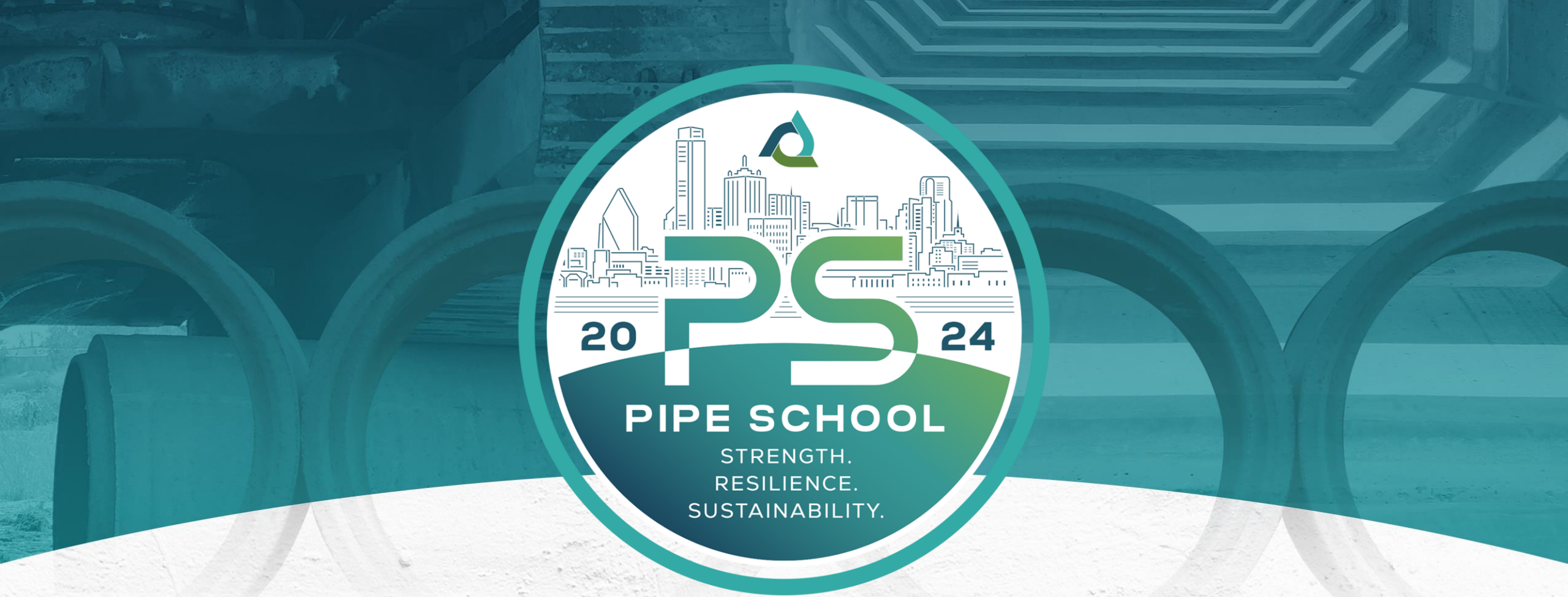

Trenchless Culvert Repair & Replacement Strategies

James Freed, PE

Rinker Materials

James Freed, P.E.

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ACPA

American Concrete Pipe Association

LEARNING OUTCOMES

- Explain the Different Causes of Deterioration
- Explain the Different Trenchless Rehabilitation Options
- Explain the Benefits of the Different Open Cut/Trenchless Solutions
- Describe the Different Pipe Rehabilitation Issues to Consider
- Identify where Pipe Rehabilitation/Repair/Replacement Strategies are located within a Transportation Asset Management Plan

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COURSE AGENDA

CAUSES OF DETERIORATION

CULVERT REPAIR/REHAB/REPLACE STRATEGIES

OPEN CUT

TRENCHLESS

TUNNEL/REPLACE

COURSE WRAP-UP & QUESTIONS

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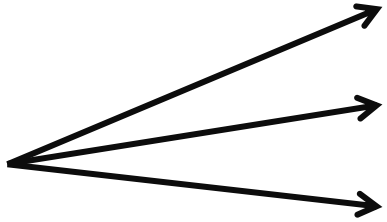
Transport Asset Management Plan (TAMP)

Rehabilitate/
Repair/
Replace



- Executive Summary
- Introduction
- Levels Of Service
- Maintenance Condition Assessment
- Life-cycle Management
- Growth And Demand
- Financial Summary
- Asset Management Practices
- Improvement Plan

Causes of Deterioration

CAUSES OF DETERIORATION

These Problems…

Lead to….

Complete Failures

Address the Problem…Before it is too late!!

CAUSES OF DETERIORATION

L
O
A
D

Live
(Design)

Dead (Soil)

