Culverts
Why they fail?
Various solutions to restore.

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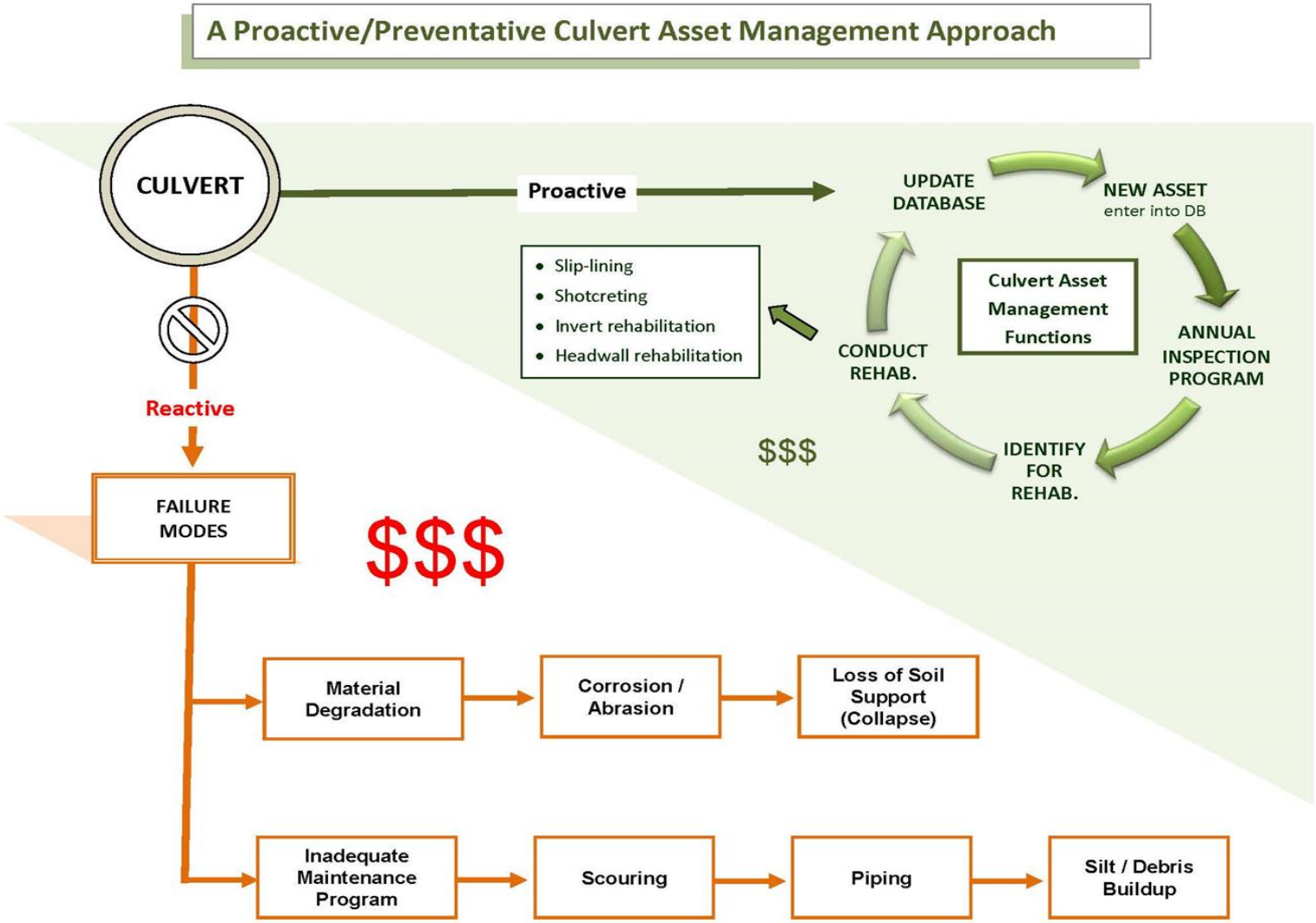
Reusing Assets Resulting in Responsible Engineering

- **Firstly, what is a pipe?**
  1. A vessel to contain a liquid.
  2. A conduit to transport a liquid.
  3. A structure to maintain a tunnel.

