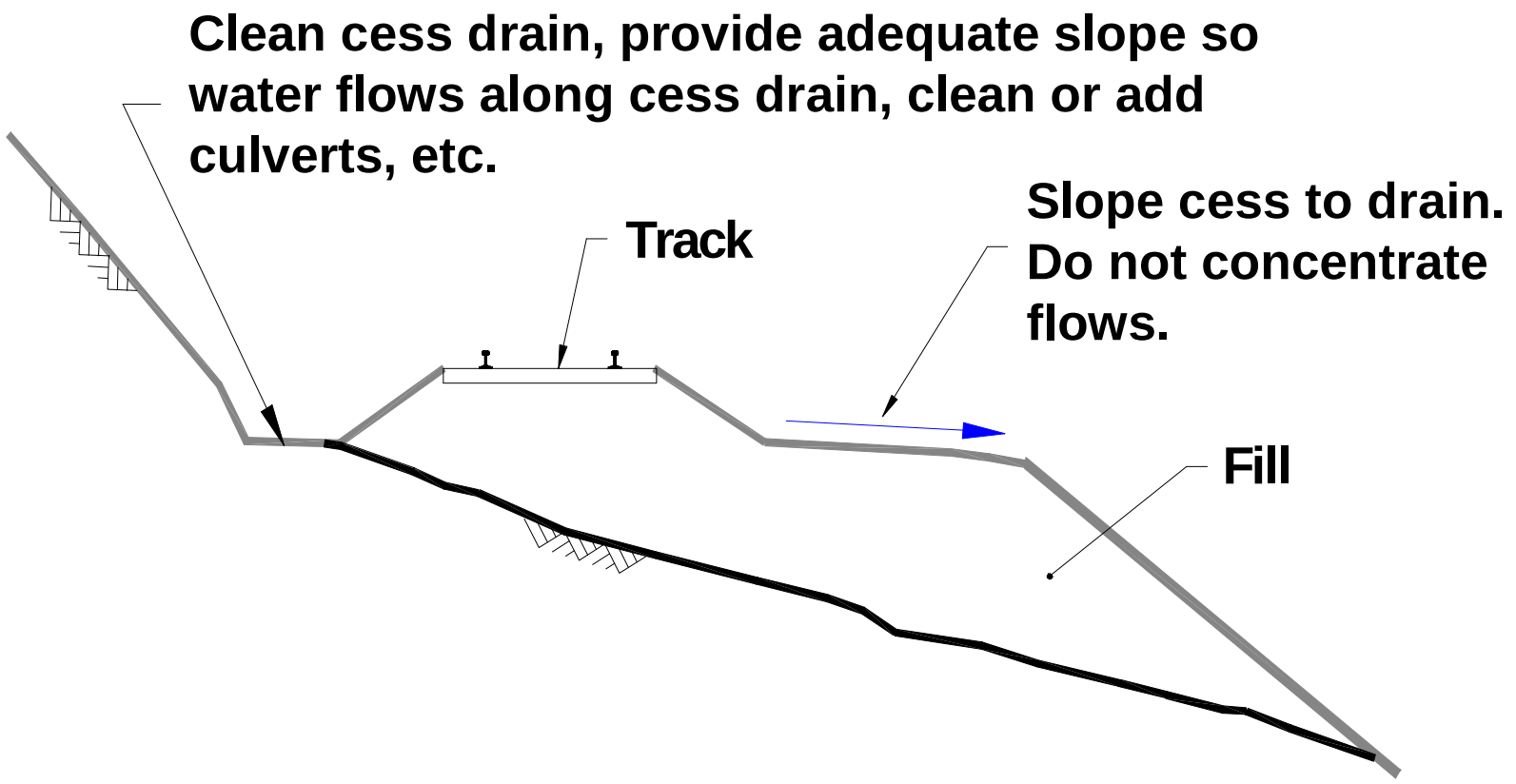
Water Ponded in Ditch and Wetlands Plants

Infiltration and Embankment Failure Resulting from Poor Drainage



Cess Failure due in part to Poor Surface Drainage

Improved Surface Drainage



Surface Drainage
Dos and Do Not's

- DO divert water away from track
- DO keep cess drains clean and graded
- DO keep cesses clean and sloped to drain
- DO NOT let water pond
- DO NOT let water infiltrate the embankment

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Subsurface Drainage Systems

… are effective for

- draining water from soil
- draining water from ballast pockets
- draining water from cracks in the ground
- lowering the groundwater elevation
- intercepting water flowing toward the track

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Examples of Subsurface Drainage Systems

- Drains oriented perpendicular to the track
- Drains oriented parallel to the track
- Drains in wet areas further away from the track

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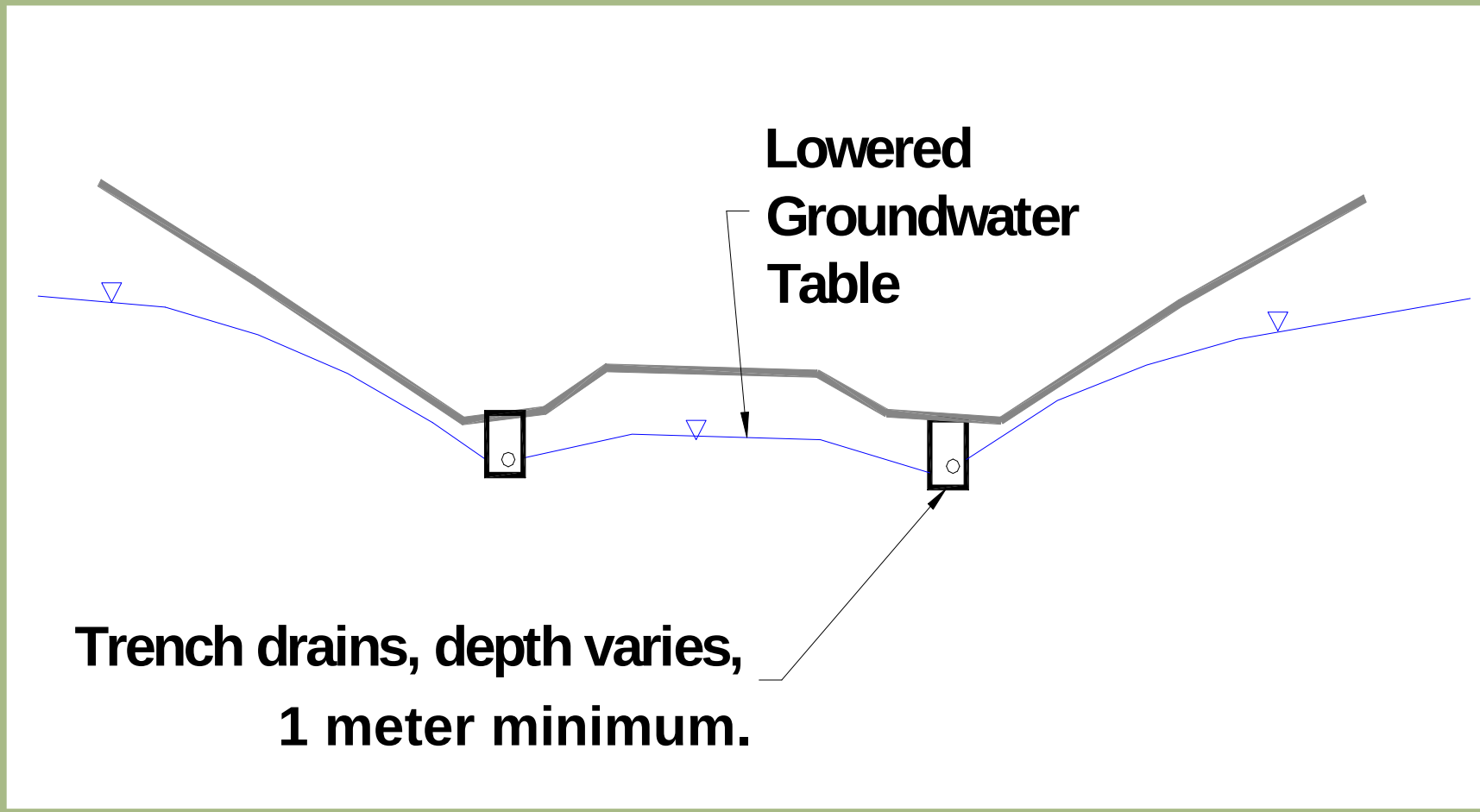
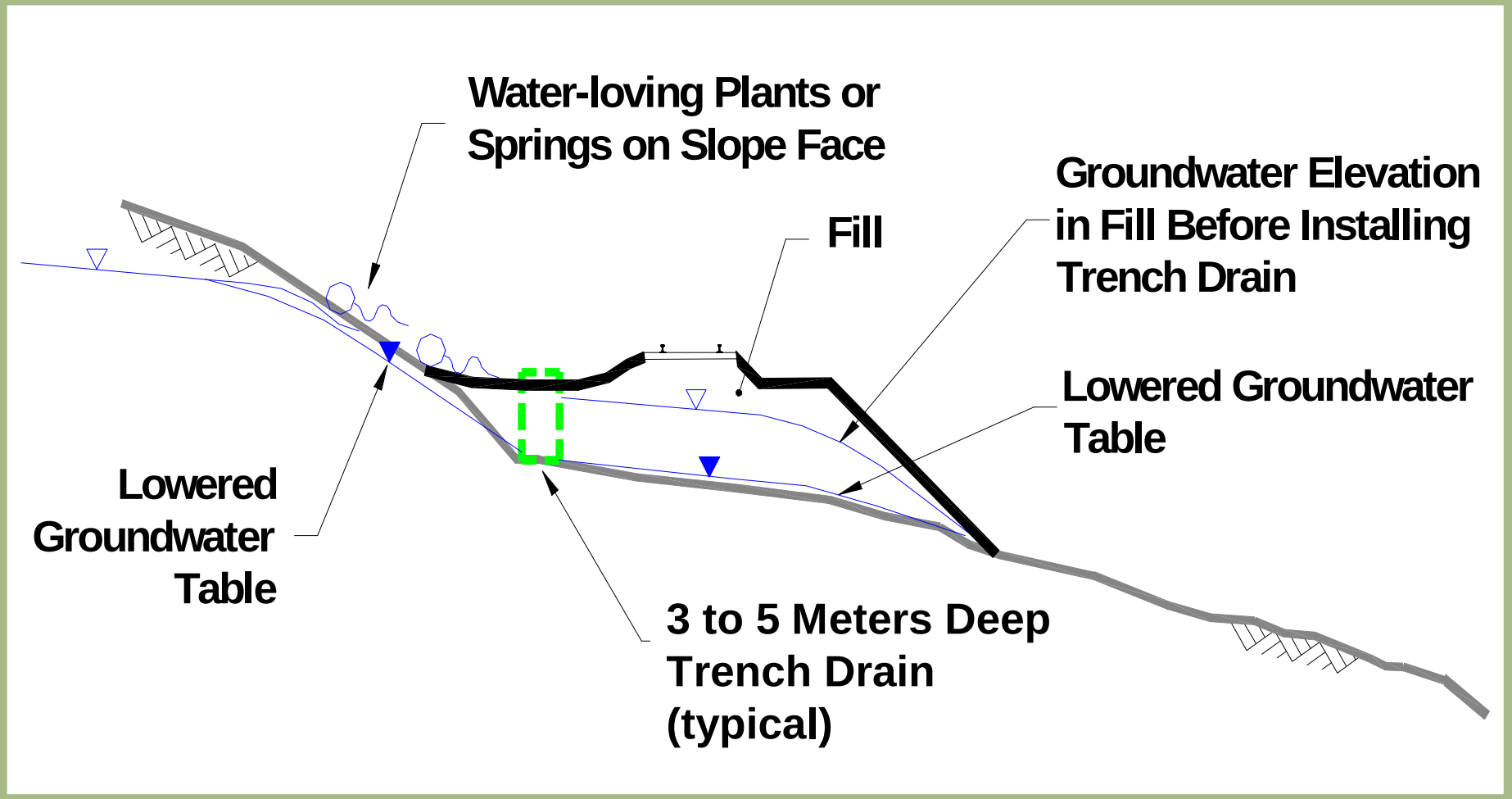
Trench Drains Perpendicular to Track