Construction

CAUSES OF DETERIORATION

Increased Runoff from Development

Bed-load and Debris

Undermining and Washout

Improper Culvert for Cover/Backfill

+ Various Environmental Factors

CAUSES OF DETERIORATION

Loss of Soil Envelope

Joint Separation

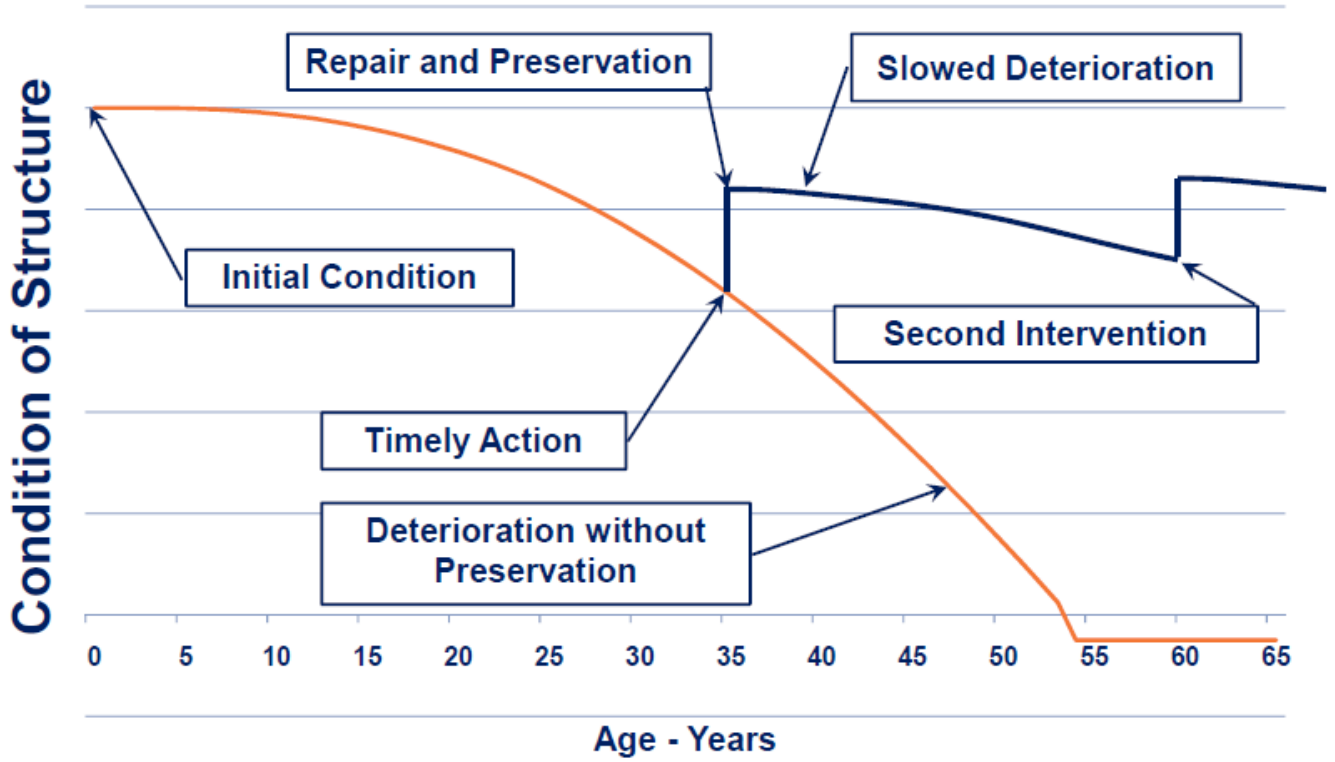
CAUSES OF DETERIORATION

Wrong Application

Fire

Bed Load/Abrasion

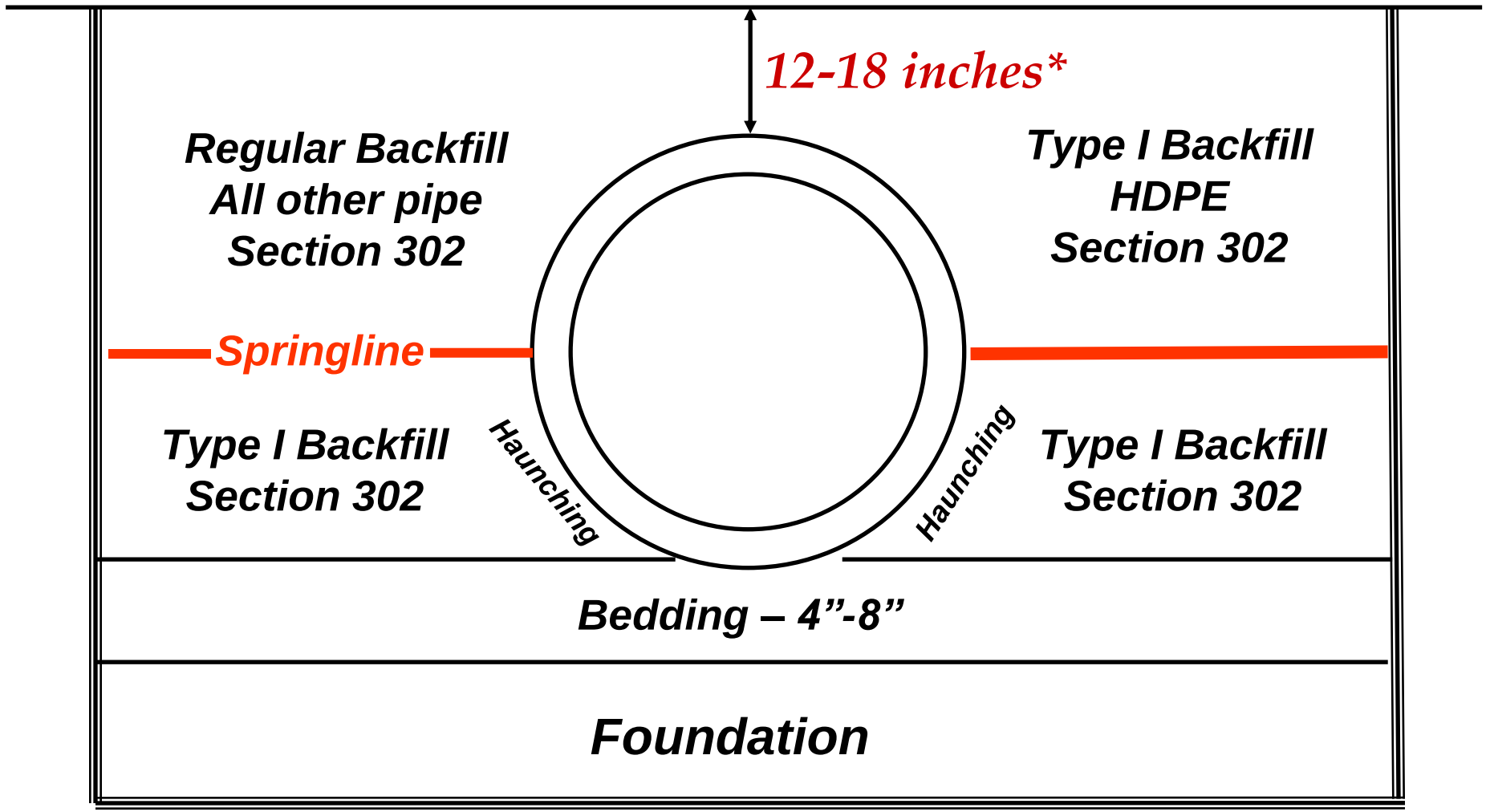
WORKING TOWARD INDEFINITE LIFE



<u>Indefinite LIfe</u>
Manage number of interventions


REPLACE
• NEW INFRASTRUCTURE
REHABILITATE
• EXISTING RETURNED TO GOOD CONDITION
REPAIR
• EXISTING MAINTAINED TO A SAFE CONDITION

Final Backfill



ISSUES TO CONSIDER

What is the condition of the pipe

Is the pipe located in a hostile environment

What is the height of cover over the existing pipe

What impact will liner create on hydraulic capacity

Will liner increase outlet velocity

Load distribution changes

Replace:
Increased Hydraulic Capacity
New Structural Integrity

Rehab:
Reduced Hydraulic Capacity

- Open Cut/Dig & Replace
- Trenchless
  - Tunnel - *Replace*
    - Jacking Pipe
    - Tunnel liner plate
    - Pipe Bursting
  - Lining - *Rehab*
    - Cured in place
    - Shotcrete
    - Plastic products
  - Sliplining - *Rehab*
    - Plastic liner
    - Tunnel liner plate

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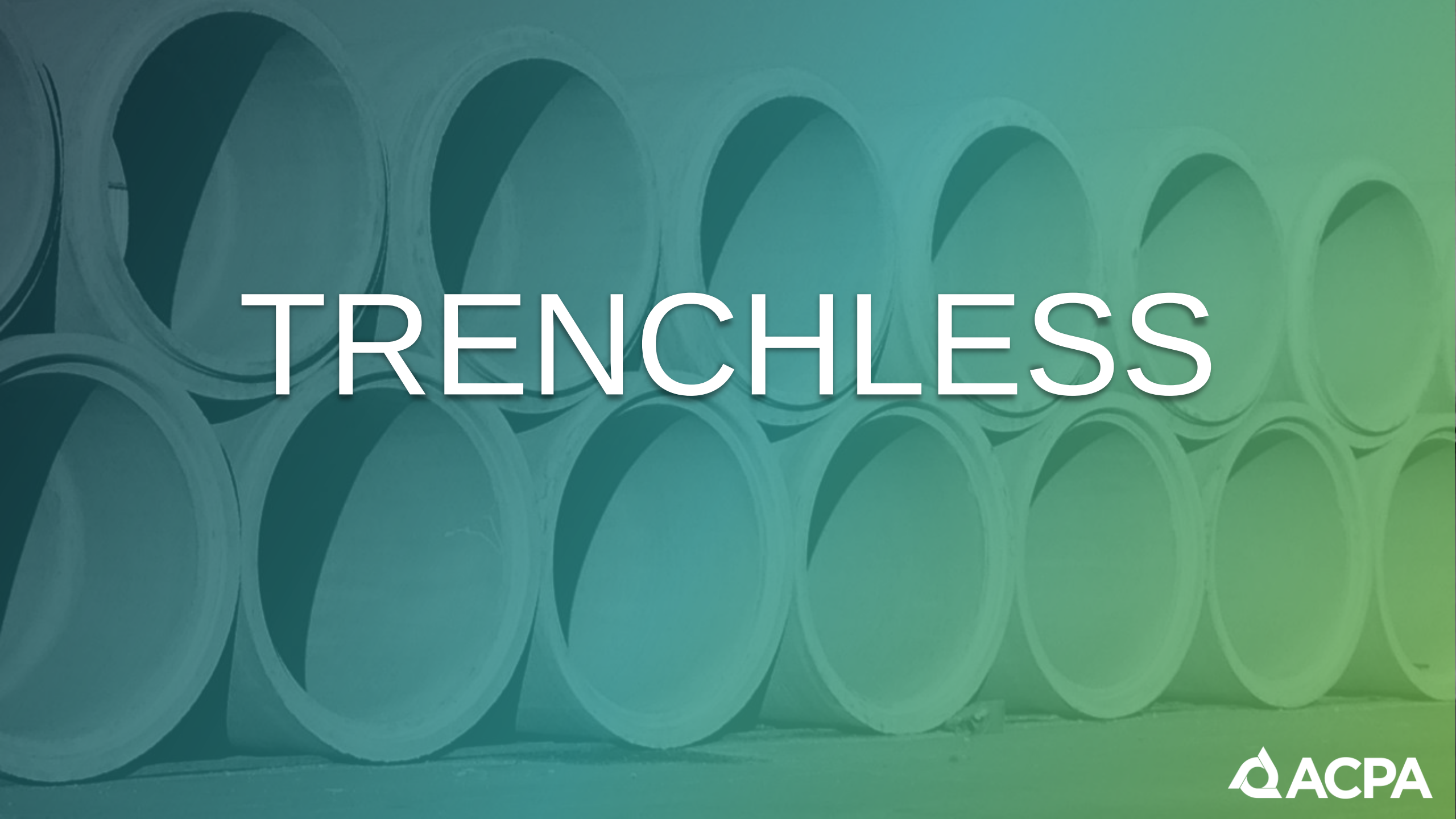

TRENCHLESS
ACPA

WHAT IS TRENCHLESS TECHNOLOGY?

No-Dig approach to condition assessment, rehabilitation and new installations.

- ***Trenchless Technology*** *is defined as a type of subsurface construction work that requires few trenches or no continuous trenches. It is a rapidly growing sector of the construction and civil engineering industry. (Wikipedia)*