Benefits of Proactive plans:

- Planned Budgeting
- Efficient repairs
- Reduced Carbon Footprint
- Reduced flooding



Reactive Repairs

- **Flaws with pictures**

- Notice NO RAIN
- No festive lights.
- **Problems with reactive repairs.**
- Lack of material choices.
- Rushed Engineering
- 24/7 traffic control

- Culvert Management
  - Inventory
  - Inspection
    - The Culvert
    - The Channel
    - The Approach
  - Assessment & Rehabilitation

Different types of pipe used in culvert construction.

1. **Corrugated pipe (CSP) - 60% and use falling slowly**
   A. Entrance controlled culvert
   B. Exit controlled culvert
2. **Wood stave - 10% and use falling quickly.**
3. **Concrete culvert - 15% and use stable.**
4. **Plastics - 15% and use rising quickly.**

Corrugated Steel Pipe and why we use it?

1. It is inexpensive.
2. CSP is strong and does not fail suddenly.
3. The elastic modulus of CSP is closer to an asphalt road structure than any other pipe material.
4. Very suitable in larger diameters >1.5m.
5. The structural design depends on the surrounding backfill.

Main Type of Failure on CSP

- Entrance controlled culvert
- We tend to see an invert failure in these culverts with abrasion caused invert corrosion from 5.30 to 6.30 positions.
- These culverts can be repaired with just a treatment of the invert.
- If repair is delayed, then we see minor pipe failures, which then results in major bedding failure and leading to total failure structural eventually.

Inlet controlled

Notice the invert of the corrugations gone first. This pipe breakdown is caused by abrasion between 5.30 and 7.30.

These culverts are easier to inspect , no standing water .

Second Type of Failure on CSP

- Exit controlled culvert
- As these culverts generally have a build up of mud and silt in the invert, we tend to see the failures of these culverts at the haunches.
- These culverts need a more radical rehabilitation extending further up the sides of the pipe.

Very local failure but a complete collapse - Hwy 99
100mm above or below the failure the material is original 6mm steel . Structure still in place JUST harder to inspect .


Shear failure only slight
movement (so far)
structure failed but only
slightly

Chilliwack culvert under Hwy 1 vessel failure / structurally good

- The bedding was such that it acted to stabilize itself. I do not think the designer thought of then when designing?

Wood Stave Pipes
Failure Modes

- Wood stave pipes can fail with little or no notice.
- They are a compression structure with little shear strength.
- Obvious items like rotten wood, scouring, missing sections are warnings
- Very susceptible to point loadings from utilities above them.
- Lack of ability to bridge faults/breaches/holes
- Ability to burn (very well)
- Wood stave pipes have little/no structural redundancy.


Slight Failure lack of
redundancy in structure.