… are discussed in the second half of the course

Shallow Trench Drains Installed Parallel to the Track



Deep Trench Drain Parallel to Track



Subsurface Drainage Dos and Do Nots

- DO drain ballast pockets
- DO construct cutoff drains upgrade of soft track
- DO NOT construct deep drains without the assistance of experienced personnel
- DO NOT get in trenches

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Presentation Outline

- Soft Track
- Ballast Pockets
- Drainage
- **Culverts**
- Over Steepened Slopes
- Construction Practices
- Riprap
- Record Keeping

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Culverts

… are part of the surface drainage system …

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Common Culvert Problems

- No culvert installed
- Culvert too small
- Spacing between culverts too great
- Culvert plugged
- Culvert damaged
- Drainage toward inlet not properly graded
- Culvert discharges onto embankment

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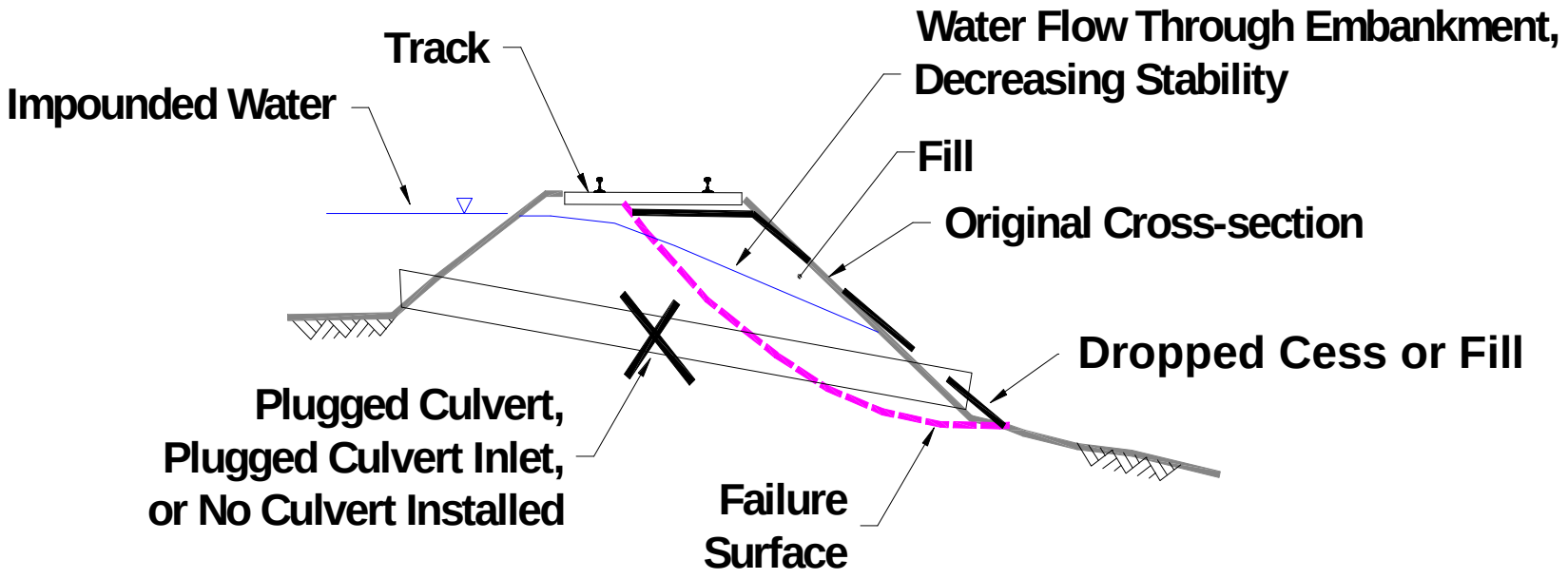
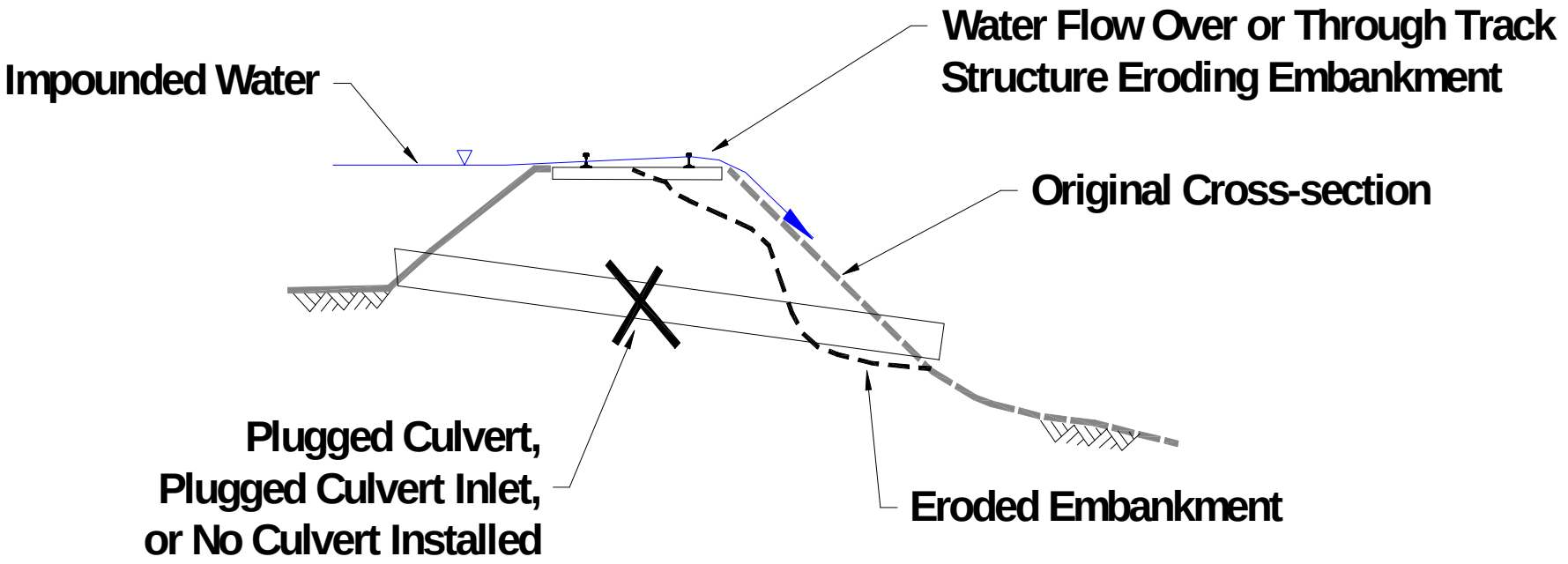
Embankment Failure Resulting from Impounded Water



Erosion of Embankment Slope by Water Flowing Over the Embankment



Culvert Issues

- **Maintenance**
- Installation
- Inlet Protection and Trash Racks
- Outlet Erosion Protection

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Plugged Culverts

Washout because of Plugged Culvert

Beaver Dam around Culvert Inlet

Embankment failure after beavers plugged inlets

Culvert Issues

- Maintenance
- **Installation**
- Inlet Protection and Trash Racks
- Outlet Erosion Protection

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Culvert Installation

… when done properly ensures that the culvert and embankment function properly …

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Prepare Foundation and Bedding