Trenchless Installation

Advantages

Minimal surface disruption

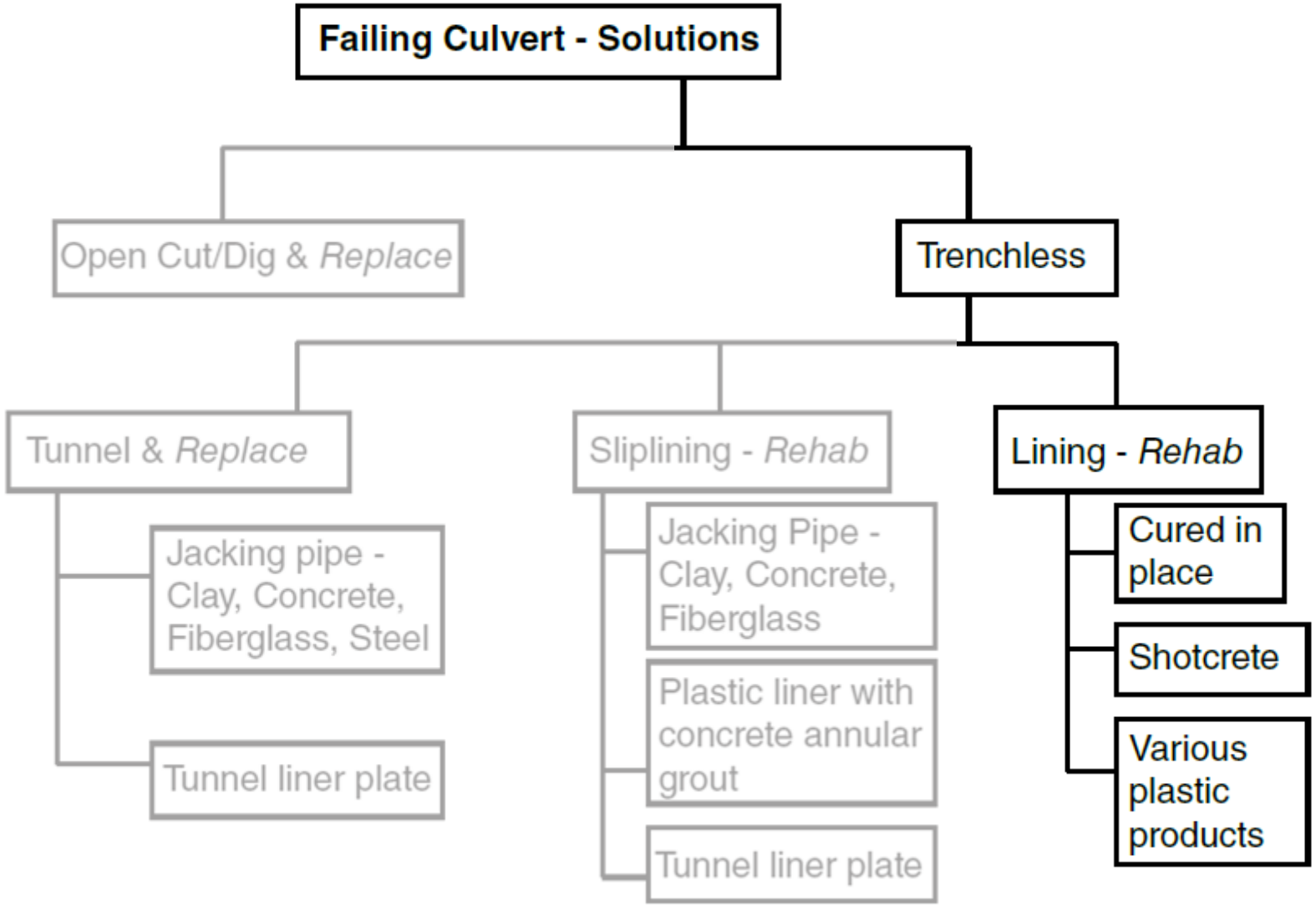
Less risk of settlement

Lower volume of excavated material

Reduces or eliminates dewatering

Special crossings with no other access

- Highways
- Railroads
- Runways
- Rivers & Streams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Cured in place
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Various plastic products

LINING - *REHAB*

- Lining - *Rehab*
  - Cured in place
  - Shotcrete
  - Various plastic products

CIPP LINING

CIPP (Cured In Place Pipe lining)

Needle Felt or Glass Reinforced UV-Cured

Thermal or UV-light curing methods

UV = ideal for wet pipe conditions, culverts

Diameter range of 6” to 120”+

Very versatile lining technology

CIPP LINING

Round pipe, elliptical, egg-shaped, box culverts possible

- ASTM F1216 design criteria
  - Fully Deteriorated Condition
  - Partially Deteriorated Condition
- Stand-alone, lining system
- Does not rely on bond to pipe
- Styrene issues being evaluated
- End seals recommended
- Factory or in-field wet-out

CIPP RESIN IMPREGNATION

CIPP resin impregnation with:

- Polyester resin (suitable for civil wastewater)
- Vinylester resin (suitable for aggressive wastewater)
- Epoxy formulations (styrene-free, ultra-thin liners)

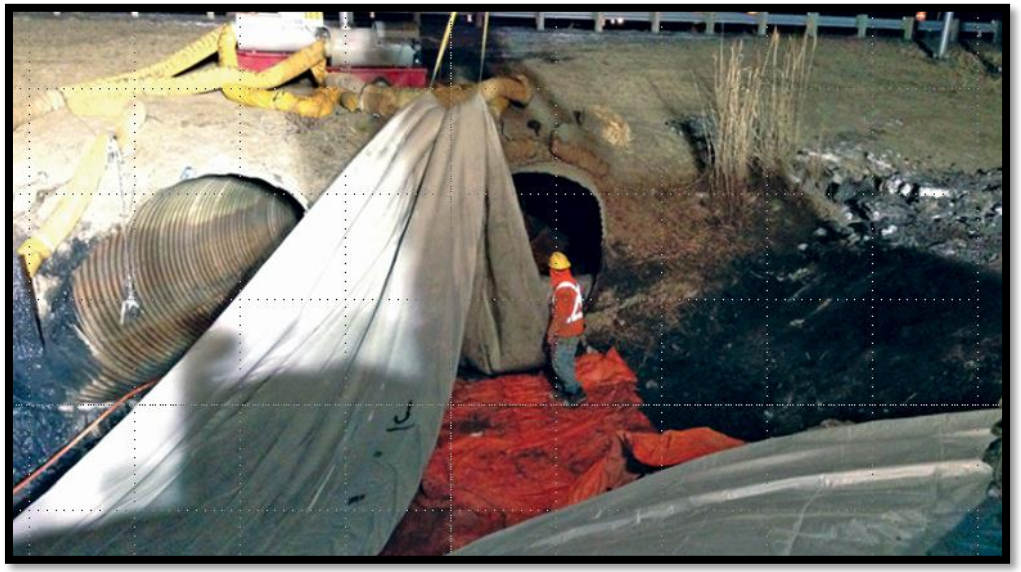
Factory Impregnation System – UV CIPP

UV-CURED CIPP

- Outer protective bladder stops resin dilution & styrene release
- Computer controlled curing process ensures verifiable, fast, complete cure throughout including in areas with heat sinks
- Thinner liner, higher strength materials, minimal shrinkage
- Pre-inspection capabilities, high degree of quality control
- Smaller footprint & easier access for difficult access locations

CIPP LINING

- Lining - *Rehab*
  - Cured in place
  - Shotcrete
  - Various plastic products

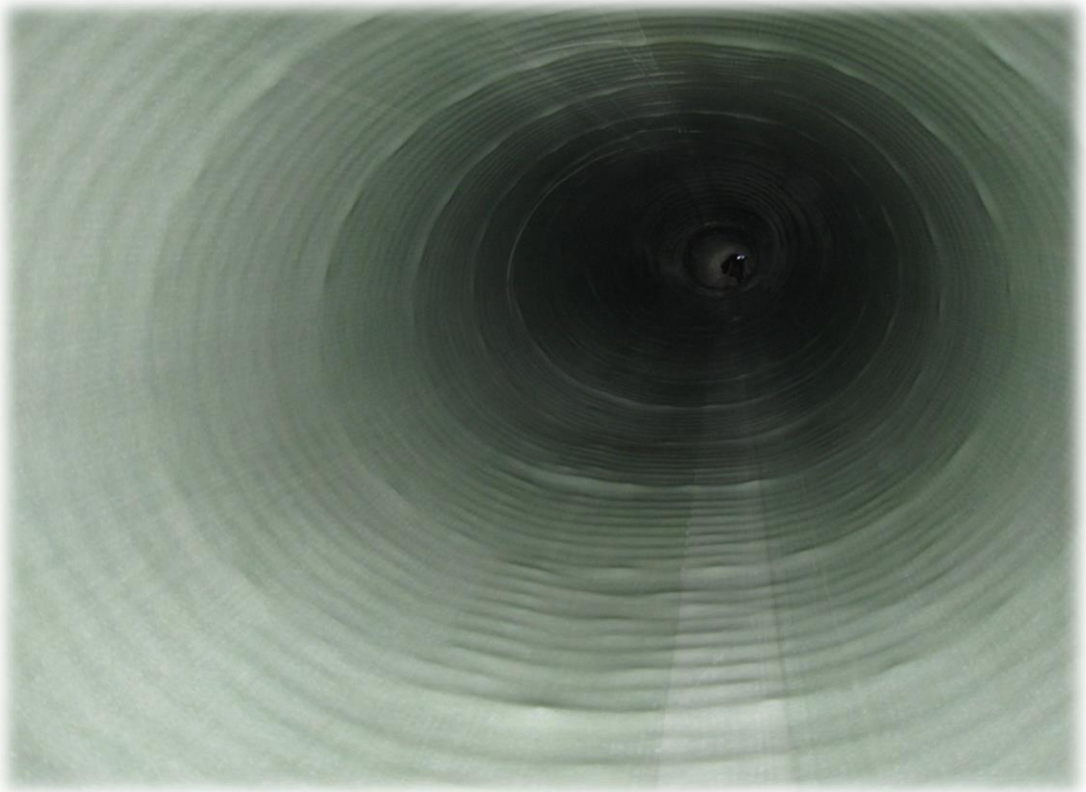


Air or water expands sock
Matches shape of host pipe

Resin-soaked Felt sock
Polyurethane Coating (outside)
Styrene resin in inner tube (wetout)
Fed inside out – resin against host

96 inch tube – 1.67 inches thick – 275 lbs. per linear foot.

