City of Columbus

Large Diameter Sewer Condition Assessment: Program Development and Updates to Approach

February 28, 2013

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DEPARTMENT OF PUBLIC UTILITIES

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What We'll Cover Today

- Program Development and History
- Alternatives Development with Risk-Based Consideration/Recommendations
- Lessons Learned

  - Future Direction of Program

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Program Development and History

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History of the Large Diameter Condition Assessment

- Consent Order Related
  - 8.j, “identifying and prioritizing structural deficiencies and identifying and implementing short-term and long-term rehabilitation actions to address each deficiency”.
- Initiated Study in 2005
- Initial Approach
  - Cleaning costs averaged to $39 per LF
    - Cleaning = $26 per LF
    - CCTV = $13 per LF
- Assess-First Approach
  - Sewers may not “need” 100% cleaning

Assess First Theory

- Sewers may not “need” 100% cleaning
- Utilize a risk-based approach to prioritize critical trunk mains
- Release a single large-diameter project annually
  - CCTV the entire trunk length without conducting cleaning
  - Assess the need for repairs and/or cleaning
  - Perform detailed design of repairs and/or cleaning

Assess-First Theory Costs

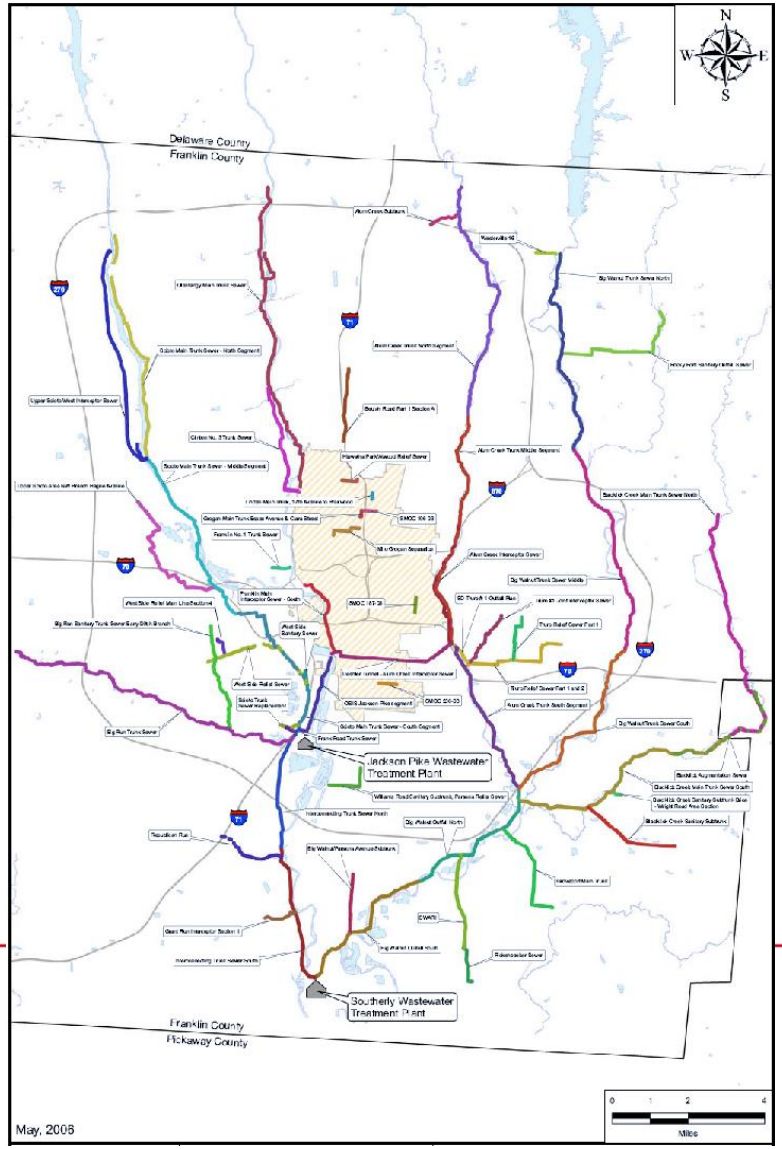
- Costs savings potential
  - Alum Creek North (Total Length 35,500 LF)
    - Cost to clean w/CCTV entire length = $1,384,500
    - Cost to CCTV entire length w/50% cleaning assumed = $1,015,300

Costs to complete Assess-First Theory

- Alum Creek North
  - $600,000 to conduct high definition CCTV, sonar, manhole inspection, survey and assessment.
  - $250,000 to complete design of all repairs and cleaning.
  - $6,000,000 estimated to complete necessary repairs.
    - » No stand-alone cleaning required