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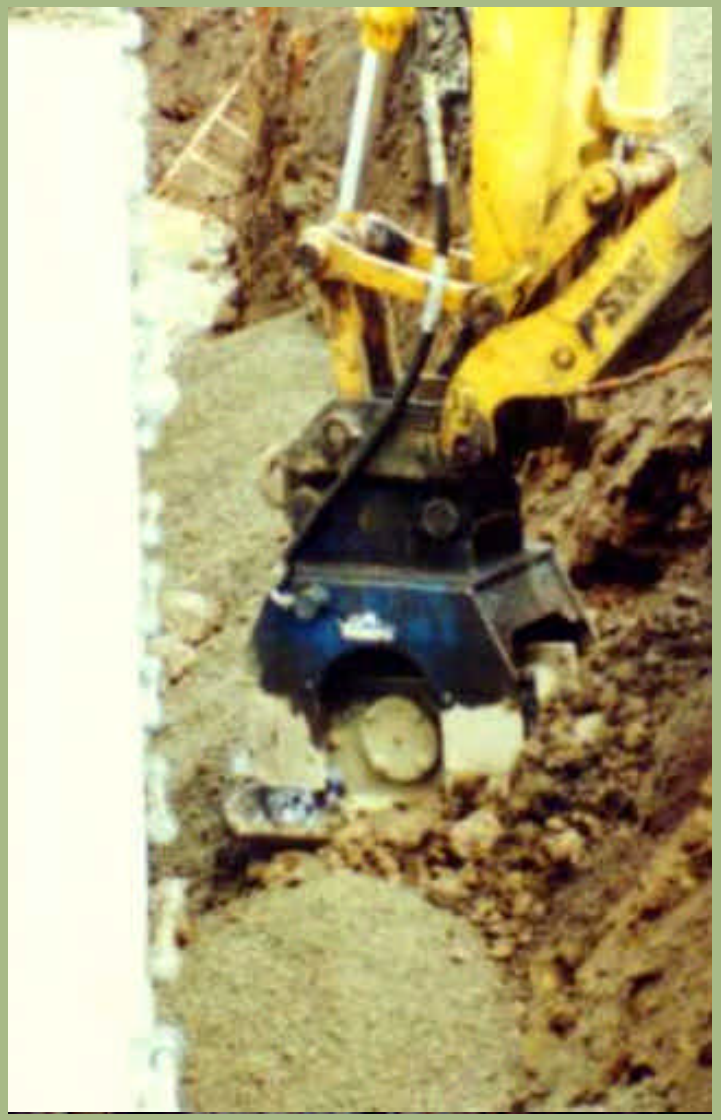
Trench Safety !

Sloping, Benching, and Shoring !

Use appropriate backfill material

Place fill below pipe haunches

Compact Backfill Material !



Remove temporary supports after completing installation

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Additional Installation Concerns

- Grade cess drain so that water flows toward culvert inlet
- Use low permeability backfill soil around inlet end of culvert
- Construct concrete headwall or cutoff wall around inlet

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Culvert Issues

- Maintenance
- Installation
- **Inlet Protection and Trash Racks**
- Outlet Erosion Protection

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Consider inlet structures, flared inlets, and other protection for inlets

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Lined inlet channels and cess drains are sometimes appropriate

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Culvert Inlet Trash Racks

… are one method to reduce the potential for culverts and culvert inlets to become plugged with debris …

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Horizontal Trash Rack may be easily Plugged with Debris

Riser Trash Racks over existing Horizontal Trash Racks

Vertical Trash Rack

Overflow Risers / Secondary Inlets

Culvert inlets with trash racks and overflow inlets

Culvert Issues

- Maintenance
- Installation
- Inlet Protection and Trash Racks
- **Outlet Erosion Protection**

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Erosion Below Culvert Outlets

… another all too common contributor to embankment failures …

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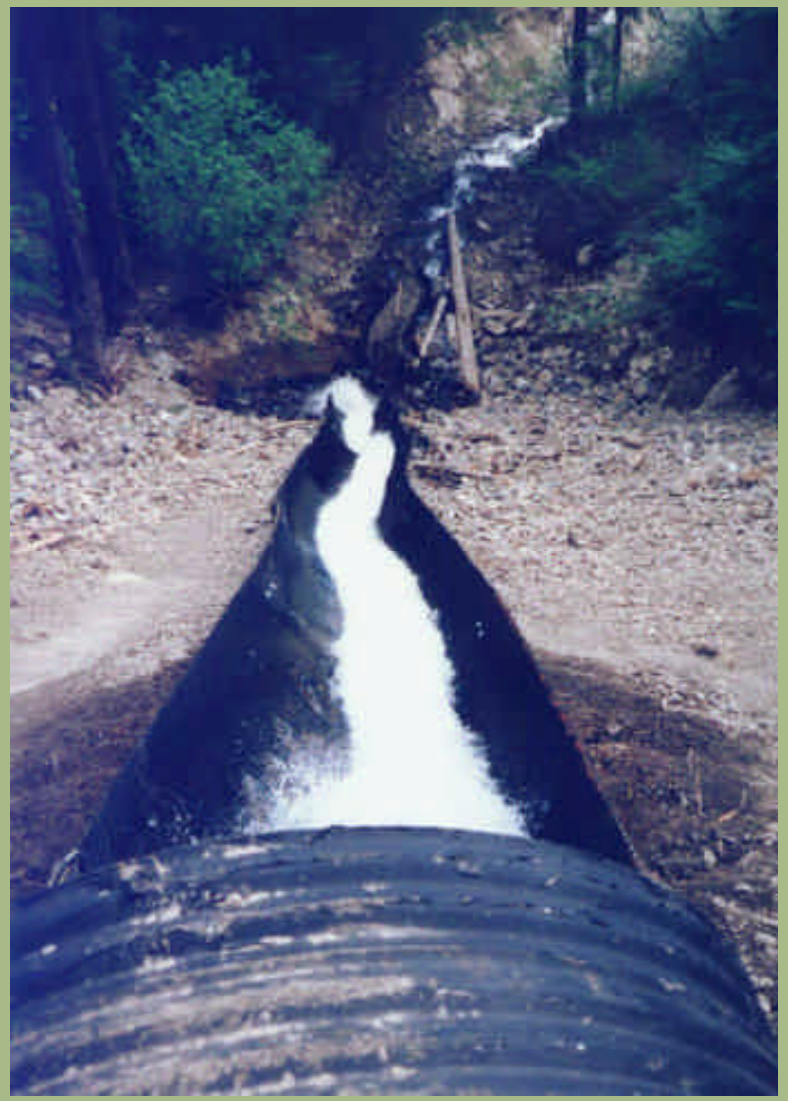
Erosion Below Culvert Outlet

Erosion below Culvert Outlet

Extend Culverts or Protect Slope

Discharge at Toe of Slope



Line Discharge Channels with Riprap

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Use Outlet Structures if Appropriate

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Culvert Dos and Do Nots

- DO maintain culverts in good condition
- DO replace culverts that are too small
- DO properly install culverts
- DO install inlet structures and trash racks where appropriate
- DO NOT let culverts or culvert inlets become clogged
- DO NOT discharge culverts on unprotected embankments