42” CMP CULVERT – CIPP LINING



42” Elliptical CMP

SPRAY APPLIED CEMENTICIOUS LINING

- Spin-cast cementitious & geopolymer high-build systems
- Can line pipelines 30” to 120” in diameter
- Corrosion protection, structural integrity, improved hydraulics
- Surface preparation, design criteria not well defined
- Applied in multiple passes, invert must be re-established
- High build applications – thickness of ½” to 2” are common

OTHER OPTIONS

Spray-Applied Polymeric Lining

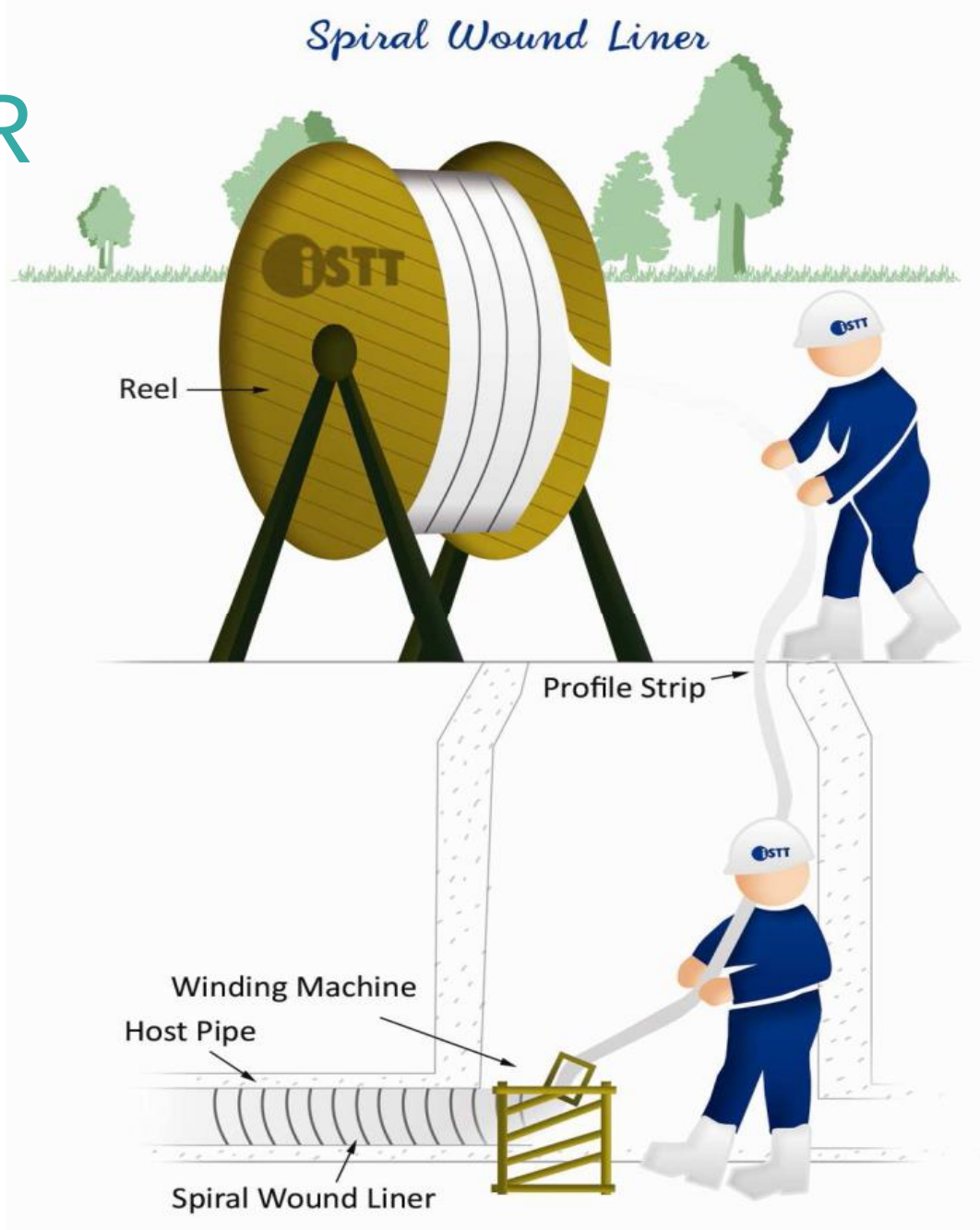
- Epoxy, urethane, poly-urea products available
- Fast application and can be variable thickness
- Intimately bonded to substrate pipe
- Corrosion protection, semi-structural
- Design criteria not well defined
- Surface preparation is CRITICAL!

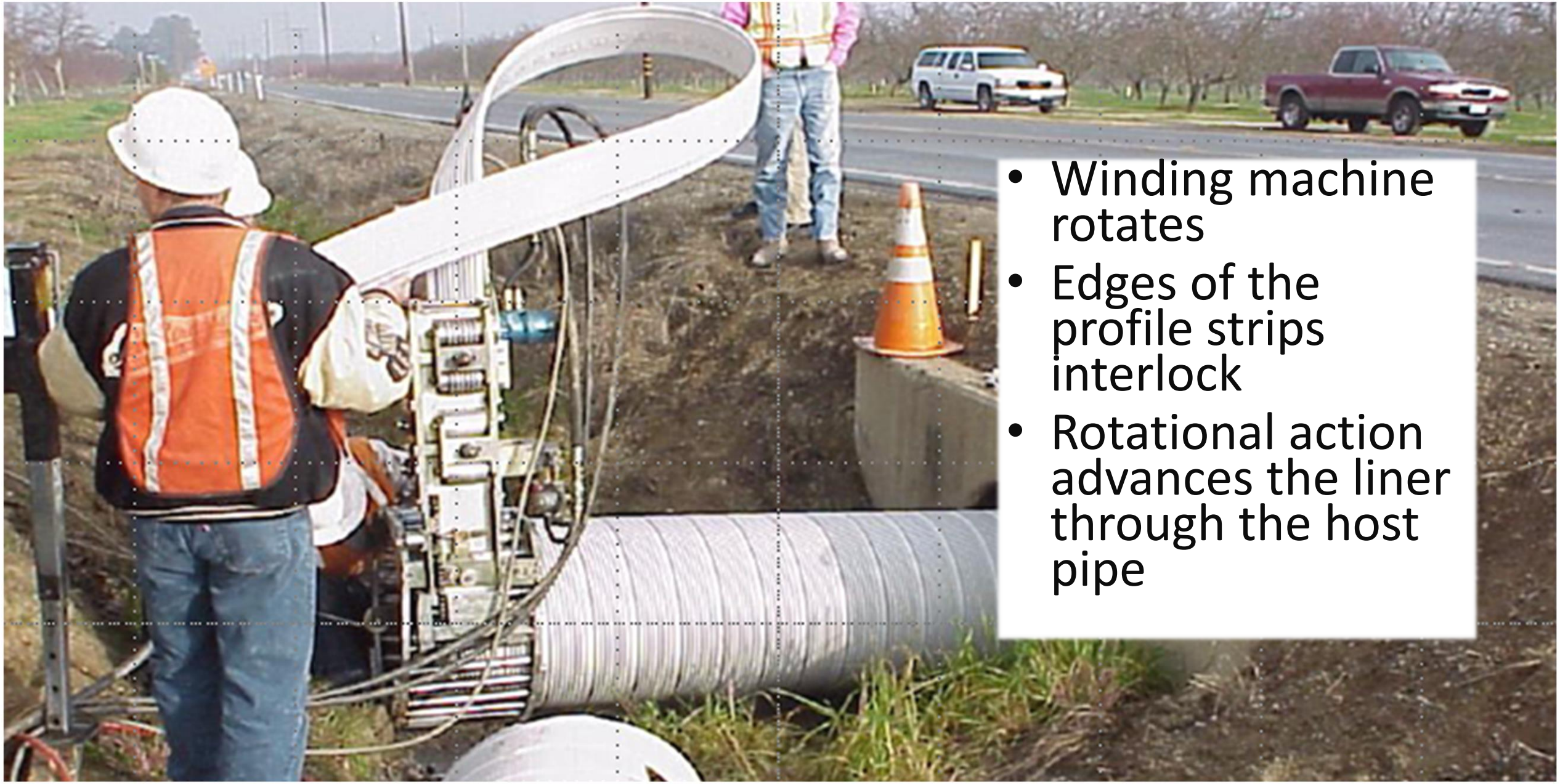
Spiral-Wound Lining

- Used for larger pipe diameters
- Can be used in odd shaped pipes
- Grouting of annular space required