Large Diameter Pipe Condition Assessment & Cleaning Prioritization Program

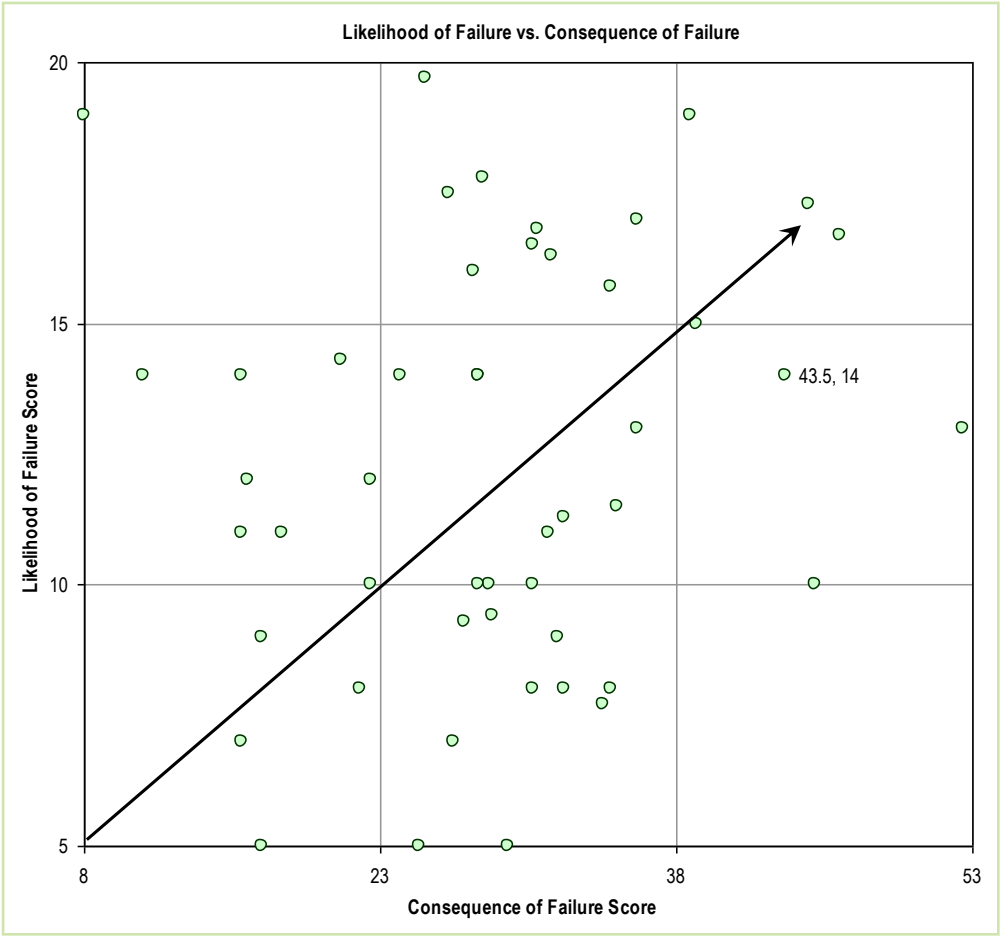
- Program Initiated in 2006
- Included all sanitary main trunk sewers (larger than 36” dia.)



2006 Prioritization Report

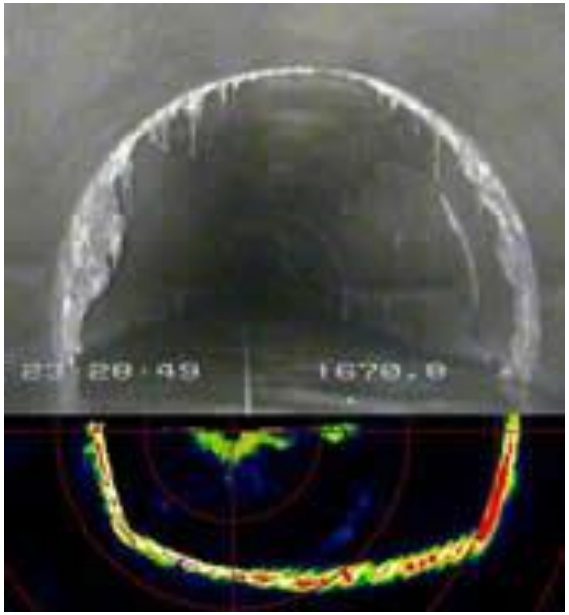
Foundation For Large Diameter Sewer Maintenance

- All trunk lines within the system (>36 inches)
- “Desktop” Indicator parameters



Likelihood of Failure

- Age (1-5)
- Material (1-5)
- Velocity / grade changes (1-5)
- Wastewater Strength/Pump Stations (1-5)
- Historical Info (1-5)
- Hydraulic Rating (1-5)



Consequence of Failure - Triple Bottom Line

- Size or Diameter (1-5)
- Depth (1-5)
- Specific Location (1-5)
  - Water Body/Wetland
  - Highway/Railroad/Building/ Cemetery
- General Location (1-5)
  - Land Use/Accessibility/ Social Disruption

Prioritization of Trunk Sewers

Sewer Run	Recommended Priority
Alum Creek Trunk Sewer - North	1
Alum Creek Subtrunk	1a
Alum Creek Trunk Sewer - Middle	2
Alum Creek Interceptor Sewer	2a
Alum Creek Trunk Sewer - South	3
Big Walnut Trunk Sewer - North	4
Big Walnut Trunk Sewer - Middle	5
Big Walnut Trunk Sewer - South	6
Olentangy Main Trunk Sewer	7
Deshler Tunnel	8
OSIS - Jackson Pike	9
Milo Grogan Separation	10
Upper Scioto Area NW Branch	11
Interconnecting Trunk Sewer - North	12
Interconnecting Trunk Sewer - South	13
Blacklick Creek Main Trunk Sewer - North	14
Blacklick Augmentation Sewer	15
Blacklick Creek Main Trunk Sewer - South	16
Blacklick Creek Sanitary Subtrunk	16a
Big Run Trunk Sewer	17
Scioto Main Trunk Sewer - North	18
Upper Scioto West Interceptor Sewer	19
Scioto Main Trunk Sewer - Middle	20

- 20 years to complete the LDCA program
- Have completed 4 assessments to date
- Deriving inspection and maintenance schedules for the completed trunk sewers.