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Poor Construction Practice

… can create problems that are difficult and expensive to deal with later …

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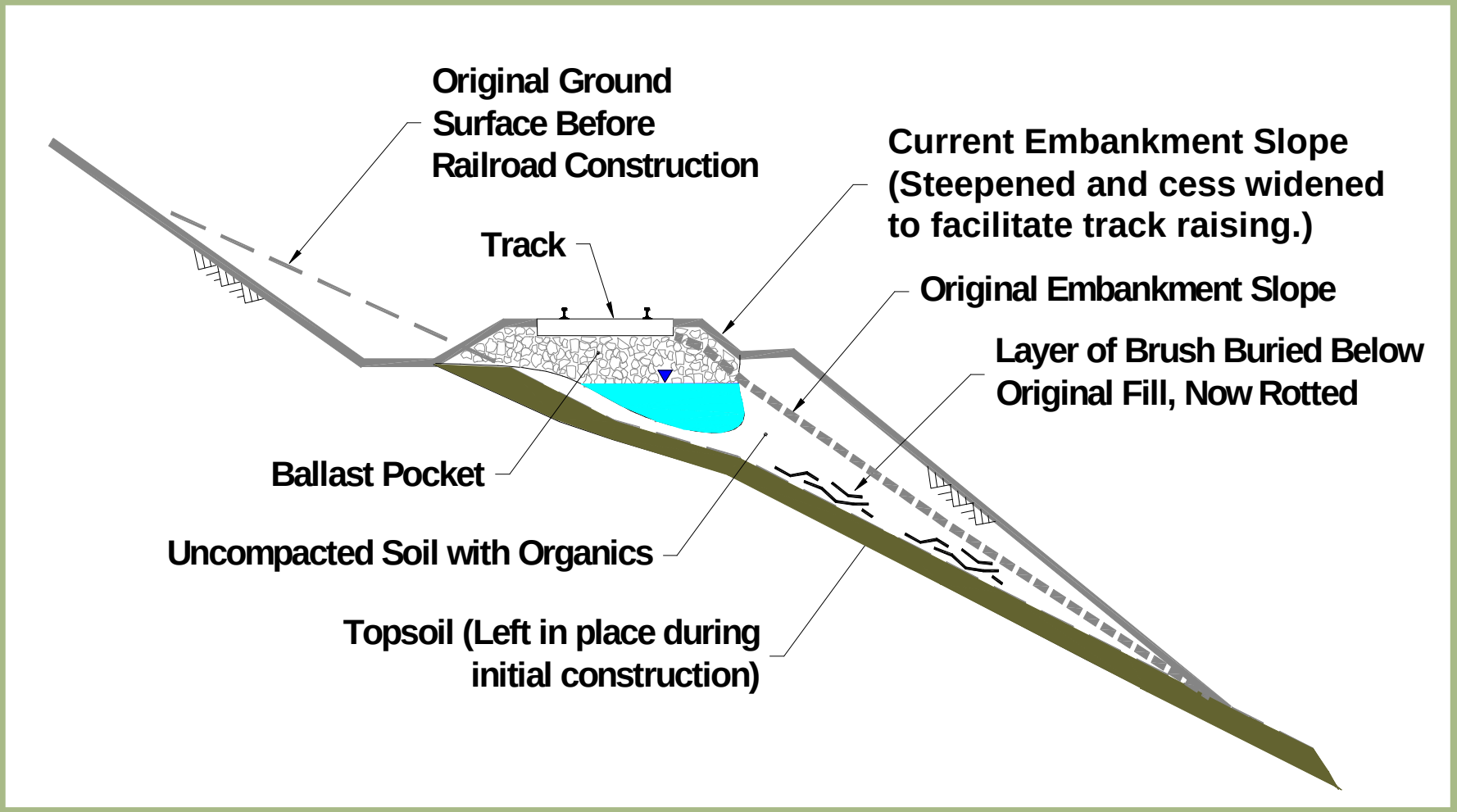
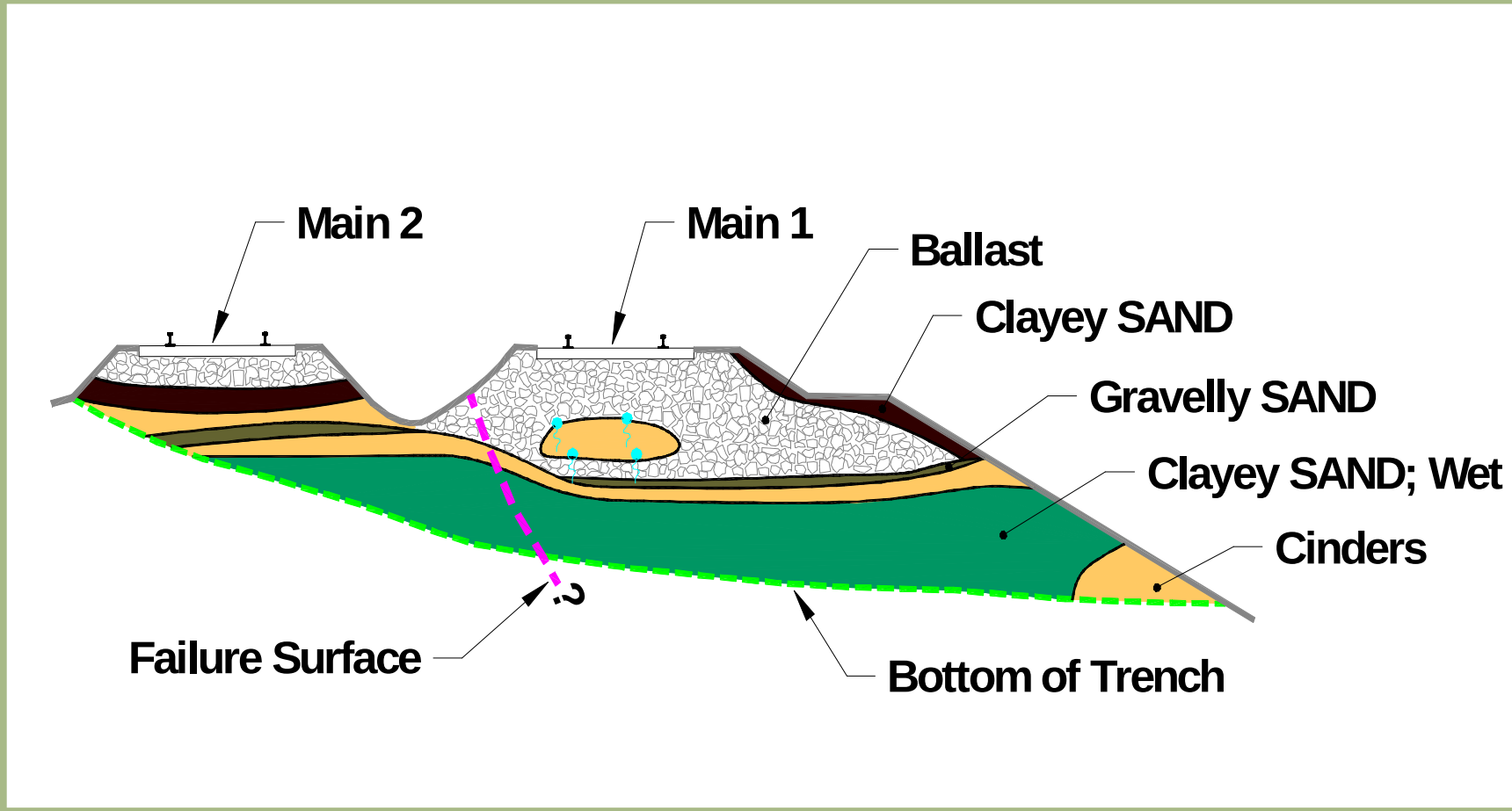
An Old Side-hill Fill Railroad Embankment



The Severity of Embankment Problems may Increase Over Time



Bridge Fills

… Embankment stability problems are frequently associated with trestles and bridges that have been replaced with fills …

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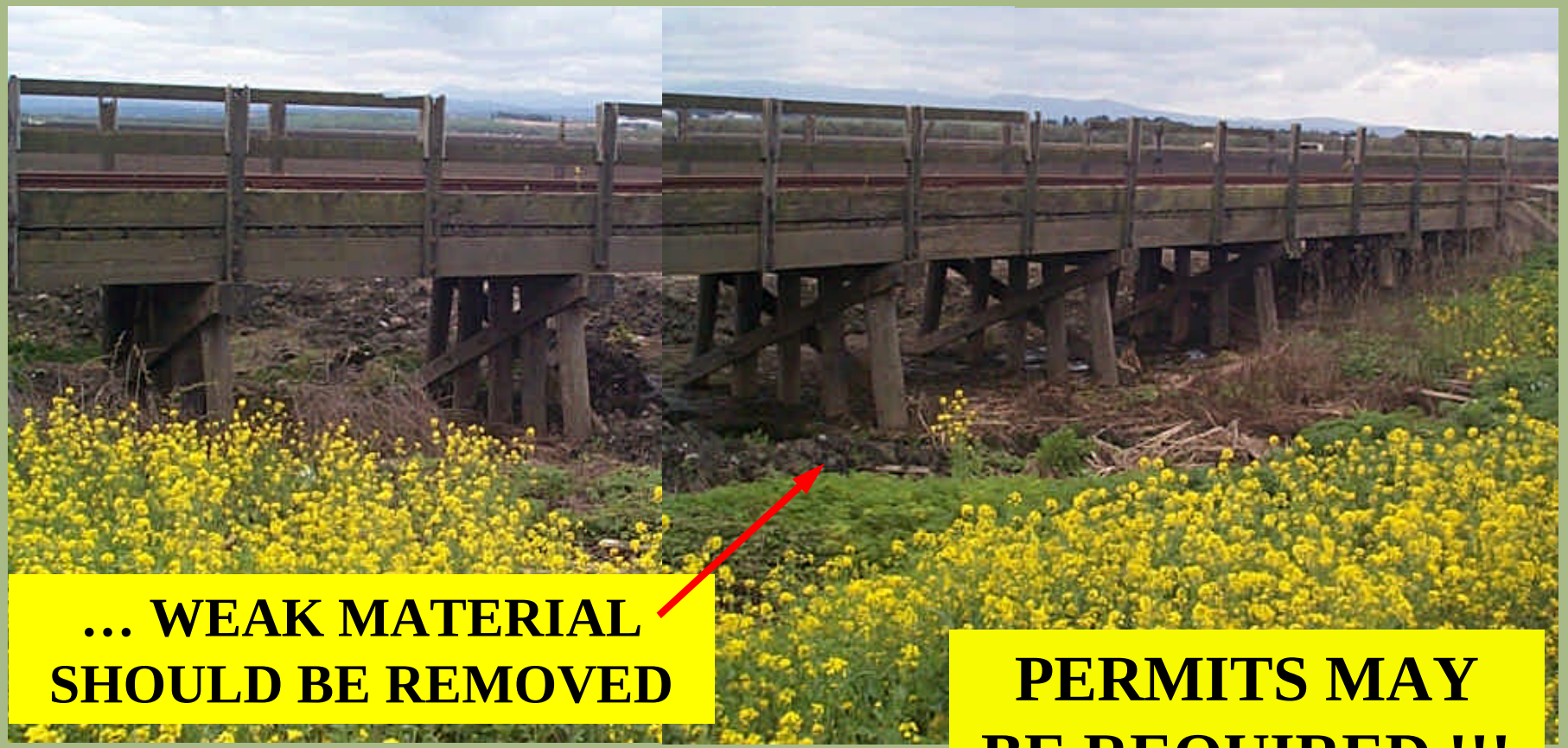
Prior to placing fill ...



… fill materials should be compacted

If compaction is out of the question

- use quality fill material or special techniques

An Example of Problems at a Timber Bridge that was Replaced with Fill

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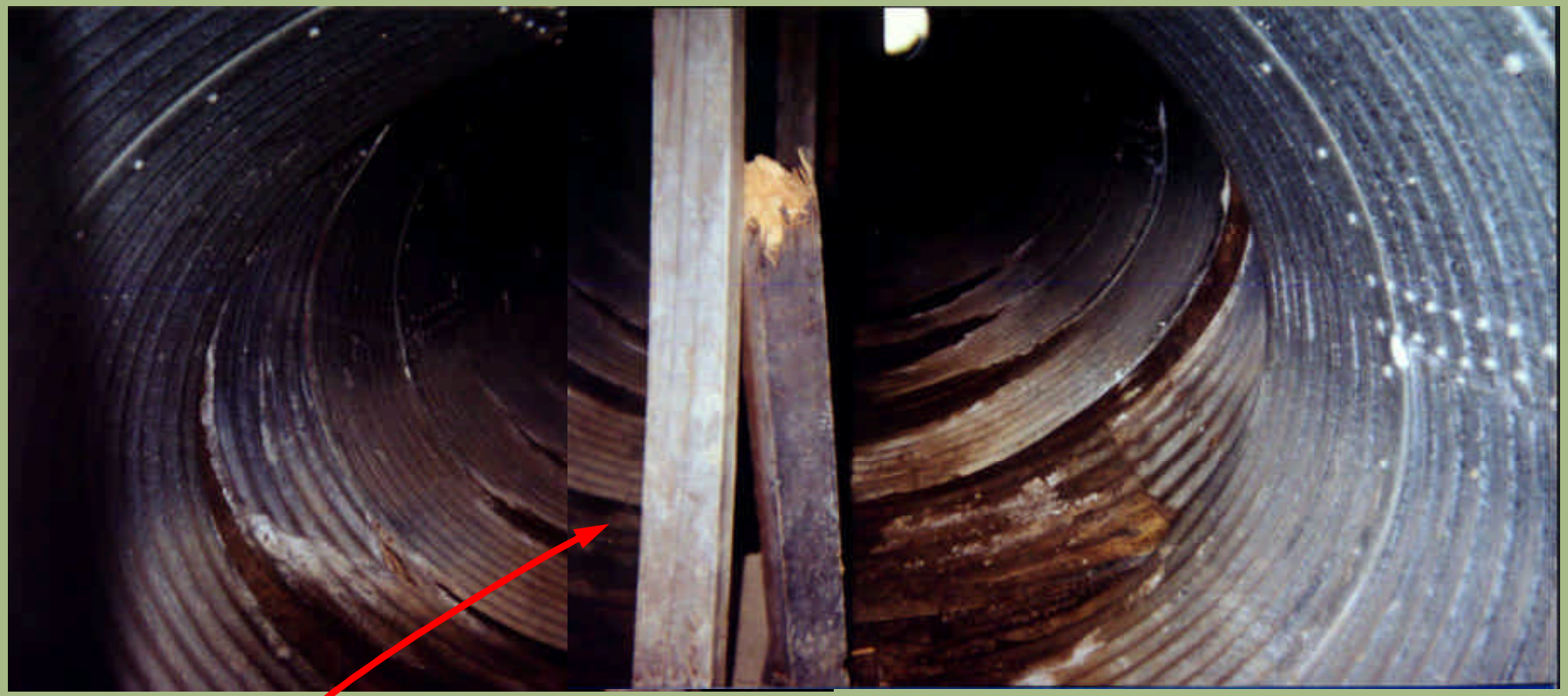
Close up of Bulge in Embankment and Offset Flume