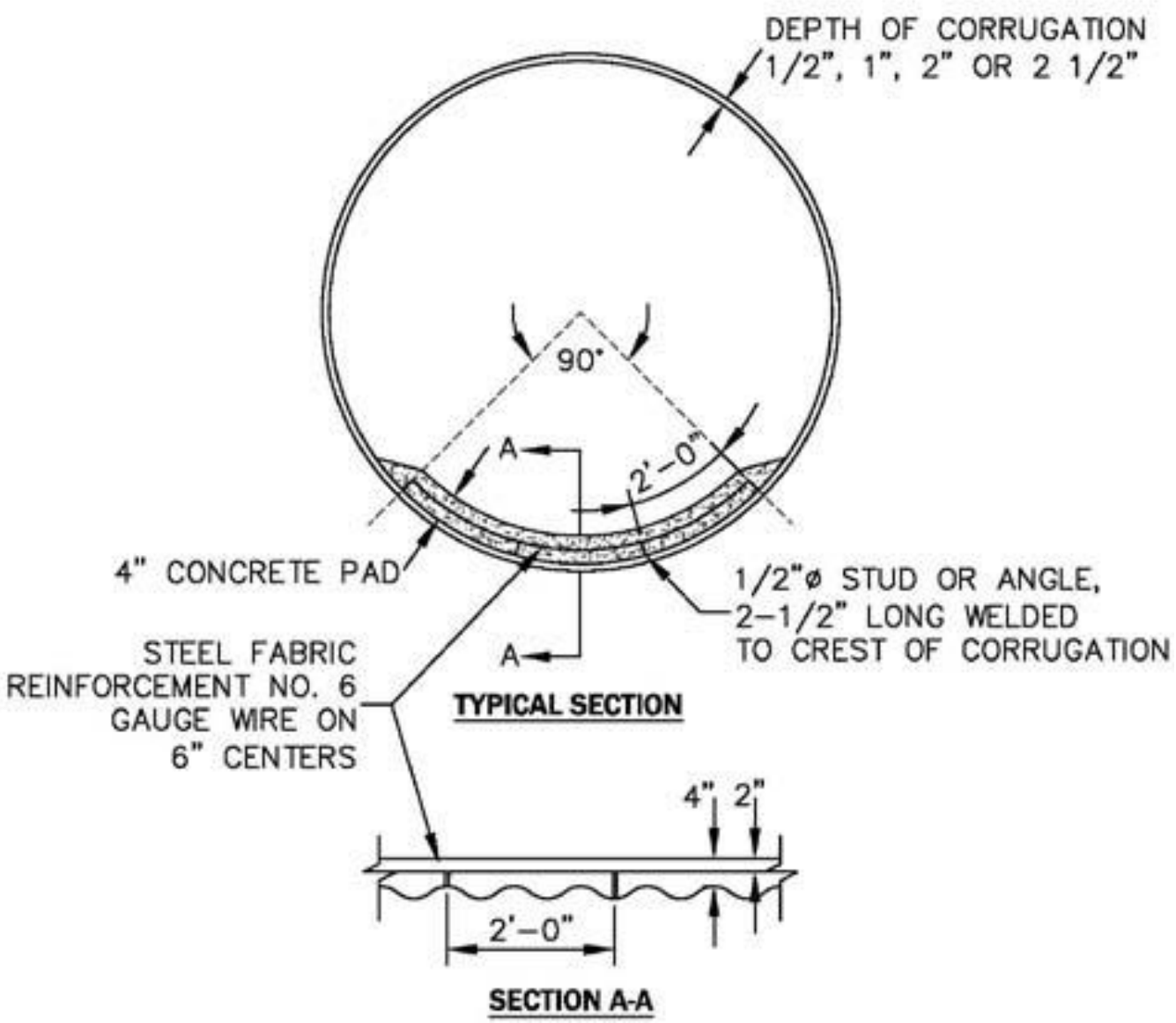
SPIRAL WOUND LINER

- Profile Strips of PVC/Steel Reinf. PVC or HDPE
- Contact with host pipe form close fit
- Installed with fixed dimension/annual space




• Winding machine rotates
• Edges of the profile strips interlock
• Rotational action advances the liner through the host pipe

SHOTCRETE – INVERT PAVING



Wet Process
Rebar welded to existing structure
Invert corroded/pipe structurally deficient
Used for pipes 72” and up

LINING *(REHAB)*

Advantages

Reduce Road User Impacts

Minimize Impact to Existing Roadway

Extends Life of Host Pipe

Limited, to no Excavation

Effectively reduce infiltration/leaks

Disadvantages

Loss of hydraulic capacity

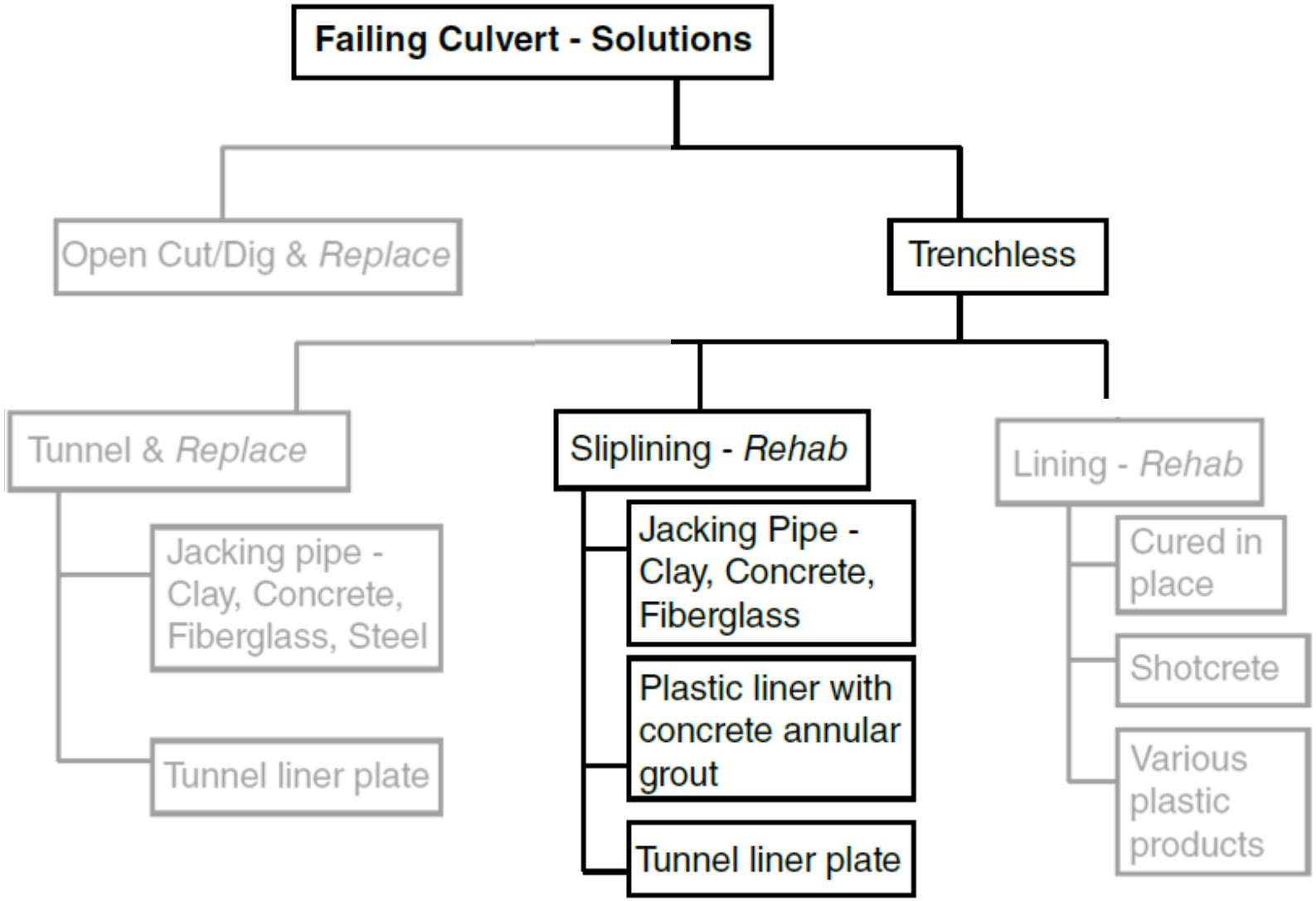
Long term Durability

Curing Concern

Costs

Host Pipe Integrity

Spiral Wound Liner
Water-Tight Seal Joint
Minimizes Impact to Hydraulic Cap.
Extends Life of Host Pipe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Trenchless
Tunnel & *Replace*
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Lining - *Rehab*
Cured in place
Shotcrete
Various plastic products

SLIPLINING

"Good back grouting practice ensures a proper job and helps develop the full supporting strength of the liner ring for final loads."

Oldest method for Rehab

Repair Leaks

Restore Structural Stability

<u>Typical Carrier Pipe</u>

HDPE

Fiberglass RP (FRP)

PVC

SLIPLINING

- Variety of materials available
  - FRP – Fiberglass Reinforced Plastic pipe
  - GRP – Glass-fiber Reinforced Plastic pipe
  - HDPE – High Density Polyethylene pipe
- Segmental & fused options
- Provides new structural pipe
- Diameter reduction
- Good for long, straight runs
- Annular space, grouting
- Live flows are possible

