OTCO Annual Class III & IV Workshop
for Water and Wastewater Operators

Large Diameter Sewer Rehabilitation,

a New Approach

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Safety Moment

ILLNESS TYPE	SYMPTOMS	RESPONSE
Heat Cramps	• Painful cramps in arms, legs, stomach or back that occur suddenly at work or later at home • Tingling in hands and feet • Heavy sweating.	• Drink water and electrolyte solutions such as Gatorade • Eat fruit such as bananas • Take a break in a cool area.
Heat Exhaustion	• Heavy sweating • Headache • Cool, pale, and moist skin • Tired and weak • Very thirsty • Panting or breathing rapidly • Blurred vision	• Get medical attention • Move to an air-conditioned room or shaded area • Lie down with feet slightly elevated • Loosen or remove excess clothing and apply cool-water-soaked cloths or ice packs to the body • Drink water or electrolyte drinks in moderate amounts
Heat Stroke	• Sweating stops, causing body temperature to rise • Person is weak, confused, upset or acting strangely • Hot, dry, red skin • Headache or dizziness. • In later stages the person can pass out and have convulsions.	• This is a medical emergency – call for assistance immediately. • Cool the individual by any means possible, including pouring water on them, ice pack and fanning. • Do not give the individual anything to drink.

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About Myself

- Originally from Toledo area
- Civil Engineer (University of Dayton)
- Cheap, frugal, stingy…according to my wife
  - Building a wood deck instead of composite (that my wife requested)

About Myself

- Worked extensively on sewer assessment and rehabilitation projects
- **Alum Creek (North & Middle) LDSA & Detailed Design** – Project Manager for the assessment, detailed design, and services during construction of around 87,000 LF of 42-inch to 96-inch reinforced concrete sewer using CCTV, Sonar, Laser, and man entry methods. The sewer was repaired with Shotcrete and CIPP lining.
- **Blacklick Creek Main Trunk LDSA** – Project Manager for the assessment and detailed design of 116,000 LF of 42-inch to 96-inch reinforced concrete sewer using CCTV, Sonar, Laser, and man entry methods.
- **Scioto Main Trunk LDCA** – Project Manager for the assessment of 105,000 feet of 36-inch to 180-inch sewer using CCTV, Sonar, and man entry methods. Portions of the project include a deep tunnel with access shafts spaced at around 2,000-3,000 feet making access a challenge. Performed analysis of the concrete using multiple.
- Over 800,000 LF of sewer inspection oversight
- 314,000 LF of Large Diameter Sewer Inspection

The Need

- EPA estimates $271 Billion is needed over the next 25 years for water/wastewater
- 95% is spent at the local level
  - U.S. Conference of Mayors
- Value is important to our clients

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No wonder we can't keep up

- Sewer repair costs are astronomical
  - Especially when all costs are factored in
- 2,100 LF 48" Cured In Place - $2.5M
  - Cleaning, televising, bypass pumping, pavement repairs, seeding…
  - Not counting engineering and CM fees
- City of Columbus
  - 2,800 miles of Sanitary Sewers
  - 2,500 miles of Storm Sewers

No wonder we can't keep up

- Need a more efficient inspection and prioritization process
- And a surgical approach to repairs
- Cannot afford to be ultra conservative
  - Wholesale lining just won't work

Typical Inspection Approach

- Large Diameter >36”
  - But were talking 60”+
- CCTV Crawler
  - Simple to advanced

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Typical Inspection Approach

- More Advanced Track Steered Systems
  - Debris
  - High Flow / Velocity
  - Long Distance – 5,000’
  - Around Bends

Typical Inspection Approach

- Floating system available for high flows
- Advanced Sensors include:
  - HD CCTV
  - Sonar
  - Laser Profiling
  - H_2S
  - Temperature

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…and the Results?

- Excellent lighting and HD CCTV
- Sonar and sediment data every foot of pipe
  - Profile plot showing total sediment
- Laser measurements showing internal diameter and wall loss
- Continuous H_2S readings
- Continuous temperature readings

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. . .how do we use this data and did we need it?