Cracks in Embankment

Culvert Damaged



Note that struts were never removed

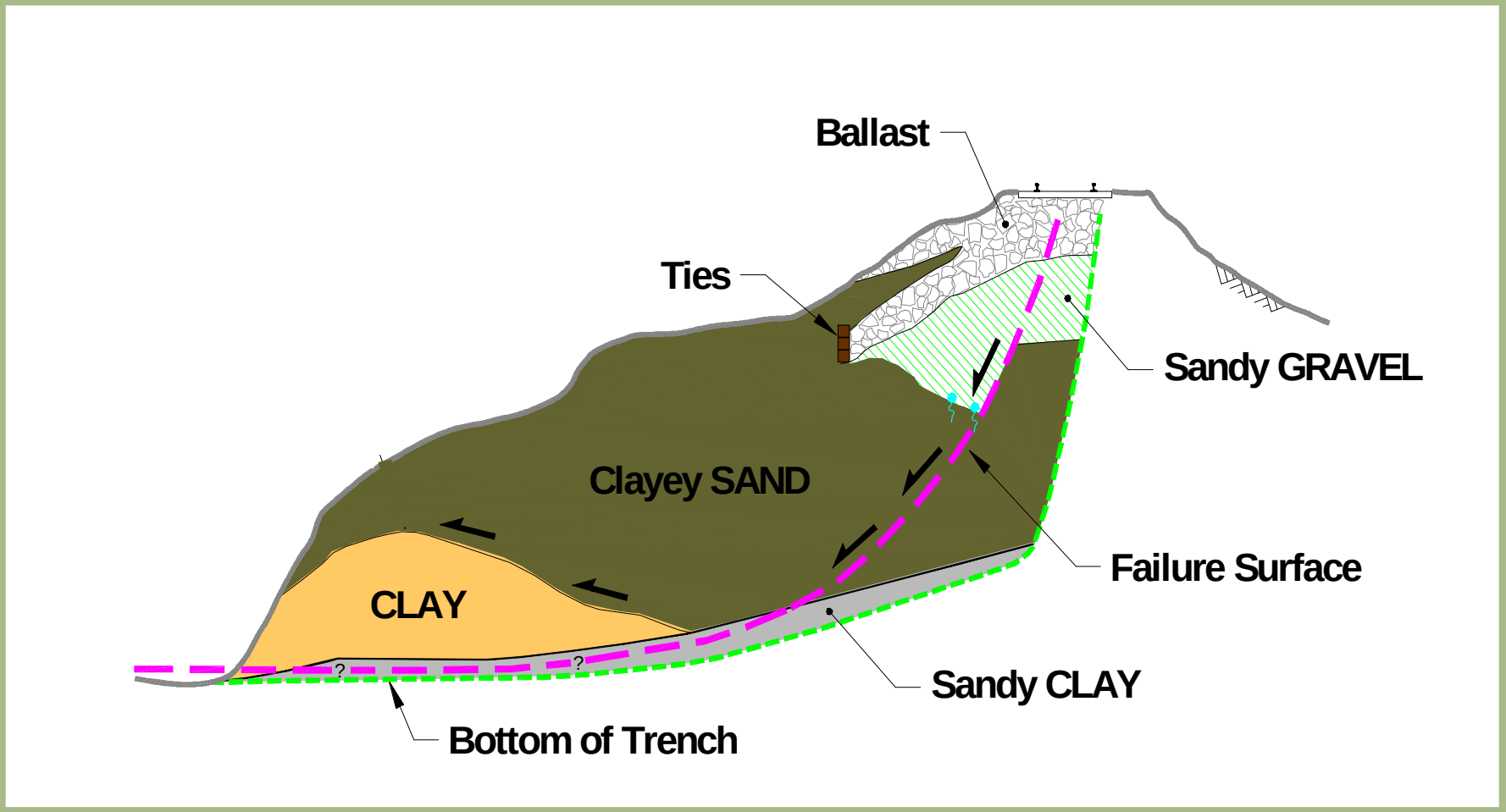
Old Bridge Piles Buried in Fill

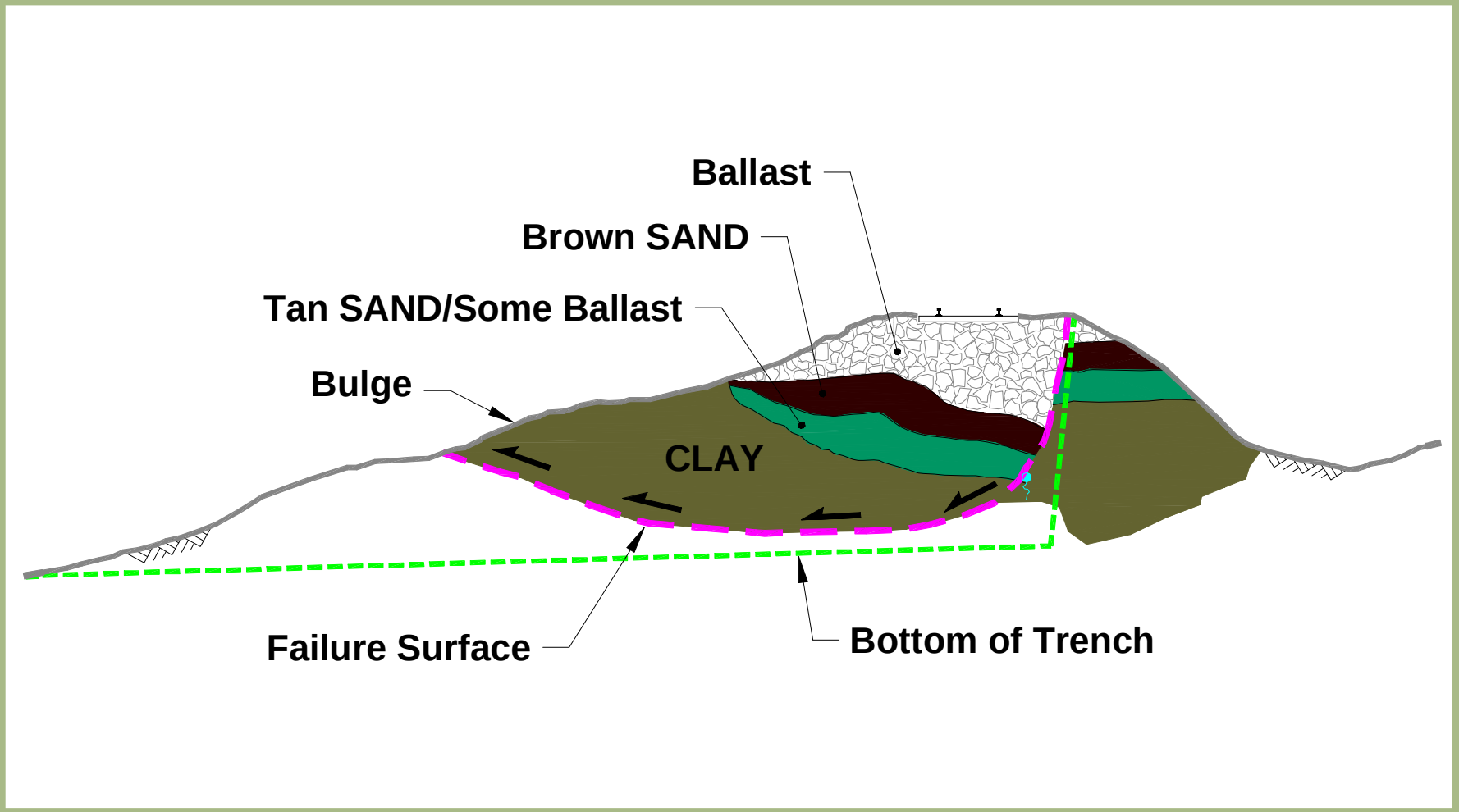
REMOVE PILE CAPS

More Old Piles in Fill

-Note, piles are leaning as a result of embankment movement

Cross Section through the Embankment




Ballast
Brown SAND
Tan SAND/Some Ballast
Bulge
CLAY
Failure Surface
Bottom of Trench

Embankment Repair - Weak Soil Replaced - Slope Flattened

Replacement performed in short segments - under the guidance of a geotechnical engineer

Riprap Placed

PERMITS MAY BE REQUIRED !!

Embankment Construction Dos and Do Nots

- DO remove unsuitable soils before placing fill
- DO compact fill materials
- DO keep slopes as flat as possible
- DO NOT forget to provide drainage

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Over Loading and Over Steepening of Slopes

… two other common causes of embankment slope failures ...