Alternatives Development with Risk-Based Consideration/Recommendations

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Questions to Answer

- What is the current state of the sewer?
  - What condition is it in?
  - What is the remaining useful life (RUL)?
- What is the required level of service (LOS)?
- What are the critical sewer segments?
  - What is the likelihood of failure (LoF)?
  - What is the cost of repair / consequence of failure (CoF)?
- What are the best Capital and/or O&M Strategies?

Overall Process

1. Condition Assessment
2. Level of Service
3. Remaining Useful Life
4. Criticality
5. Life Cycle Costing / Valuation
6. Evaluate various Capital and/or Maintenance Strategies

Condition Assessment – Project Background

- 42” to 78” Reinforced Concrete Pipe
- 45 years old
- Nearly 40,000 LF
- Average 600’ between manholes
  - Maximum at 1,700’
- Passes under I-270, S.R. 161
- Follows closely to Alum Creek
- Has never been inspected

Condition Assessment – Inspection Plan

Develop inspection plan

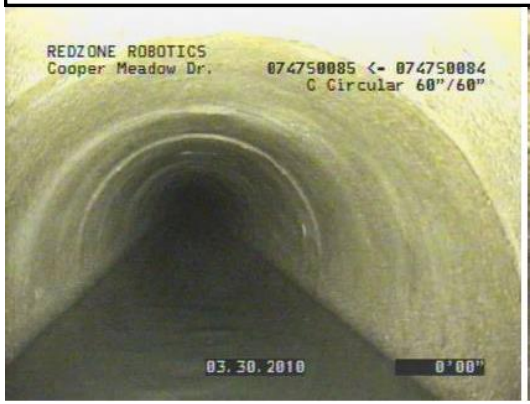
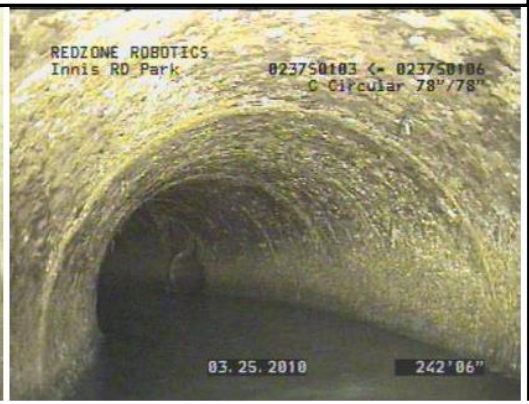
- Review existing information
- Field locate manholes
- Inspection method / technology
  - Track steered crawler, CCTV, Sonar

Contents

- Mapping
- Sewer information
  - (depth, length, size, material, etc)
- Access manholes
- Traffic control
- Right-of-entry

Condition Assessment – Sewer Inspection

- Planning was worthwhile
- NASSCO defect coding was performed

82% Good to Fair Condition		18% Poor Condition
		

Condition Assessment – Sewer Inspection

Structural

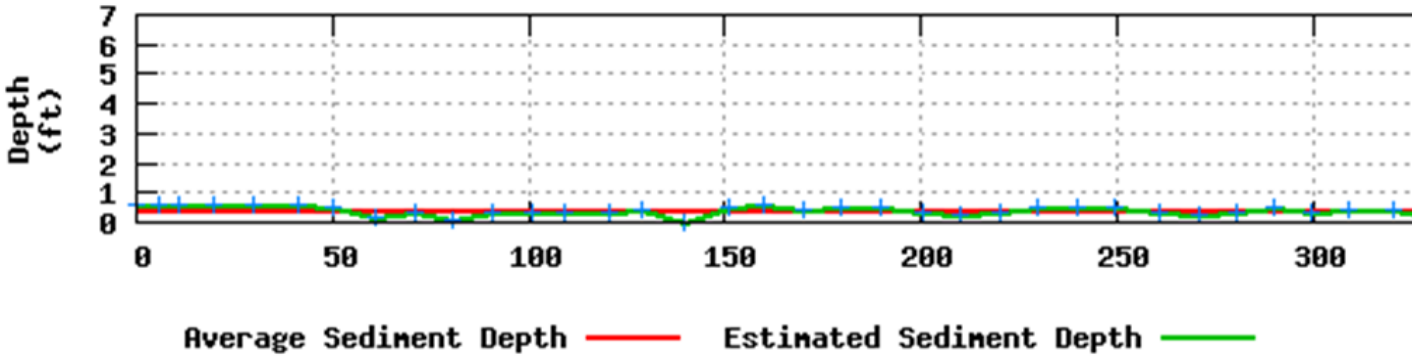
- Overall fair
  - Average NASSCO score: 3.8
- Some segments in poor condition
- Common defects
  - Surface Reinforcement Visible (SRV)
  - Surface Aggregate Visible (SAV)
  - Surface Spalling (SSS)
  - Surface Roughness Increased (SRI)
- Erosion corrosion / erosion at spring line

Condition Assessment – Sewer Inspection

Sediment Depth (inches)		
Average	Maximum	Minimum
1.1	3.6	0.0

O&M

- Overall good
- Less sediment than expected
- Less I/I than expected
- One partially blocked section



Condition Assessment – Sewer Inspection

- QA/QC of defect coding was essential
  - Scoring prior to QC was much lower due to missed codes in the field
  - Coding must consistent between the trunk sewers
  - QA/QC in field can save time and avoid re-work

Level of Service

Need to define the goal we are trying to accomplish

- Maximize hydraulic capacity originally designed for
- Prevent interruption to service

Identify Failure Modes

- Structural integrity must not affect capacity
  - Collapse, leakage, etc.