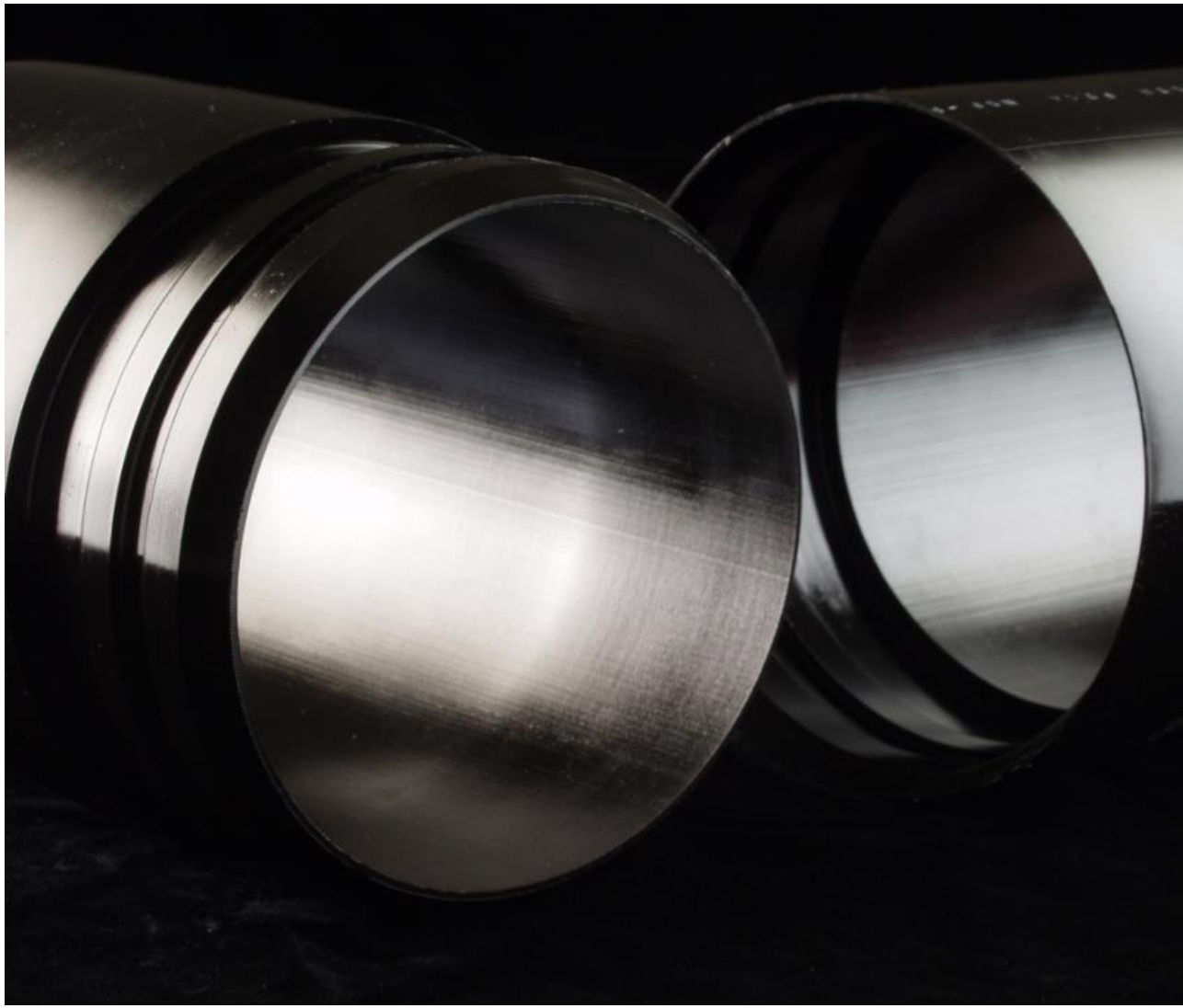
SLIPLINING – LARGE DIAMETER FRP/GRP

FRP/GRP - SLIPLINING

- FRP & GRP pipe is strong, resistant to abrasion & corrosion
- Slip line pipe has a diameter range from 6” to 142”
- FRP/GRP Pipe is pushed through existing culvert for Sliplining
- Rubberized-material gasket joints
- “N” factor of FRP/GRP Pipe is 0.008 to 0.010 (CMP at 0.024)

HDPE Sliplining Product Data

- HDPE pipe has a range from 6” – 63”
- Profile Wall HDPE Pipe ranges from 66” – 132”
- Fused or snap fit options
- HDPE Pipe can be pushed or pulled through existing culvert
- “N” factor of HDPE Pipe is 0.010 to 0.012 (CMP at 0.024)



SLIPLINING

Sliplining Methods Continuous and Segmental

<u>Technique</u>

Long continuous Pipe

Fusible PVC

<u>Annual Space Grouted</u>

Transfers external loads

Mobilize support of existing pipe

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SLIPLINING VIDEO

POINT REPAIR APPLICATIONS

Culverts

Storm Sewers

Sanitary Sewers

Service Laterals

Drain Lines

POINT REPAIR

Sectional Repair
Offset Joint
Pipe Size Transition
Broken Pipe
Seal Active
Infiltration
Drain Extension

POINT REPAIR APPLICATIONS

Pipe Diam. – 3” to 60”
Vertical or Horizontal
Bends up to 90 degrees
Joint Deflections
All Pipe Material

POINT REPAIR

SLIPLINING *(REHAB)*

Advantages

Cost Effective

Reduce Road User Impacts

Minimize Impact to Existing Roadway

Extends Life of Host Pipe

Limited, to no Excavation

Effectively reduce infiltration/leaks

Disadvantages

Loss of hydraulic capacity

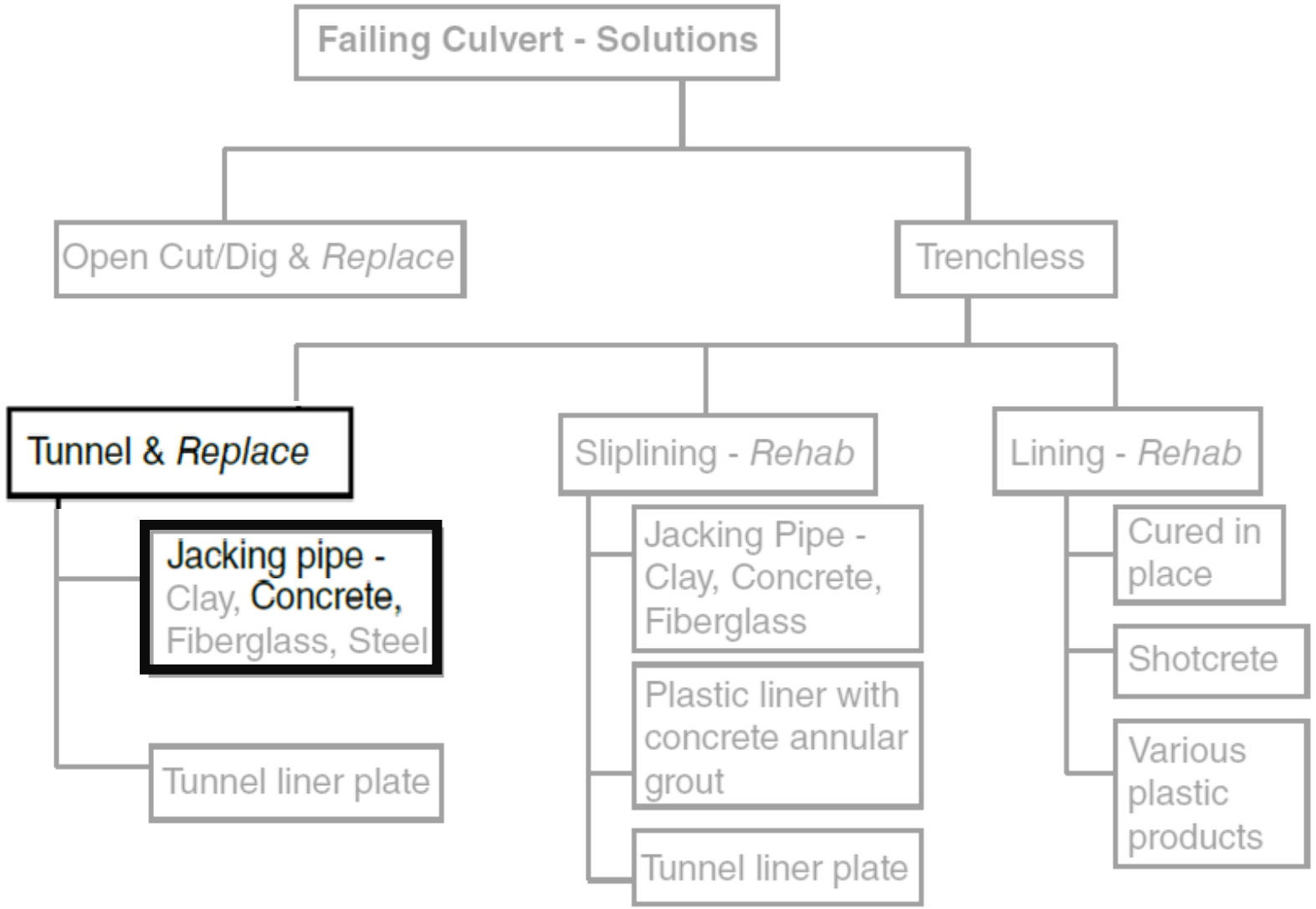
Long term Durability

Costs (Repeat)

Host Pipe Integrity

Sliplining
Grouting Annular Space Transfers Load
A Cost Effective Rehab Method
Requires Tools/Eqpt. Widely Available

TUNNEL AND REPLACE
&
JACKING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Various plastic products

Pipe Ramming

Pipe Ramming to install a parallel pipe (upstream and downstream)