Concrete Pipe / Rigid Pipe

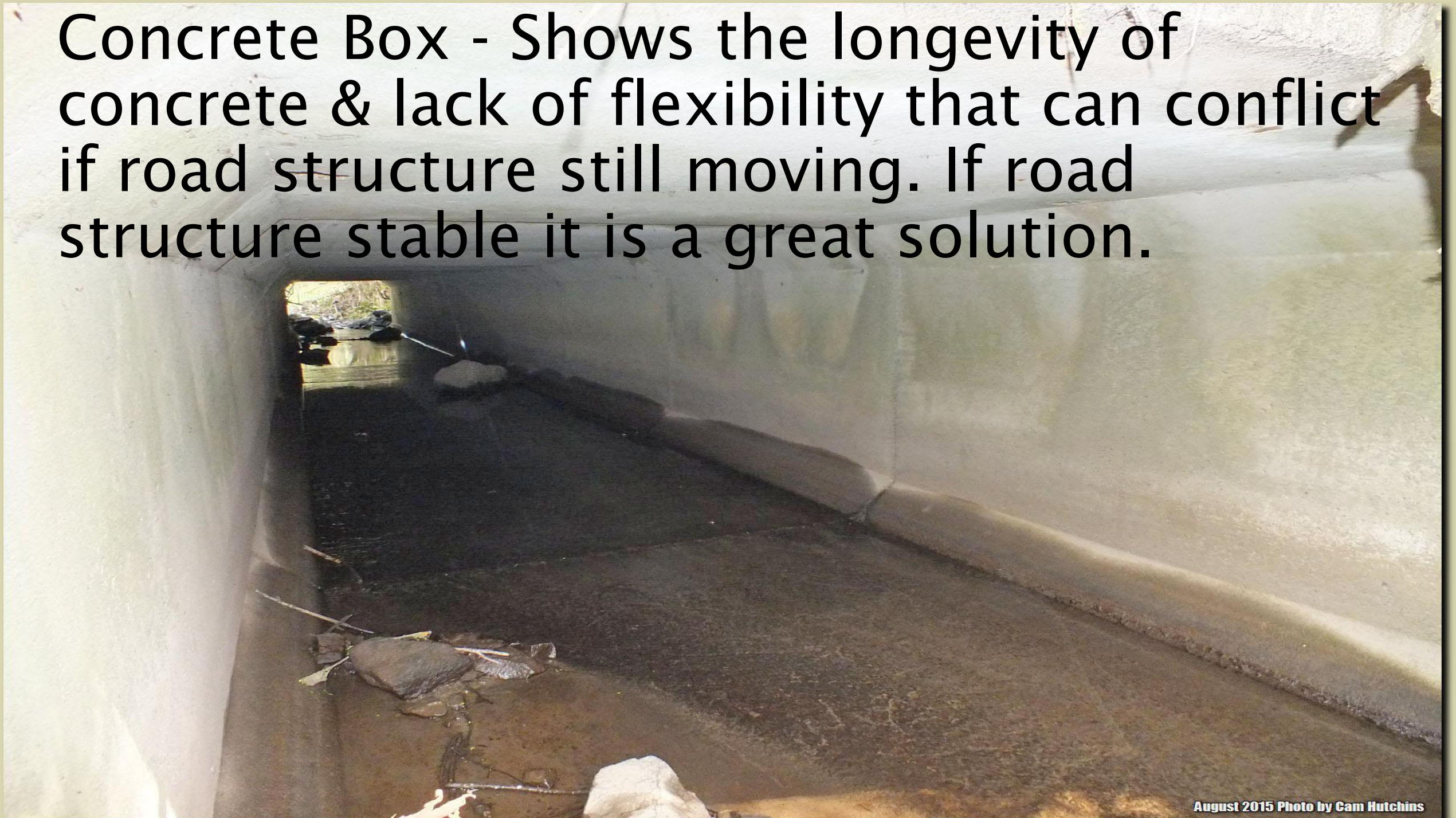
Advantages

- Long life 100 years +
- Elastic modulus similar to Concrete road structure.

Disadvantages

- Joints that open if ground moves.
- Elastic modulus very different to Asphalt road structure and this can show up on traveled surface.

Concrete Box - Shows the longevity of concrete & lack of flexibility that can conflict if road structure still moving. If road structure stable it is a great solution.



Plastics

Advantages

1. Flexibility.
2. Easy to install.
3. Does not corrode.
4. Can be very resistant to abrasion.

Disadvantages

1. Ability to burn.
2. Smaller sizes.
3. Material strength.
4. Micro plastics in environment.

Various rehabilitation methodologies

- Cement Mortar spray
- Slipline - flexible
- Slipline - rigid
- Fold and Form
- CIPP
- Spiral wound liner
- Structural Invert
- Large Diam Pipe Burst
- Pipe ramming

Again, the Basics of a Pipe

- Reinforcing this issue. The Core values of pipe rehabilitation.
  1. A vessel that contains a liquid.
  2. A vessel that carries a liquid.
  3. A structure to hold the soil open.

Importance of assessing existing culverts

- Access which function of existing culvert has failed.
- Access the other two functions and their remaining lives.
- Then decide rehabilitation strategy: total, partial or complete replacement

Solutions to Culvert rehabilitation

- **There is NO one solution**
- All the following solutions offer some advantages and some disadvantages.
- Some become cost prohibitive in larger diameters.
- Some cannot handle the haunch stress in pipe arches.
- Some cannot handle bends.

Pipe Burst

- Suitable for circular culverts only.
- Up to 1200mm diameter
- Use when existing culvert shape has failed.
- Under sized.
- Joints are sheared.
- Will increase capacity with lower “N” and increase in Dia.

Risks in CSP Bursting

- Assessment of the existing CSP needs to be accurate.
- Existing CSP Pipe needs to be cut if in good shape.