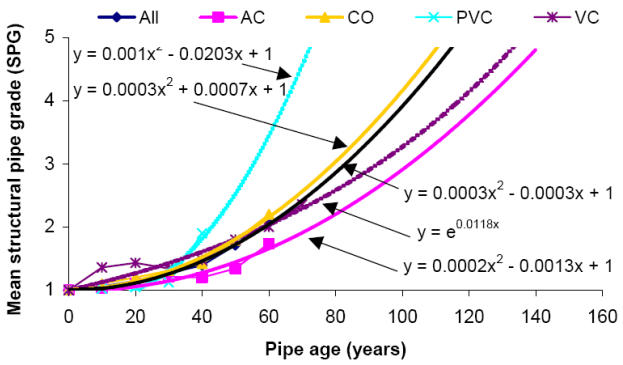
- O&M issues must not affect capacity
  - Sediment build up
    - Minor sediment observed
  - Inflow & Infiltration (I/I)
    - Minor I/I observed

Remaining Useful Life

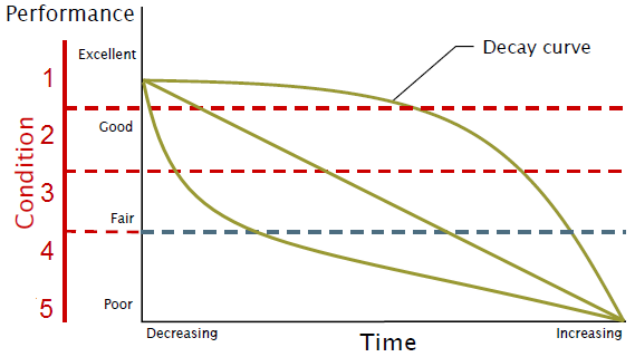
Critical in cost analysis for estimate LoF

- NASSCO PACP Method
- National Resource Council Canada
- Site Specific Decay Curves

NASSCO PACP Pipe Grades	
Grade 1	Failure is unlikely in the foreseeable future.
Grade 2	Risk of failure within **20** years.
Grade 3	Risk of failure within **10-20** years.
Grade 4	Risk of failure within **5-10** years.
Grade 5	Risk of failure within **5** years.



Source: MIIP Report: The State of Canadian Sewers – Analysis of Asset Inventory and Condition



Remaining Useful Life

Three methods were compared

Remaining Useful Life			
Condition Grade/SPG	NASSCO* Model	Regression Model	Site Specific Model
1.0	40	120	78
1.5	40	80	78
2.0	20	63	78
2.5	20	50	70
3.0	20	40	42
3.5	14	29	25
4.0	10	21	14
4.5	7	13	6
5.0	5	6	0
*NASSCO Grade 1 assumed to be 40 years and RUL was interpolated for non-whole numbers.			

Remaining Useful Life

Challenges with using NASSCO when estimating RUL

- Use the PACP index or maximum score?
- PACP index does not “code” good condition
- It is possible to code overlapping defects
  - Surface Spalling (SSS) Grade 2
  - Surface Aggregate Visible (SAV) Grade 3

Criticality

- Likelihood of Failure (LoF)
  - 1 / RUL
  - 1/5 = 20% annual chance of occurence
- Consequence of Failure (CoF)
- Business Risk Exposure
- LoF x CoF = Business Risk Exposure

Criticality – Consequence of Failure

Economic

- Diameter
- Average depth
- Under a body of water
- Under road
- Under structure or building
- Under railroad track
- Land use
- Accessibility
- Emergency work premium

Social

- Property damage potential from WIB or SSOs
- Social disruption potential

Environmental

- Cleanup
- EPA Fines

Criticality – Consequence of Failure

A few examples…

Traffic Disruption

- 120,000 veh/ day x (10 min / veh) x (1 hr / 60 min) x $45 / hr x 2 days = $1.8 Million
  - Interstate – $1.8 Million
  - Major Road – $1.1 Million
  - Minor Road – $300,000