Advantages

Able to Swallow anything smaller than diameter of casing

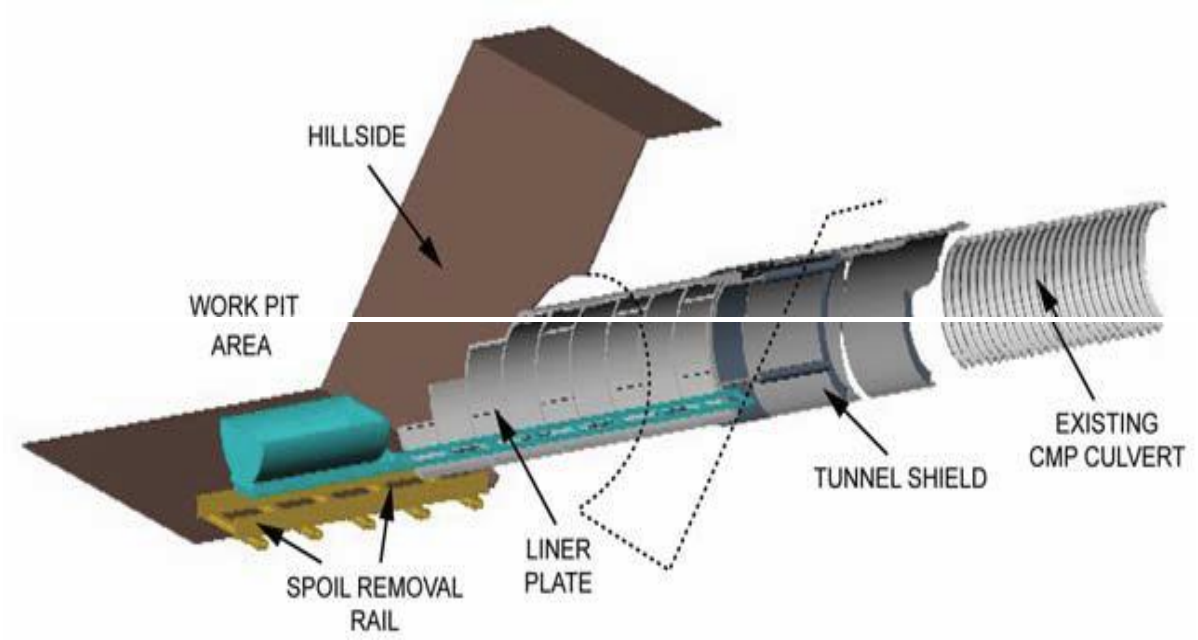
Minimizes and/or Eliminates voids in sub-grade

Reduced Soil Compaction

Can be used in a wide variety of ground conditions

Pipe Ramming – Ease of Cleanout

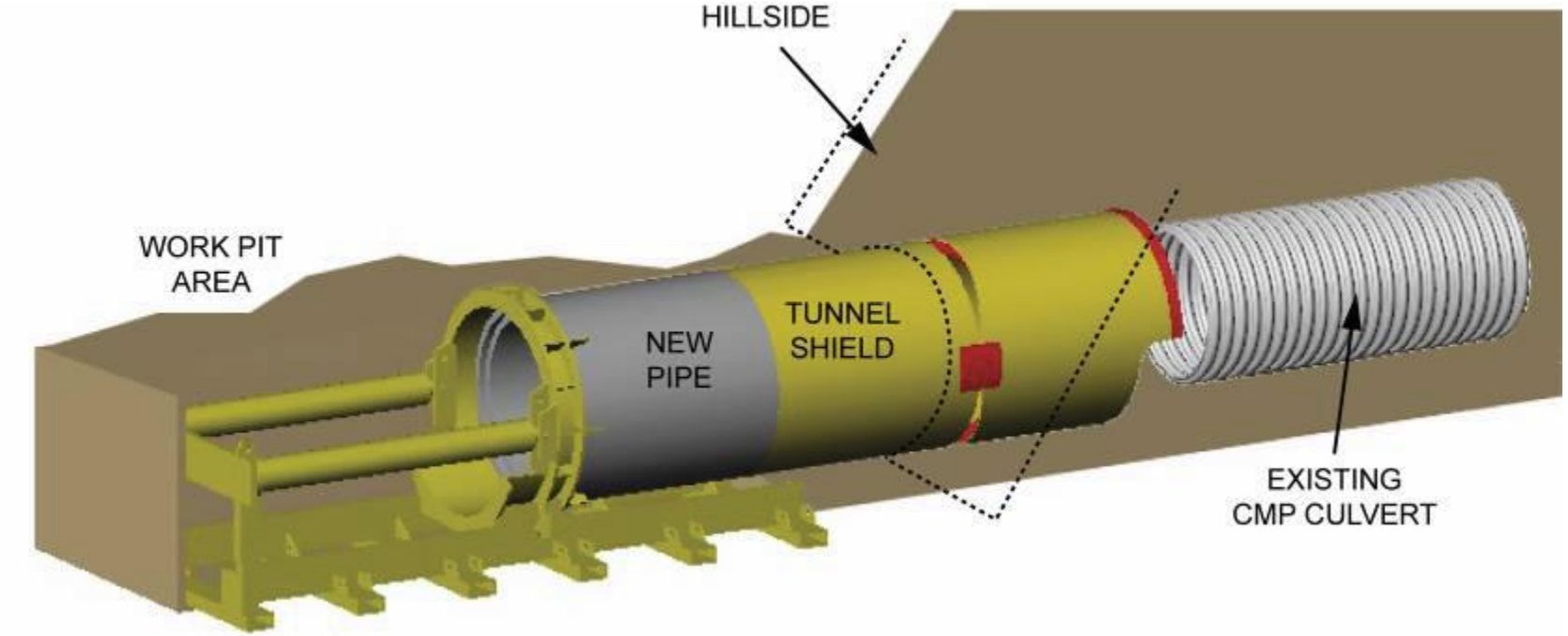
Tunneling



Consuming an existing culvert during tunneling with Liner plate

Assembled Liner Plate Ring

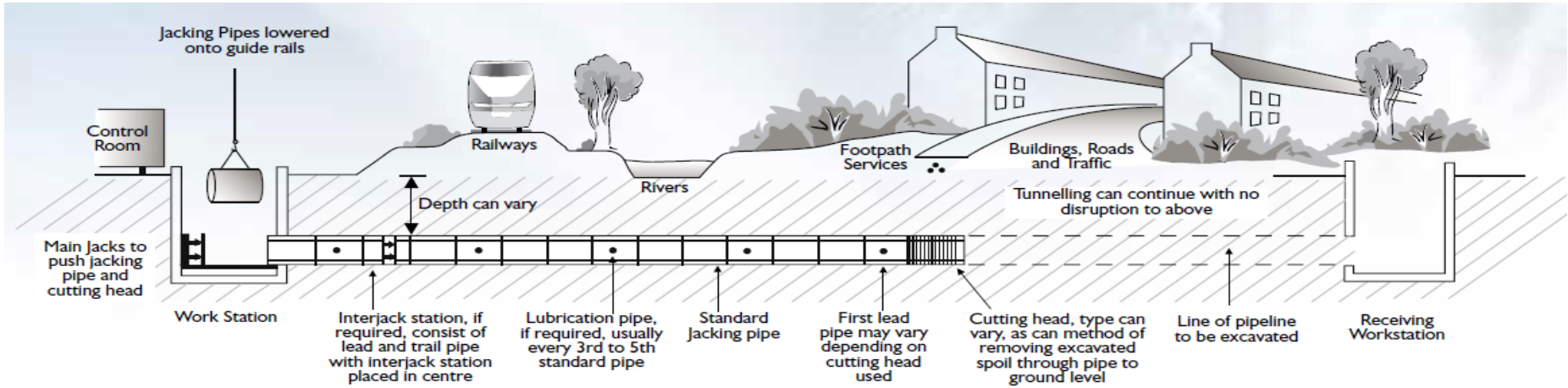
Jacking



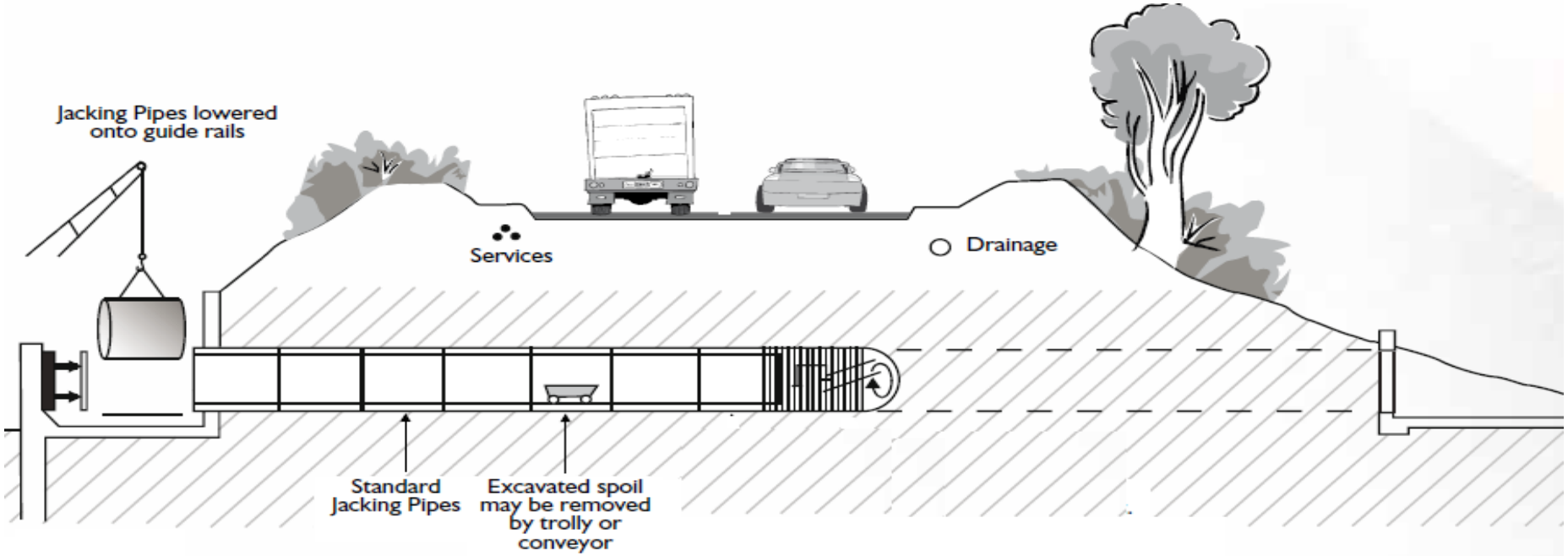
A shield and pipe jacking are used to consume an existing culvert with concrete pipe