Slipline - Rigid

- Long lead time
- Suitable for large CSP / irregular shapes and materials
- Will decrease dia.
- Needs grouting
- “N” much lower, “Q” increased.

North Vancouver / Wood Stave to GRP

Flexible/Non Rigid Slipline

- HDPE liner
- For Straight Round
- Small to Large diameter
- Needs grouting
- Lower “N”

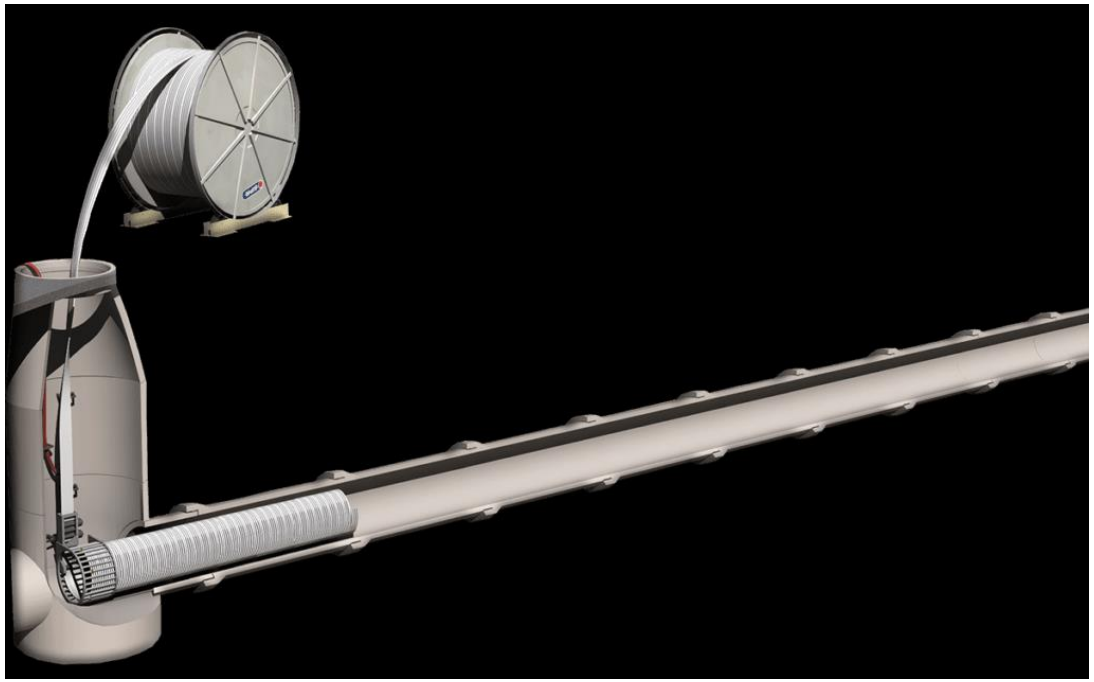
CIPP

- Long lead time
- Regular or irregular shapes
- Deformities more than 10% an issue.
- Lower “N”
- Close fit little reduction in Dia.

CIPP in a culvert setting

- Deformities more than 10% = issue.
- Lower “N”
- Close fit little reduction in Dia.
- Not cheap in bigger Dia.

Spiral wound



- Needs extensive forming system before grouting.
- Little reduction in Dia.
- Very labor intensive

Structural invert

- No delivery time issues

  Can be installed in round or pipe arch.
- Little reduction in Dia.
- Very cost effective
- Only suitable for 9 to 3 or below, failure

Fold and form

- Closed fit
- Little reduction in Dia
- Reasonable cost
- Low “N”
- Smaller Diam
- Round shape only

Pipe Ramming

- New pipe installation.
- Swallow old smaller culvert.
- Trenchless.
- Fairly extensive set up.
- Use in larger sizes mainly (3m+)

Sprayed Solutions

- Total rehabilitation Geopolymer
- Invert rehabilitation.
- Geopolymer on bigger pipes
- Polyurea's "rock guard" for abrasion.

The End

Lessons to take away.

1. Catalogue your culverts.
2. Proactive repairs are 25% of the costs of emergency repairs min.
3. Start a program of rehabilitation.
4. Nothing last forever.
5. Maximize the use of what you already have.