- HD CCTV of debris build up, grease, deposits…
  - Often was not seeing the concrete surface
  - Had to enter sewers to remove build up and see the pipe
- Sonar
  - Found that deposits were overall predictable based on CCTV
  - Crawler struggling over debris
  - Worse at surcharging locations w/low flow

-cont-

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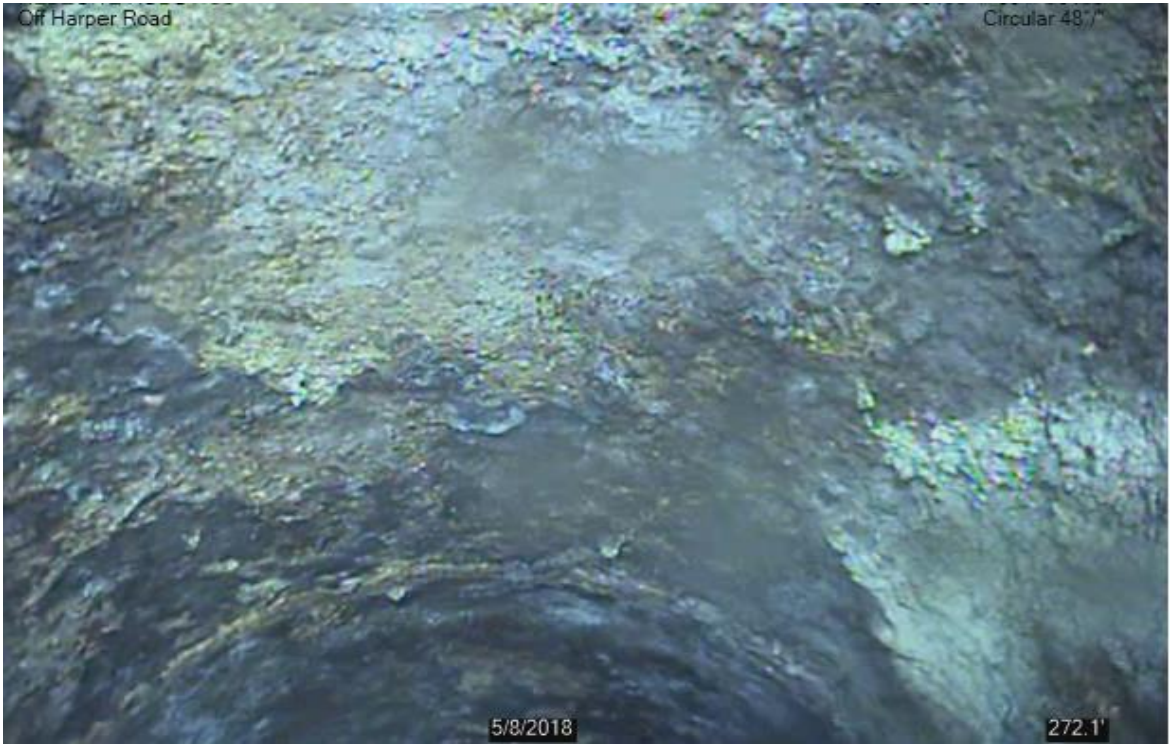
. . .how do we use this data and did we need it?



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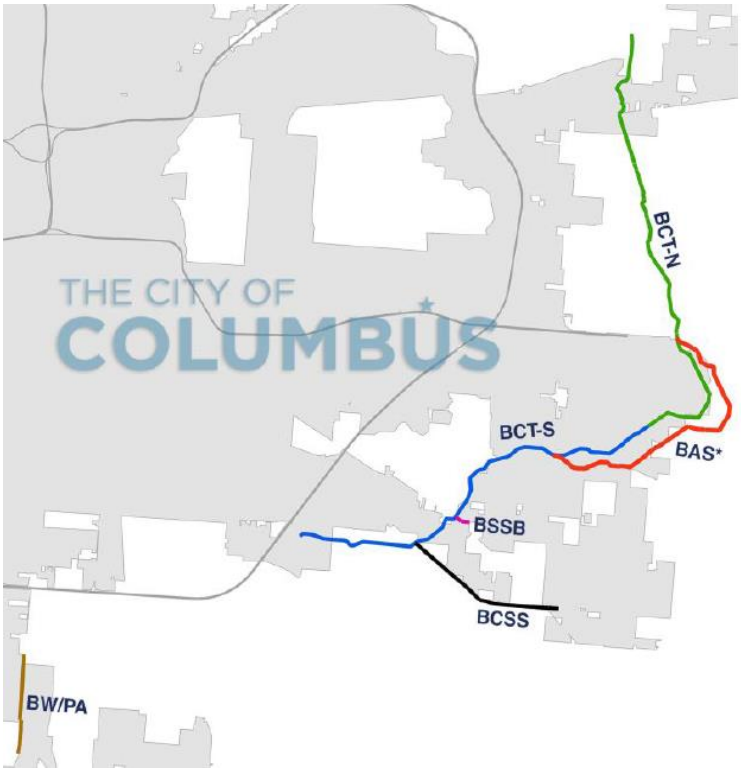
. . .how do we use this data and did we need it?