Sewer Backup

- 50 households affected, $2,000 per household
- $100,000 per event

Life Cycle Costing

Alternatives

- Do Nothing
- Spot Repair
- Lining
- Replacement
- Combination

Direct Costs

- Operation
- Maintenance
- Renewal

Risk Costs

- Economic
- Social
- Environmental

Life Cycle Costing

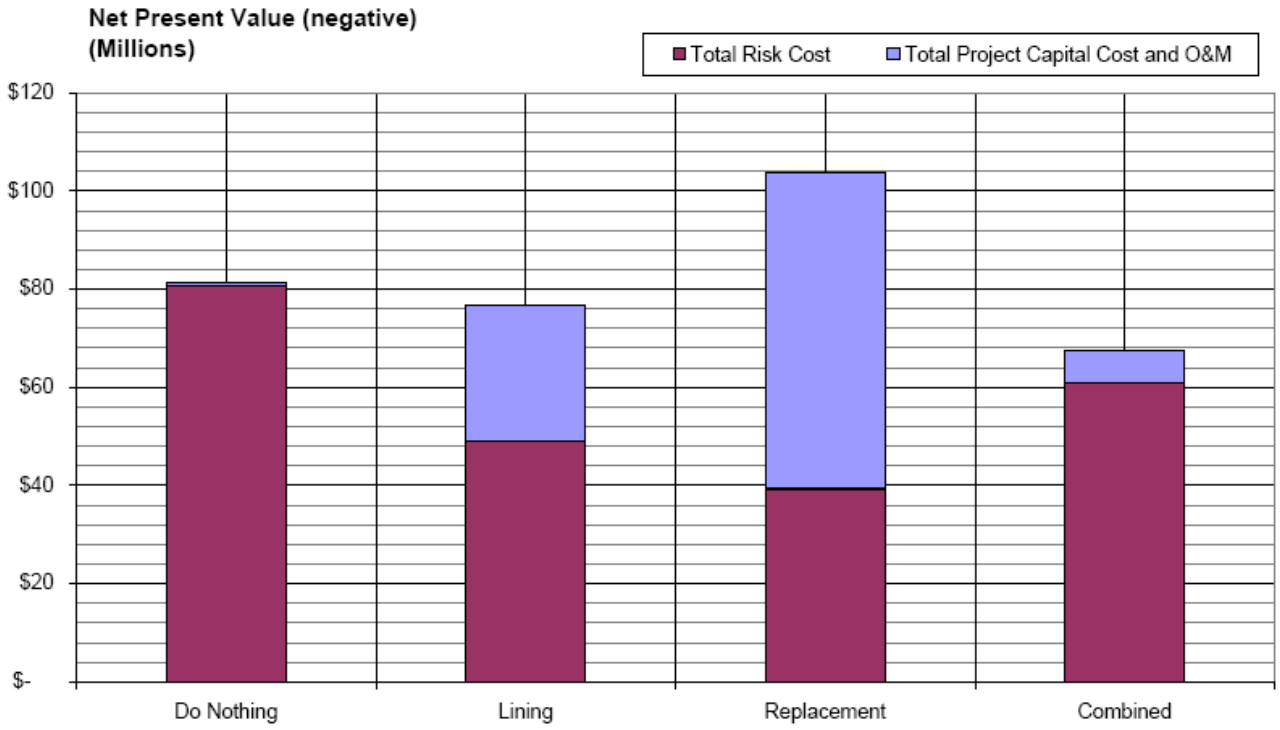
Net Present Value

- Annual Costs
  - Capital, O&M, Risk

Benefit Cost Ratio

- Benefit is reduced risk

Life Cycle Costing



BCR 1.2 **BCR 0.65** **BCR 3.34**

Sensitivity Analysis

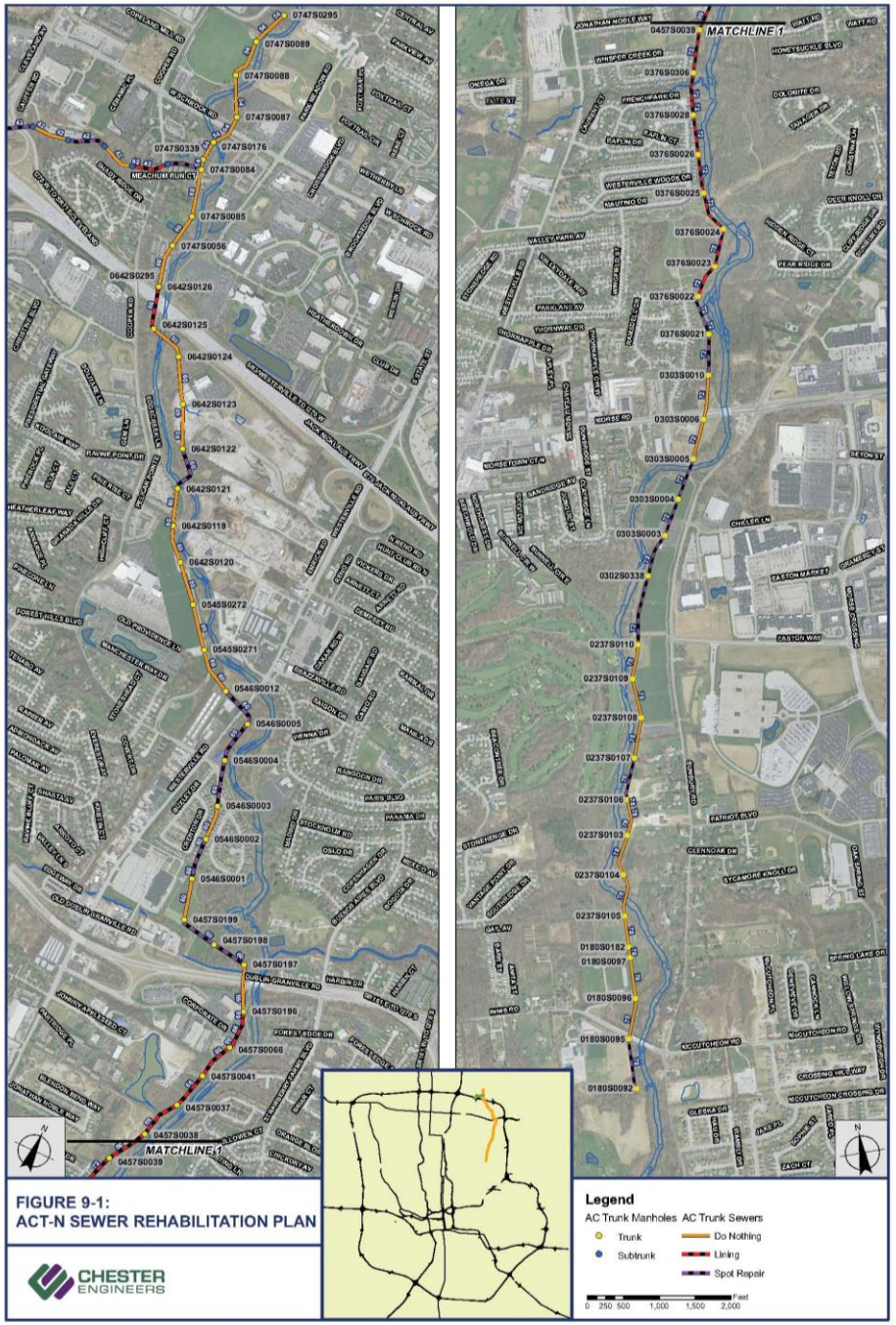
Variables with a significant impact on the financial analysis :