Jacking Pipe

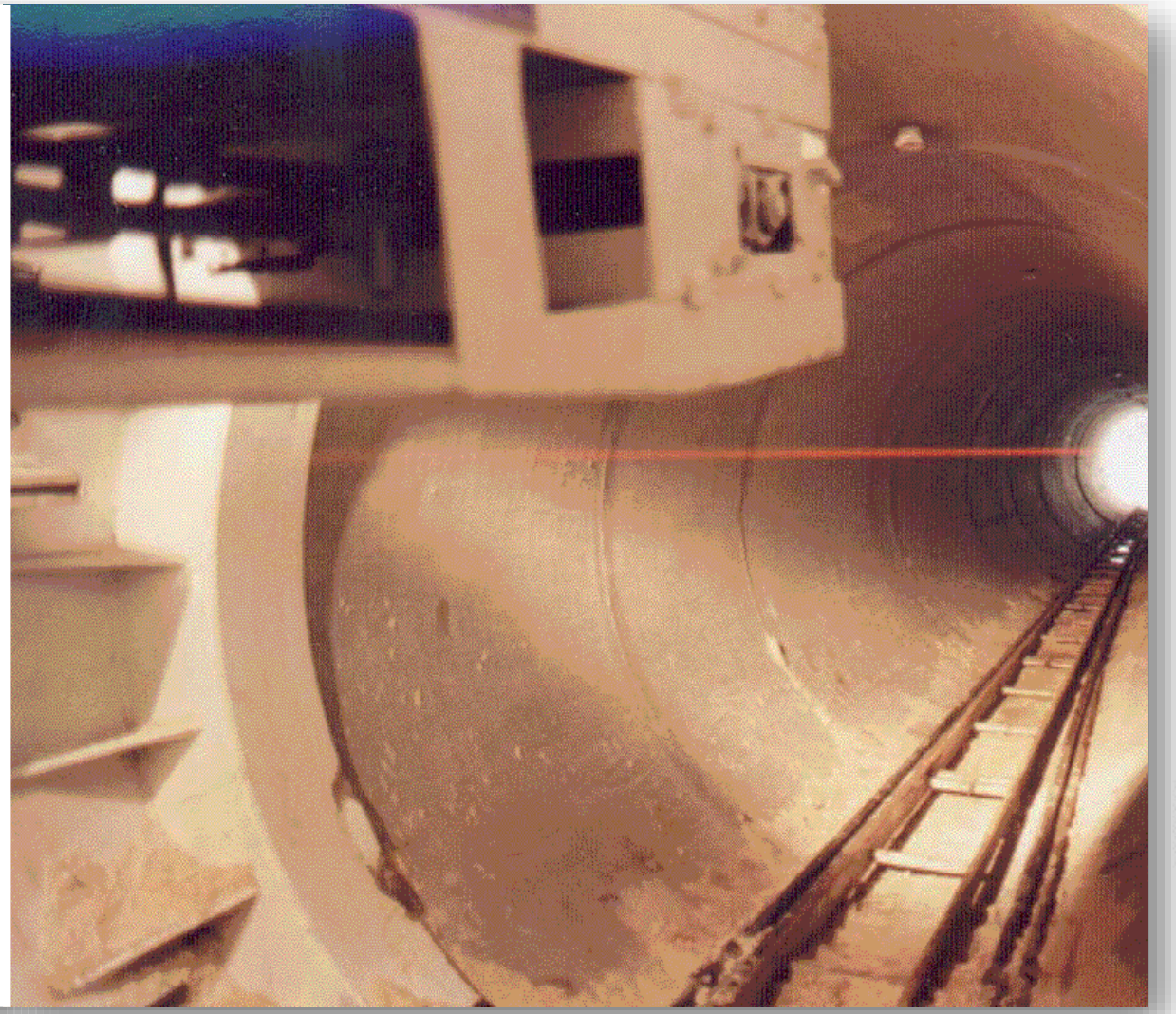
Closed System

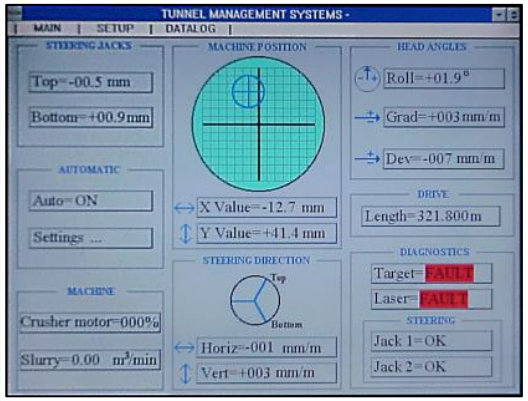


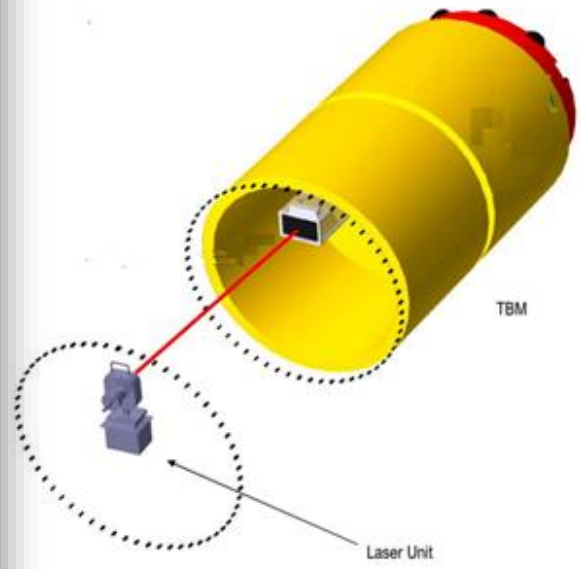
Open System



Jacking




TUNNEL MANAGEMENT SYSTEMS -
MAIN
SETUP
DATALOG
STEERING JACKS
Top=-00.5 mm
Bottom=+00.9mm
AUTOMATIC
Auto=ON
Settings ...
MACHINE
Crusher motor=000%
Slurry=0.00 m³/min
MACHINE POSITION
X Value=-12.7 mm
Y Value=+41.4 mm
STEERING DIRECTION
Top
Bottom
Horiz=-001 mm/m
Vert=+003 mm/m
HEAD ANGLES
Roll=+01.9°
Grad=+003mm/m
Dev=-007 mm/m
DRIVE
Length=321.800m
DIAGNOSTICS
Target=FAULT
Laser=FAULT
STEERING
Jack 1=OK
Jack 2=OK


TBM
Laser Unit

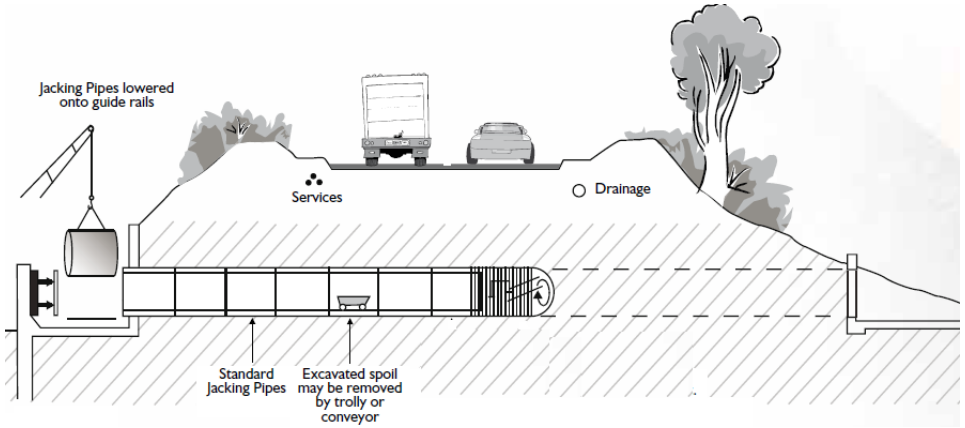
Jacking/Ramming/Tunneling

Replace

Reduce

Reduce Road User Impacts

Reduce Costs



Improve

Improve Long Term Durability/Quality

Improve Work Zone Safety

Improve Hydraulic Capacity

JRT

Addresses Eroded Bedding/Backfill

Maintains Hydraulic Capacity

Eliminates Sags in Culverts

Minimize

Minimize Environmental Impact

Minimize Impact to Existing Roadway Alignment

Disadvantages

Costs

Special Skill / Equipment

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