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Over Loaded and Over Steepened Slopes Occur as a Result of:

- Excessive raising of the track
- Disposal of material on the slope
- “Bank Widening”
- Erosion of the toe of the slope
- Undercutting of the toe of the slope

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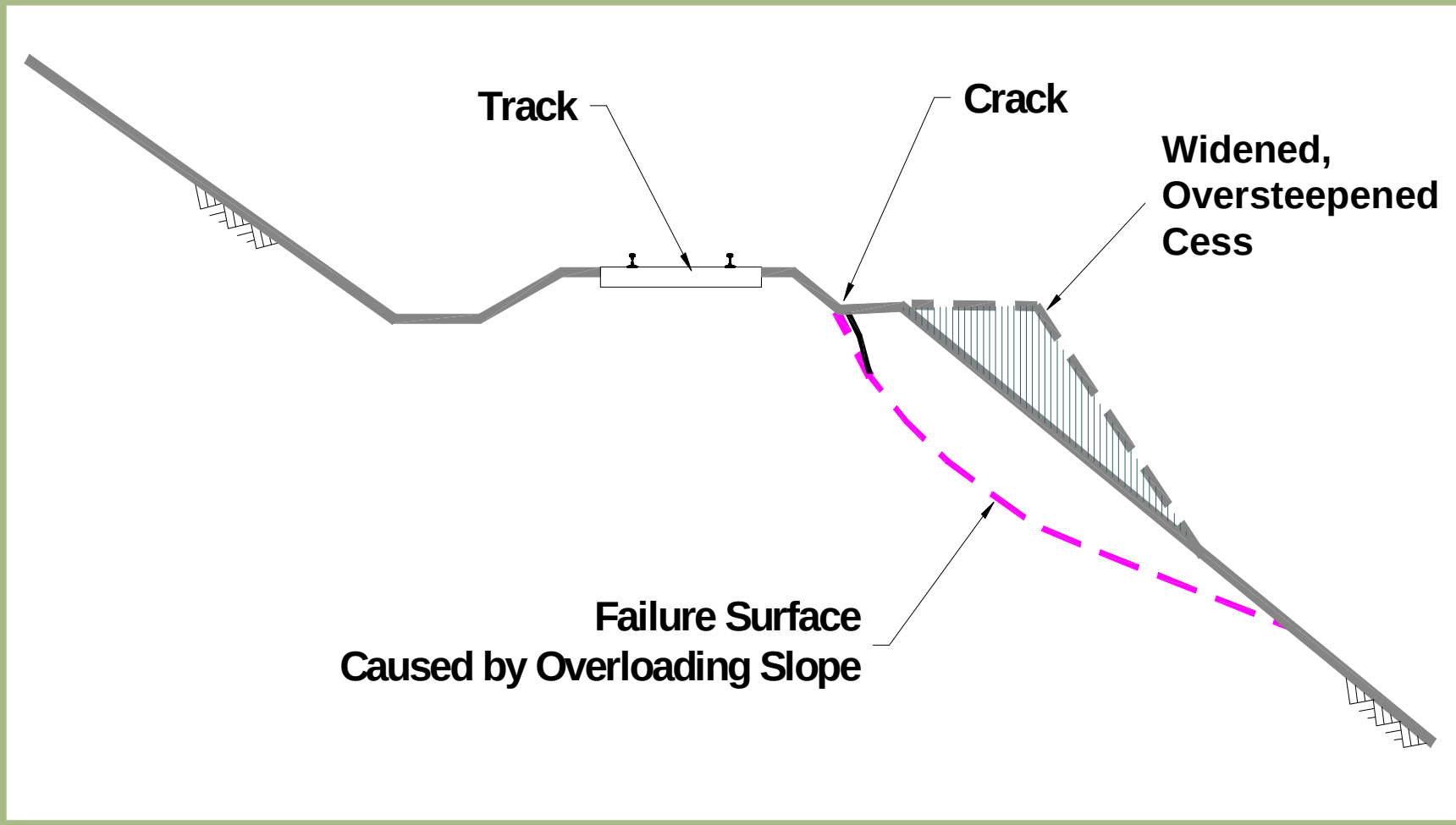
Over Loading and Over Steepening of an Existing Slope



Over Loading Slope

MATERIAL REMOVED FROM DITCH PILED ON CESS.

EMBANKMENT CESS WIDENED

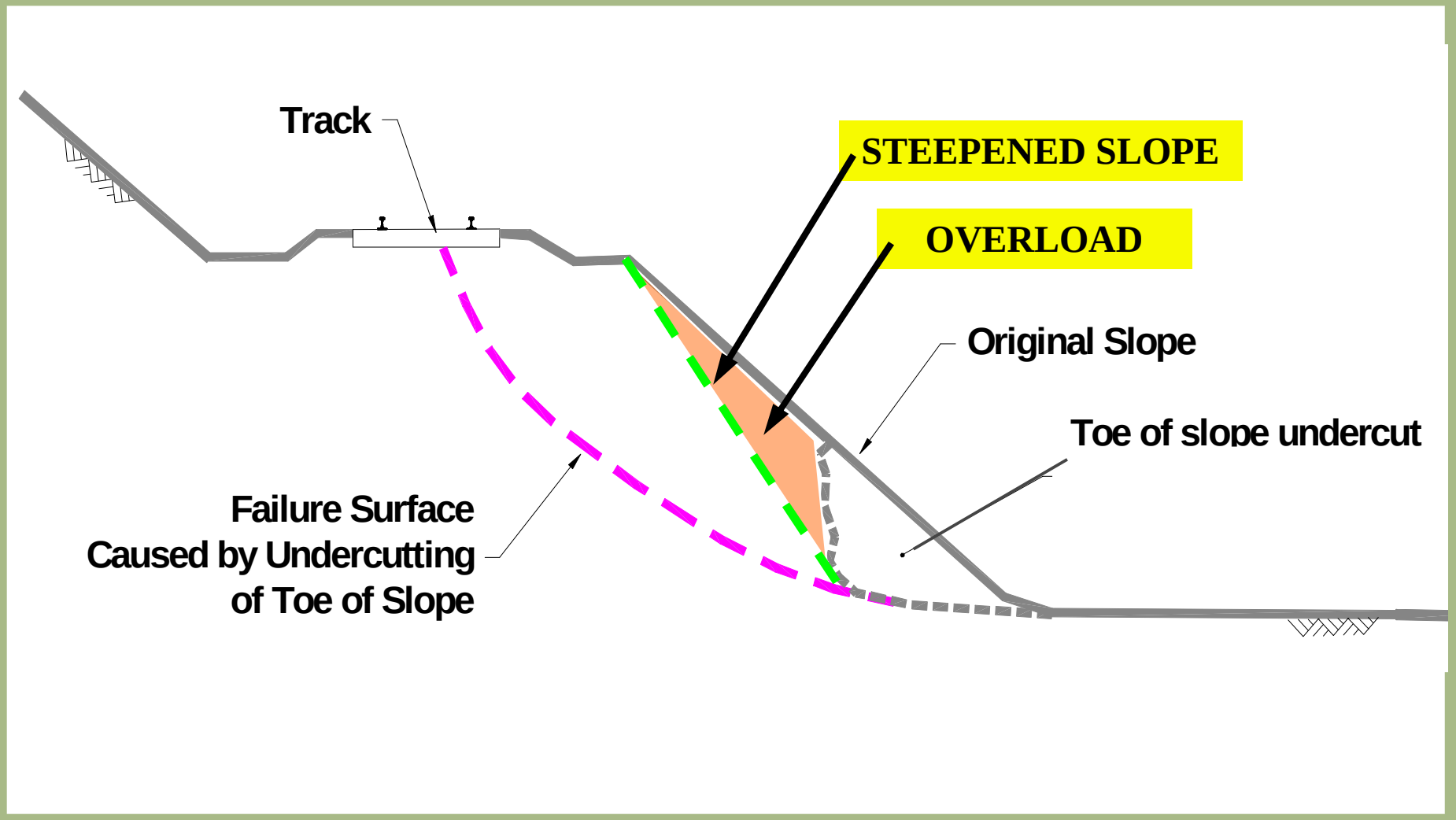

8. 4. 2000 12:07

Failure of Over Loaded and Over Steepened Embankment

SOIL AND ROCK PLACED ON SLOPE

POOR SURFACE DRAINAGE ALSO CONTRIBUTED TO THIS FAILURE

Undercutting Embankment Toe



Slope Failure Caused by Erosion at Toe

Slope Over Steepened by Erosion at Toe

Over Steepened and Over Loaded Slopes Dos and Do Nots

- DO protect slopes from being eroded or undercut
- DO NOT dispose of spoil material on slopes or near the top of slopes
- DO NOT perform “Bank Widening”
- DO NOT steepen the slopes of existing embankments

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Embankment Flattening and Buttressing

… flatter slopes are more stable than steep slopes ...