- Estimate of remaining useful life
- Average vs. maximum sewer segment condition grade (SPG)
- Risk costs
- Interest rate
- Useful Remaining Life estimation based on the Decay Curve model, NRC Deterioration Regression model and NASSCO model for remaining useful life model results
- Sewer segment condition rating based on the average and maximum structural condition (SPG)
- Significantly increase and decrease the risk costs
- Significantly increase and decrease the interest rate

Capital / O&M Strategies

- Perform cementitious spot repairs whenever possible
- Selectively line sewers in poor condition when spot repairs are numerous

Capital / O&M Strategies



Future Direction of Program

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Process Refinement

- 4 Assessments Completed
  - Scioto Main/West Side Relief
  - Olentangy Main
  - Alum Creek Trunk (North)/Alum Creek Subtrunk
  - Alum Creek Trunk (Middle)/Alum Creek Interceptor

- Results Comparison
  - Utilize lessons learned from previous projects
  - Review need for technologies used; i.e. high def CCTV, sonar, laser, etc.
  - Review and utilize emerging technologies

Debris Accumulation (Sonar)

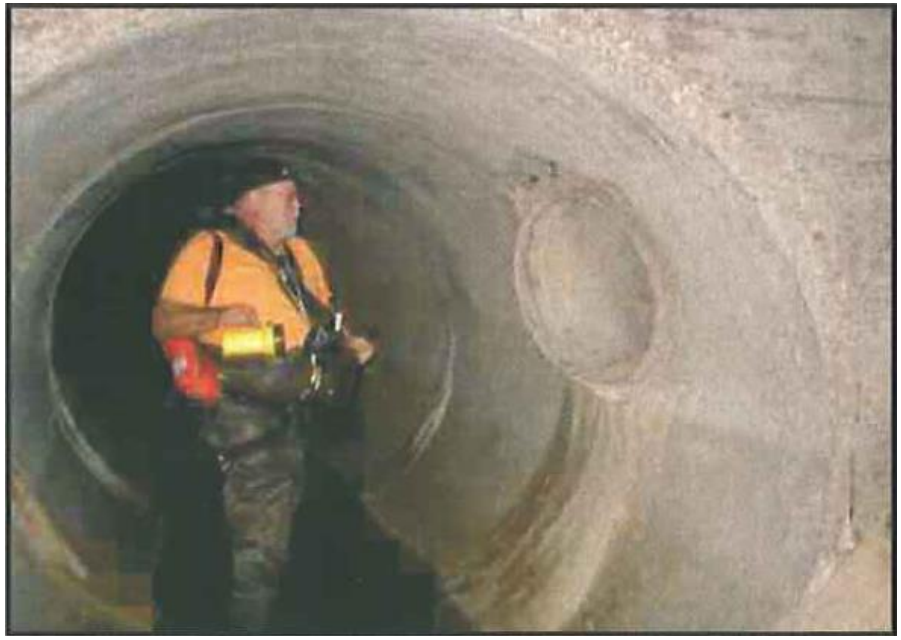
- Not as much as expected
- Unit prices for cleaning not any better
- Inspections are snapshot in time – Material wasn't there

Laser Data

- Difficult to estimate RUL
- Comparing to future inspections is unlikely (only paper reports provided)
- Most advantageous for undocumented curves, deflected brick sewers, and sliplining projects

Good Old Fashioned Man-Entry!

- Debris Volumes estimated at manholes; 10 foot intervals
- Helps determine full extent of repair areas
- Cost comparable
- Localizes labor



Delaying Detailed Design Process

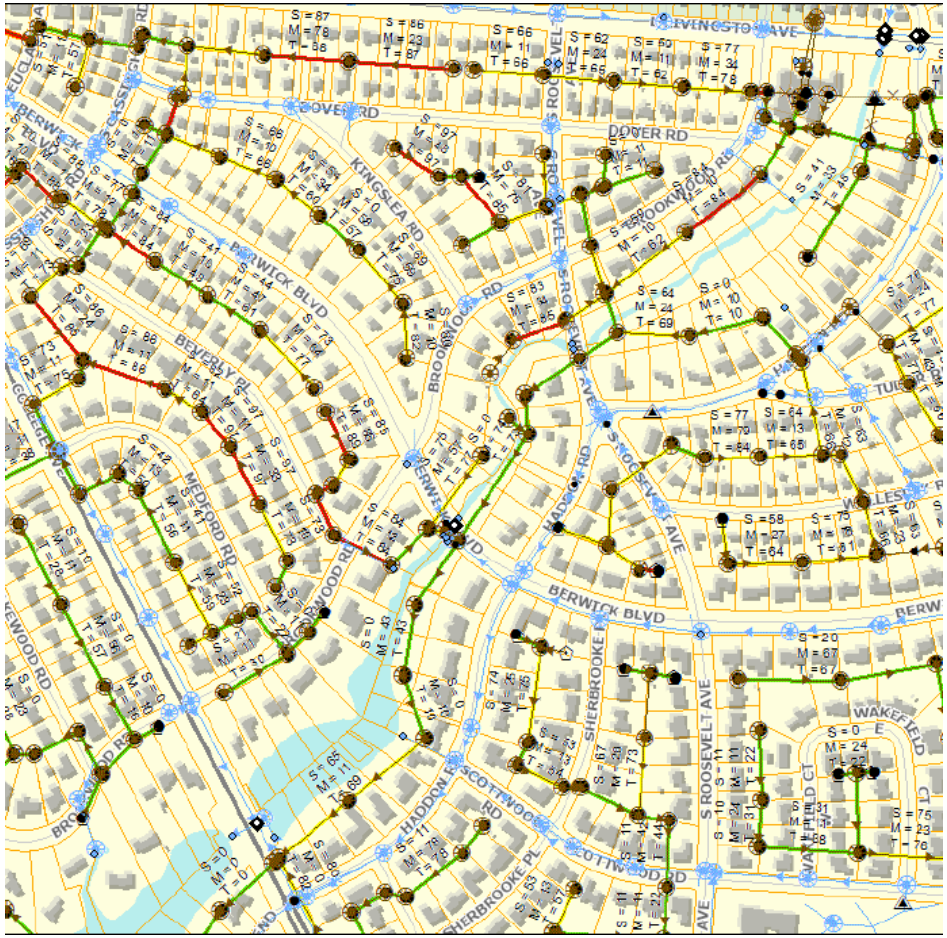
- Pipes simply weren't that bad
- Exposed rebar does not mean imminent collapse
- Defects were predominantly category 3's
- NASSCO scoring reduced 5's to 4's for several corrosion codes