- Laser Profiling
  - Not necessary for every foot
  - Spot checks would be sufficient
- H_2S
  - Not necessary every foot
  - Spot checks with Odalog
- Temperature
  - Never used the information

Blacklick Creek Sanitary Subtrunk

- 13,870 feet
- 42-inch RCP
- 40 years old



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Blacklick Creek Sanitary Subtrunk

- Inspected with HD CCTV
- Contractor was concerned about pipe collapse
- Concrete falling off walls

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Blacklick Creek Sanitary Subtrunk

- Hire sewer cleaning contractor to power wash
- Man Entry Inspection at Manholes
- Concrete Sounding
- pH Measurement

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Blacklick Creek Sanitary Subtrunk

- Condition was much better than appeared on CCTV
  - Many times can't see the actual concrete (but you think you do)
- Softened concrete paste and exposed aggregates
- Poor durability properties (high permeability)

Blacklick Creek Sanitary Subtrunk

- Deferred $6M in repair costs
- Allowed higher priority repairs to move forward

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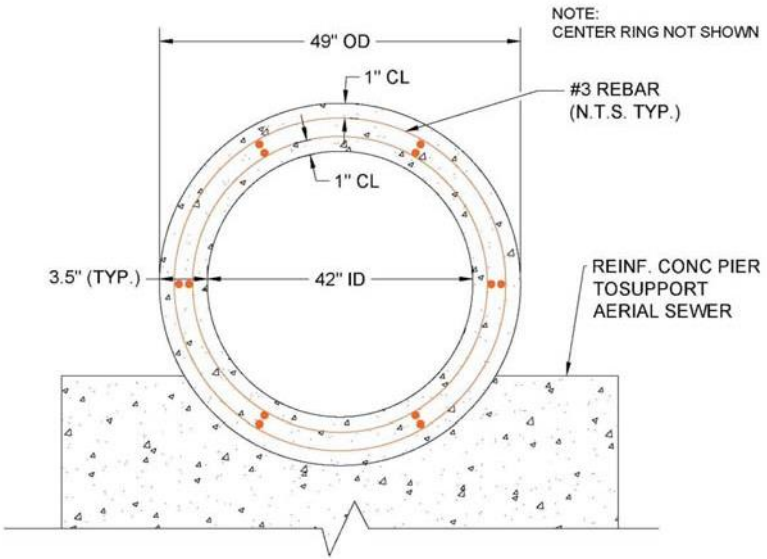
Alum Creek Trunk North

- Minimal rebar cover
- Only ½” concrete loss



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Alum Creek Trunk North

- Sound concrete between the spot defects
- Full lining is unnecessary
  - CIPP, etc.
- Condition looks worse on CCTV than it really is

We Propose a Different Approach

- Basic CCTV Inspection
- Man Entry Concrete Testing
- H_2S Testing

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We Propose a Different Approach

- Basic CCTV Inspection
  - Rent your own / buy your own?
  - PACP Coding needed?
    - GO pro?
  - Train your staff
  - Get a representative sample
    - Target critical locations
  - Pole camera spot checks at manholes
  - Use GIS or Asset Management to prioritize condition

We Propose a Different Approach

- Man Entry Inspection to Test Concrete Condition
  - Concrete Sounding & Scraping

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We Propose a Different Approach

- Man Entry Inspection to Test Concrete Condition
  - Core Samples
    - Strength, Petrographic Analysis
    - Depth of acid penetration
    - Permeability of concrete

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We Propose a Different Approach

- Use Man-Entry Inspection to Test Concrete Condition
  - pH Readings
    - Needed for surface preparation and application of repair materials
  - Limits of Spot Defects
    - Help with bid quantities
  - Rebar locator
    - Verify cover, size, spacing

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We Propose a Different Approach

- Measure H_2S at strategic locations
- Rather inexpensive to rent and easy to deploy

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Inspection is Complete…
now what?