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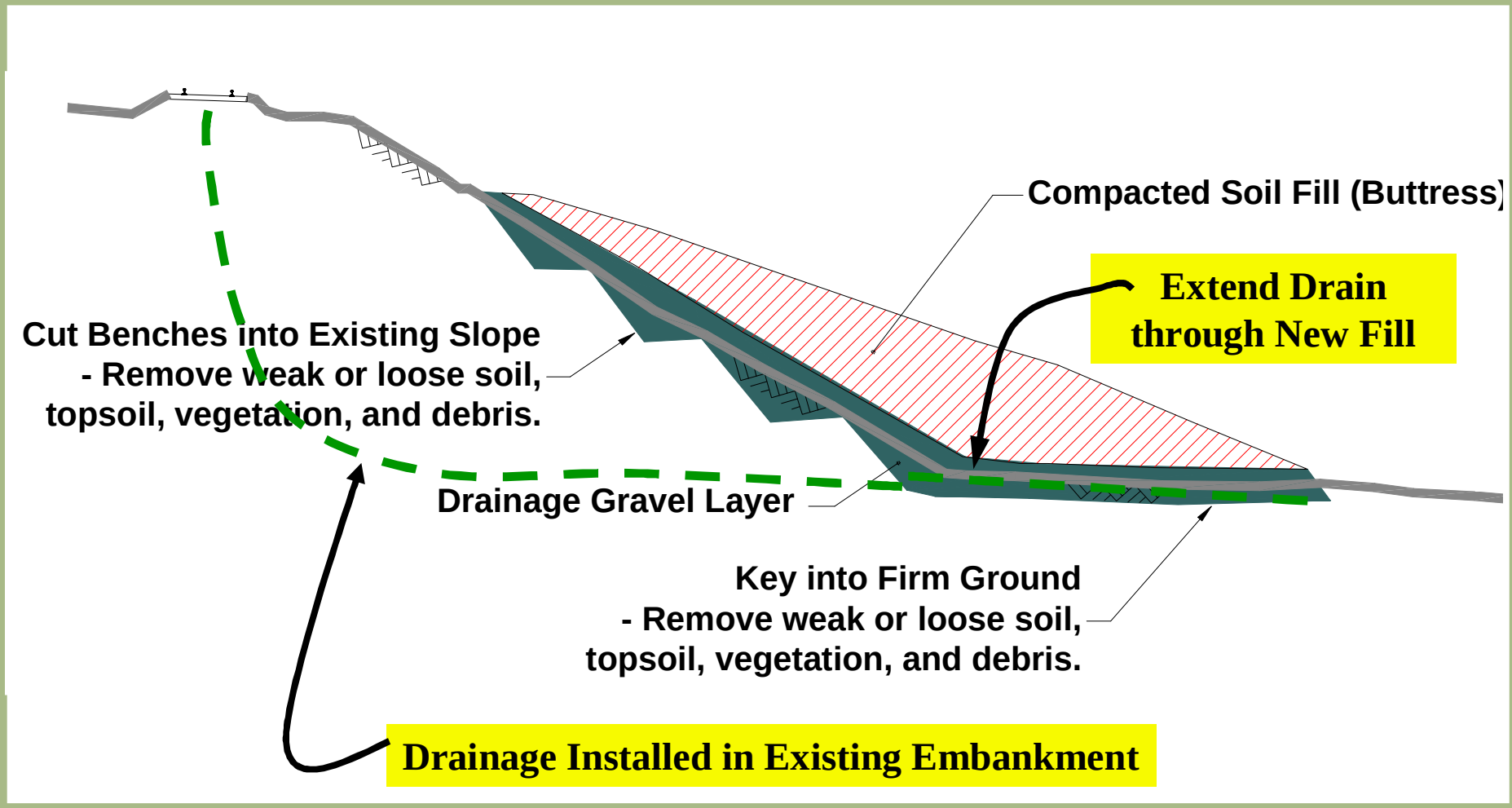
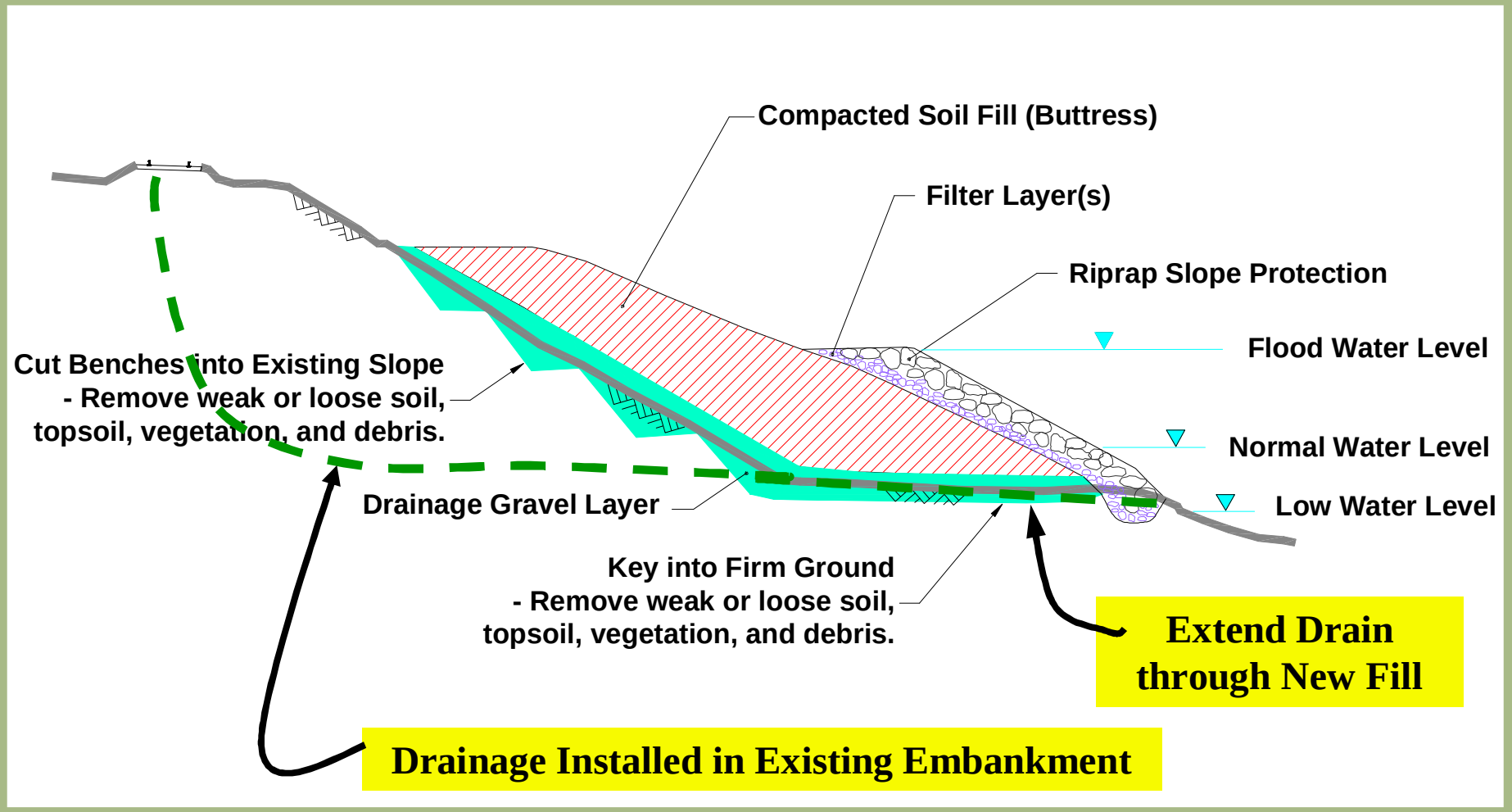
Embankment Stability Improved by Flattening the Slope