- Back to the roots of the program
- Pipes have corrosion/scaling, but are structurally sound
- Work is focused and well-defined, yet still not competitively bid
- Eases perceptions of designer liability and resulting conservatism

Delaying Detailed Design Process

- Instead of “Find & Fix”;
  “Find, Prioritize, & then Fix”
- Rehab can be prioritized within context of the entire system
- Better packages of work grouped together

- SCREAM Model
  - Consistency/Uniformity
- Tailored
- Speed
  - Condition Rating and Overall Project



Accelerated Inspection Timelines

- Reduced costs and reallocated detailed design funds
- Reduced 20 year program down to 10
- Added in downtown combined sewers including OSIS
- Not tackling storm yet

Old Process
Length: 40,000 LF
Assessment: $600K
Design:$400K
Construction: $5M

VS.

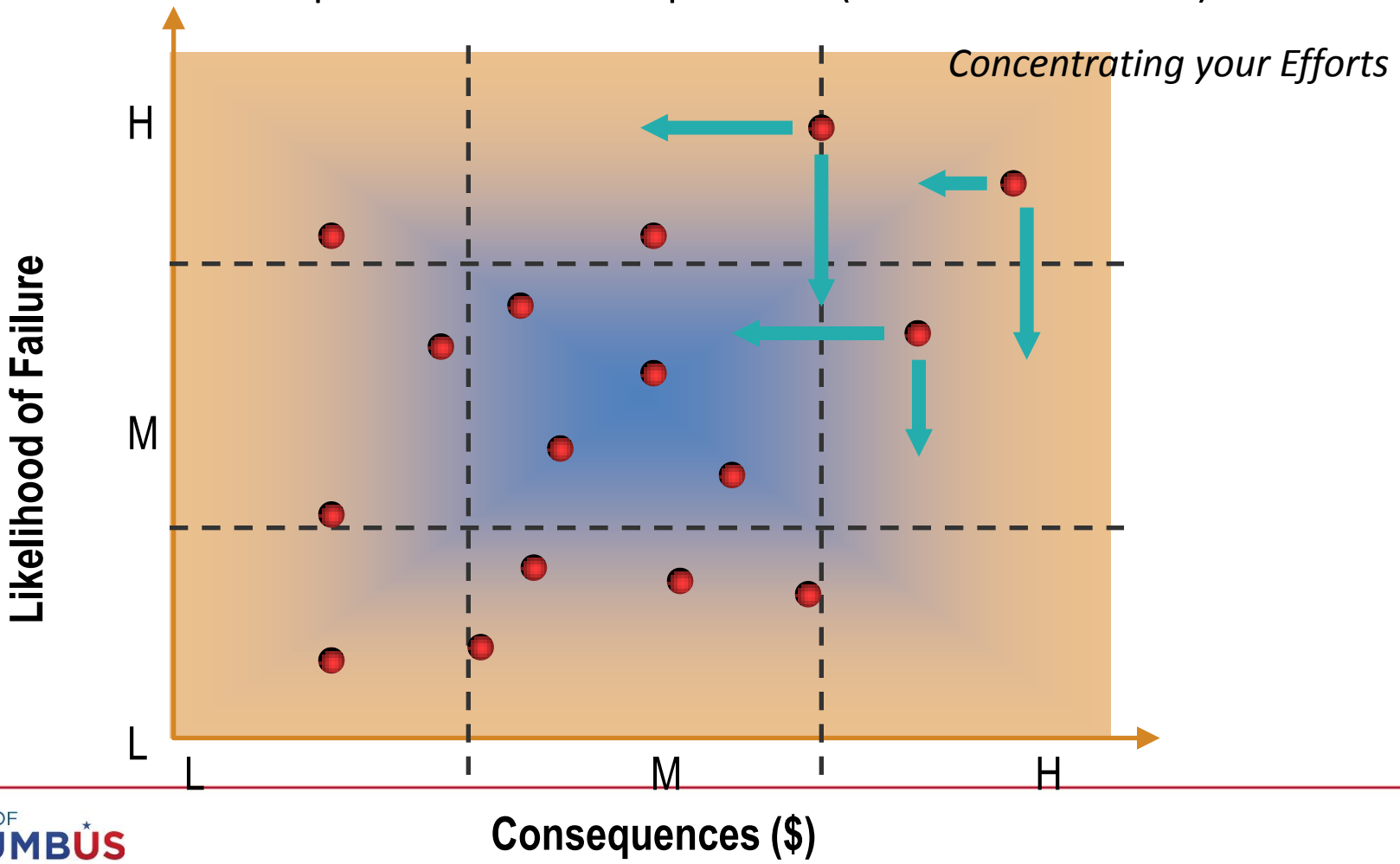
New Process
Length: 120,000 LF
Assessment: $1.2M
Design: Delayed
Construction: Delayed