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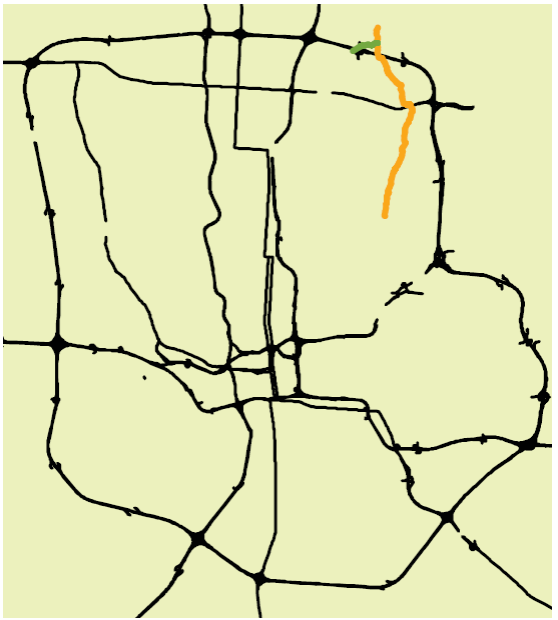
Alum Creek Trunk North

- 2010 Condition Assessment and BCE
- 50 years old
- 38,000 LF
- 42” to 78” RCP



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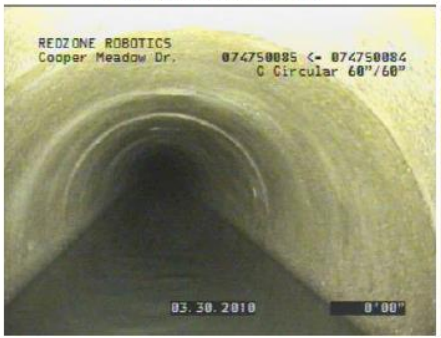
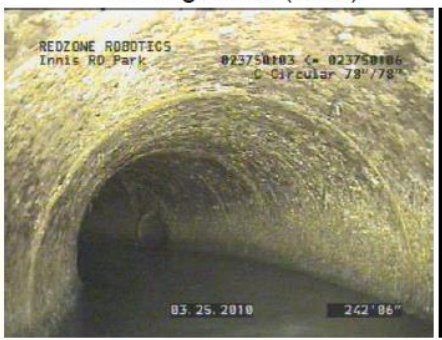
Alum Creek Trunk North

Good Condition
6 Segments (9%)



Fair Condition
29 Segments (43%)



Poor Condition
32 Segments (48%)

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Alum Creek Trunk North

Alternative	Includes	Length of Repair
Do nothing (Televising)	Routine CCTV/Sonar	N/A
Spot repair	2" thick Shotcrete, pipe cleaning, and routine CCTV/Sonar	Grade 4 & 5 defects in the sewer segment that can be spot repaired
Lining	Cured in place pipe (CIPP), pipe cleaning, and routine CCTV/Sonar	Entire sewer segment
Pipe replacement	Open cut replacement and routine CCTV/Sonar	Entire sewer segment

Alum Creek Trunk North

- Spot Repair
- Replacement
- Lining
  - CIPP
  - Sliplining
  - Grout in Place Lining
    - spiral wound, panel, segmental

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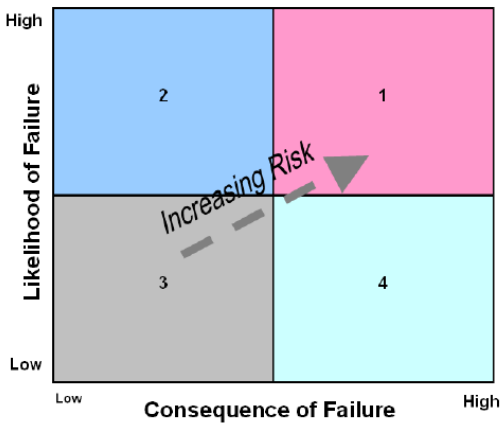
Alum Creek Trunk North

- Rigorous Alternatives Analysis of Each Sewer Segment
  - Lifecycle Costs
  - Consequence of Failure
  - Probability of Failure
  - "Triple Bottom Line"
    - Environmental
    - Social
    - Economic