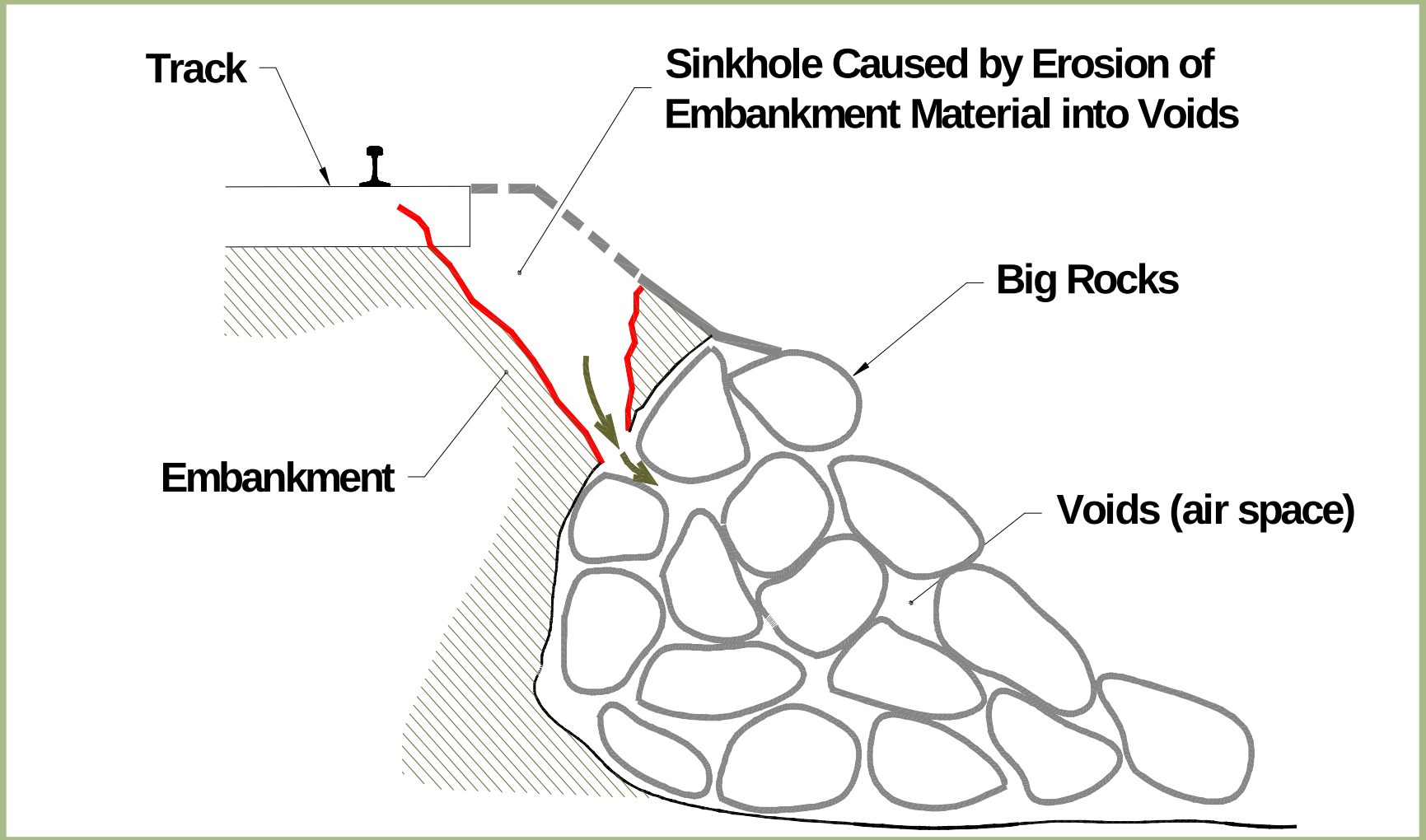


Embankment Stability Improved by Buttressing the Slope

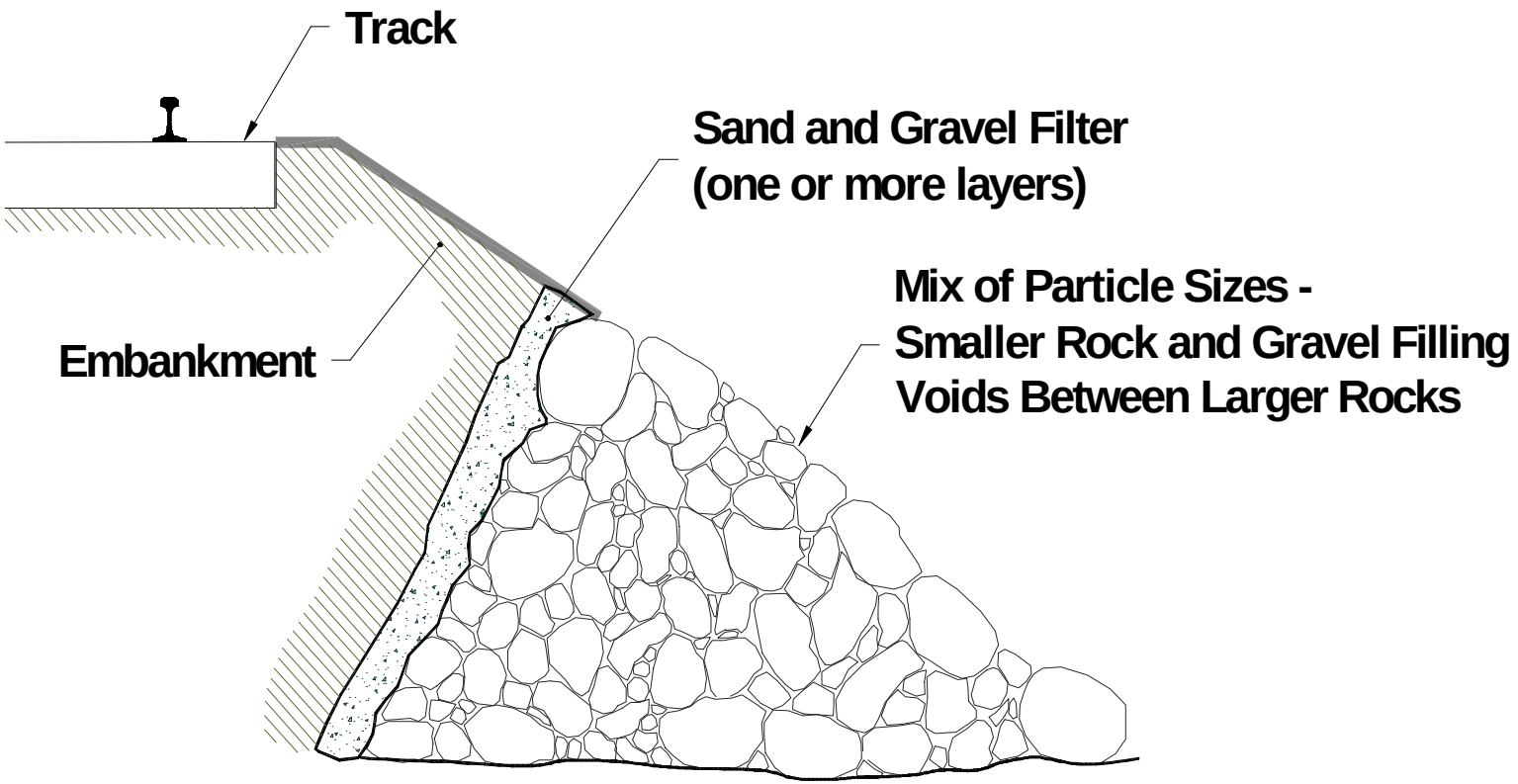


Flattened Slope

Slope Repair, Flattening or Buttressing with Large Rock is Not Recommended



Slope Repair, Flattening or Buttressing with Well-Graded Rock and Filter Layer (if necessary) is Preferred



Embankment Buttressing and Slope Flattening Dos and Do Nots

- DO construct slopes as flat as practical
- DO use compacted soil or well-graded rock and filter layers
- DO provide drainage
- DO NOT use big rock

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Presentation Outline

- Track Components
- Soft Track
- Ballast Pockets
- Drainage and Culverts
- Construction Practices
- Over Steepened Slopes
- **Riprap**
- Record Keeping

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Riprap Erosion Protection

… a routine erosion protection measure that is often constructed incorrectly …

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Washout at a location where riprap had been dumped

Rock that has been Dumped down a Slope is Subject to Failure

SMALL ROCK AT TOP OF SLOPE

LARGE ROCK AT BOTTOM OF SLOPE

However, During Emergency Situations Dumping Riprap may be the Practical and Timely Solution

SMALL ROCK AT TOP OF SLOPE

LARGE ROCK AT BOTTOM OF SLOPE

Prepare Slope for Riprap Placement

Start at the bottom of the slope

Key Riprap into Stream Bed

***** PERMITS REQUIRED *****

Place and Compact Riprap

Engineering assistance is recommended for sizing riprap and filter materials

Completed Riprap Slope Protection

Riprap Placed at Culvert Outlets

***** PERMITS MAY BE REQUIRED *****

Riprap Erosion Protection Dos and Do Nots

- DO use well-graded properly sized rocks
- DO use filter layers (if appropriate)
- DO key riprap along bottom and at ends
- DO get permits
- DO get engineering assistance
- DO NOT dump riprap unless absolutely necessary

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Presentation Outline

- Track Components
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- **Record Keeping**

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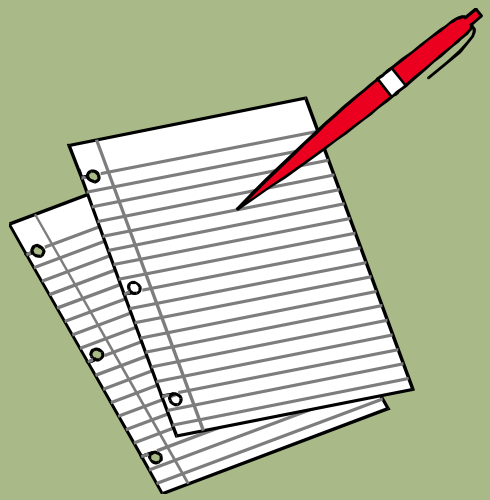
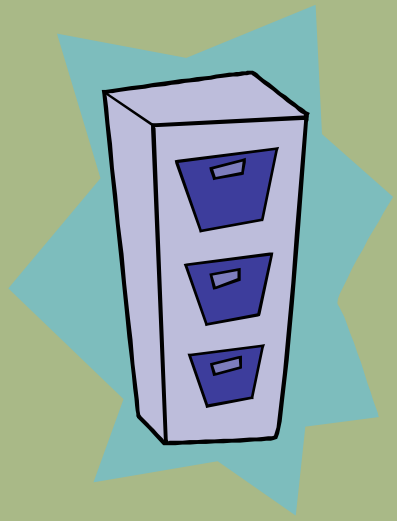
Record Keeping

… a critical part of cost effective resource management …





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What to Record

- Location
- Name of person making record entry
- Date and time
- Description of problem
- Length of track affected
- Description of site
- Measurements
- Recent weather
- Repairs undertaken

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Record Keeping
Dos and Do Nots

- DO keep a record for each location
- DO include description of problem and repairs
- DO be accurate
- DO document recent weather
- DO NOT rely on memory - write things down as soon as practical

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Dos and Do Nots Summary

<u>Water</u> is a factor in most soft track situations, and …

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DRAINAGE

DRAINAGE

DRAINAGE

DRAINAGE

SURFACE DRAINAGE

CULVERTS

GROUNDWATER

TRENCH DRAINS

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Dos and Do Nots Summary

- DO drain surface water away from track
- DO maintain culverts and install properly
- DO NOT let water pond
- DO provide subsurface drainage

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Dos and Do Nots Summary (cont.)

- DO NOT ignore ballast pockets
- DO NOT overload, oversteepen, or undercut slopes
- DO properly construct fills and riprap
- DO keep records

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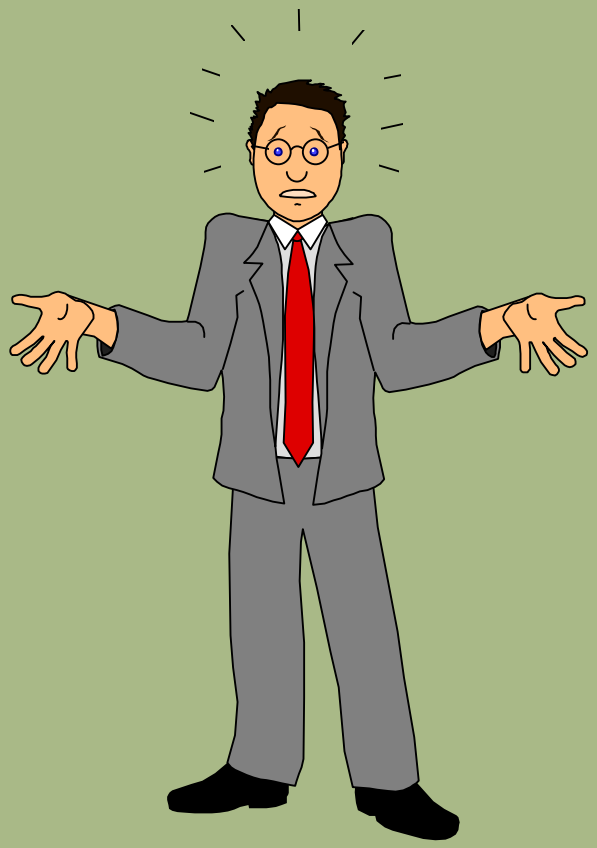
Get the Help of a Geotechnical Engineer When Appropriate



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