Pole Camera Inspections

- Cursory Evaluation of system
- Cheaper and faster than traditional inspections
- No individual defect coding, but can be incorporated into GIS
- “Sample” inspections can be extrapolated

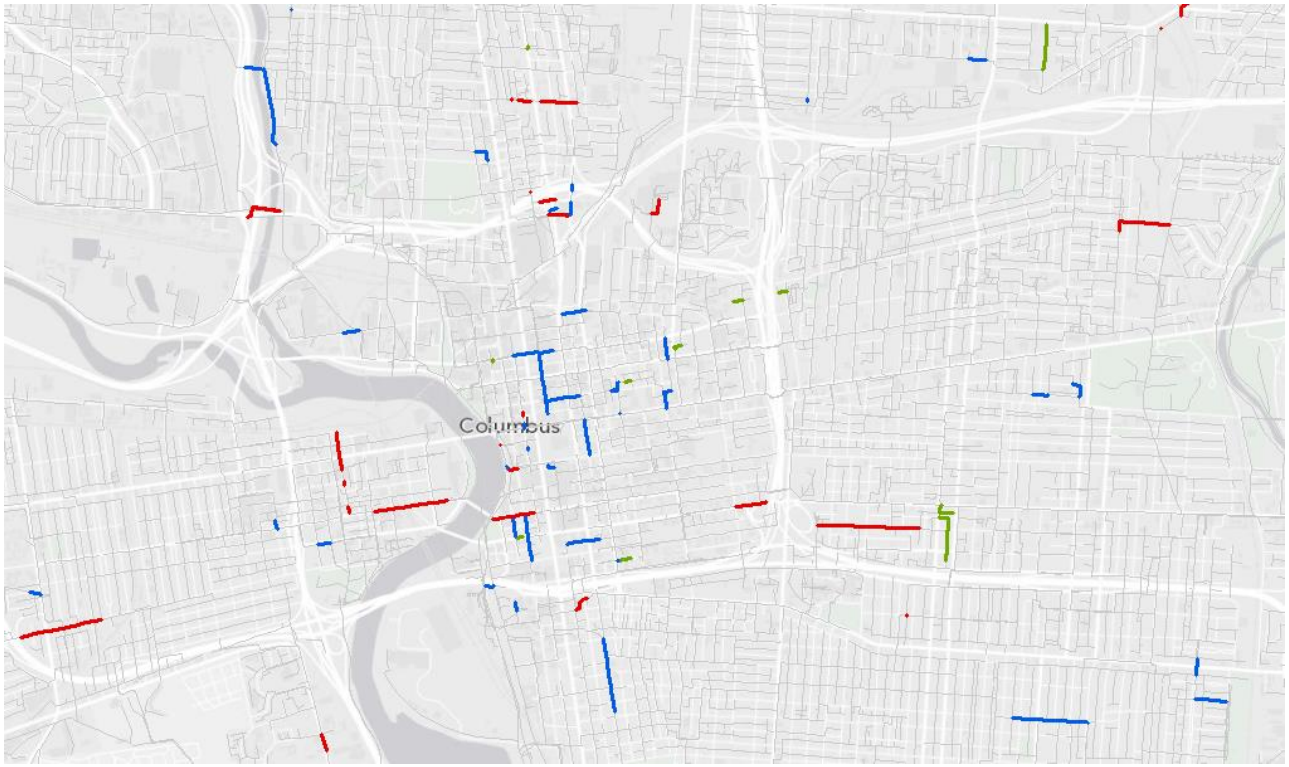
Pole Camera Inspections

- Allows for further prioritization of inspections (Lowers overall risk)



Extrapolation of Results

- SCREAM modeling
- Sample size may not be large enough yet



Highest Priority
Moderate Priority
High Priority
All Sewer Mains

Rehab Methods

- Traditional
  - Spot Repairs ($200/SF)
  - CIPP
  - Shotcrete
  - Sliplining & Segmented panels

Rehab Methods

- Non-Traditional
  - 2-in cement layer - nozzle gun
  - 2-in cement layer - centrifugally spun
  - Spiral wound pipe

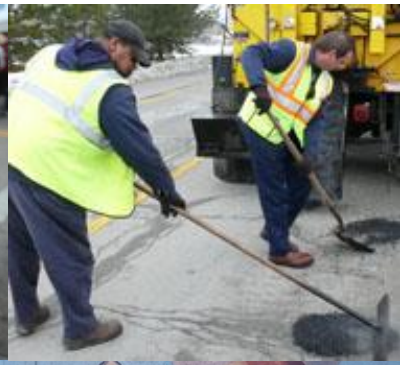
Design/Build

- Receive proposals and select the best approach not just the lowest cost
- Leverages the experience and creativity of the contractors
- Scioto Main - 120” Rehab

Summary

- Sonar & laser have their place and should be used where appropriate
- Stepwise approach more cost effective for procuring services
- Make rehab materials compete against one another
- Essence of Asset Management is “continuous improvement”
- Use the data obtained to make better decisions about future work

Thanks!



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Questions?