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Alum Creek Trunk North

- BCR>1 is a good investment
- Wholesale lining = 1.14
- Spot repairs = 14.5

Financial Metrics	Do Nothing	Spot Repair	Lining	Replacement	Combined
Net Present Value (NPV)	$ (81,366,887)	$ (67,716,157)	$ (76,600,459)	$ (103,617,001)	$ (67,427,490)
Total Annual Cost	$ (9,908,909)	$ (2,444,563)	$ (1,869,002)	$ (2,284,558)	$ (2,139,274)
Total Project Capital Cost	$ -	$ (1,000,250)	$ (27,117,055)	$ (63,966,617)	$ (5,884,555)
Total O&M Cost	$ (710,742)	$ (580,904)	$ (430,270)	$ (345,356)	$ (535,575)
Total Risk Cost	$ (80,656,145)	$ (66,135,002)	$ (49,053,134)	$ (39,305,027)	$ (61,007,360)
Total Reduced Risk	N/A	$ (14,521,143)	$ (31,603,011)	$ (41,351,118)	$ (19,648,785)
Benefit / Cost Ratio (BCR)	N/A	14.52	1.17	0.65	3.34

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Alum Creek Trunk North

- Rehabilitation Included:
  - Cementitious spot repairs
    - Surface prep to sound concrete
    - Restore surface to original condition
  - Cementitious Continuous Lining
    - 2” thick shotcrete w/polypropylene fibers
    - Many products available
    - Many admixtures with corrosion resistance
    - Want a mix that has low permeability
    - High strength mix is available
    - Pipe within a pipe

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Shotcrete

- Placed shotcrete field tested at 8,000 - 10,000 psi average

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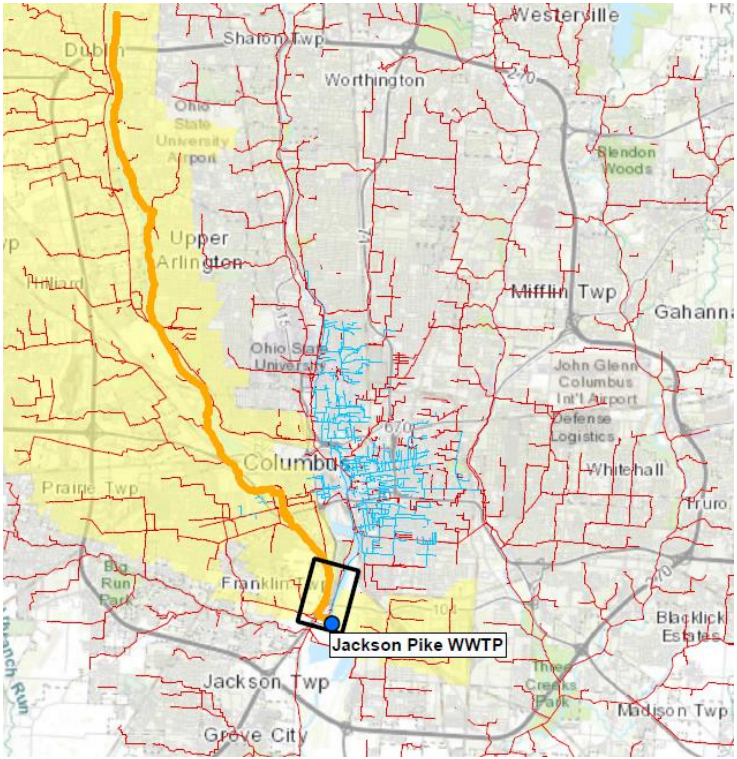
Polymeric coatings

- Polyurethane Coatings
  - Requires dry surface
- Epoxy Coatings
- Materials are very costly
  - Less favorable BCR

Scioto Main 120”

- Linabond
- PVC panels adhered by primer and epoxy
- Failed after 8 years



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Scioto Main 120”

- Linabond can’t be repaired
- Must be removed if another coating is installed
  - Grinding?
  - Abrasive Blasting?
- Plastic liners can be hard to maintain when they fail

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Summary

- Increase Inspection Frequency
- Decrease Inspection Cost
- Repair what is critical
- Avoid ultra conservative repairs (i.e. wholesale lining)
- Use a surgical approach
- Consider cementitious products first

Thank you for your time. Any questions?

This concludes this Session for the 2019 OTCO Class III & Class IV Annual Workshop for Water and Wastewater Operators

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Blacklick Creek Trunk South

- 20 segments with surface reinforcement visible at random locations (spot defects)
- 3,650 feet of 96-inch RCP showing continuous severe concrete corrosion with visible reinforcement

So….how do you fix THAT?

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