



System-wide Sewer Rehabilitation: Efficiency in Design

May 5, 2011

OWEA Collection Systems Specialty Workshop

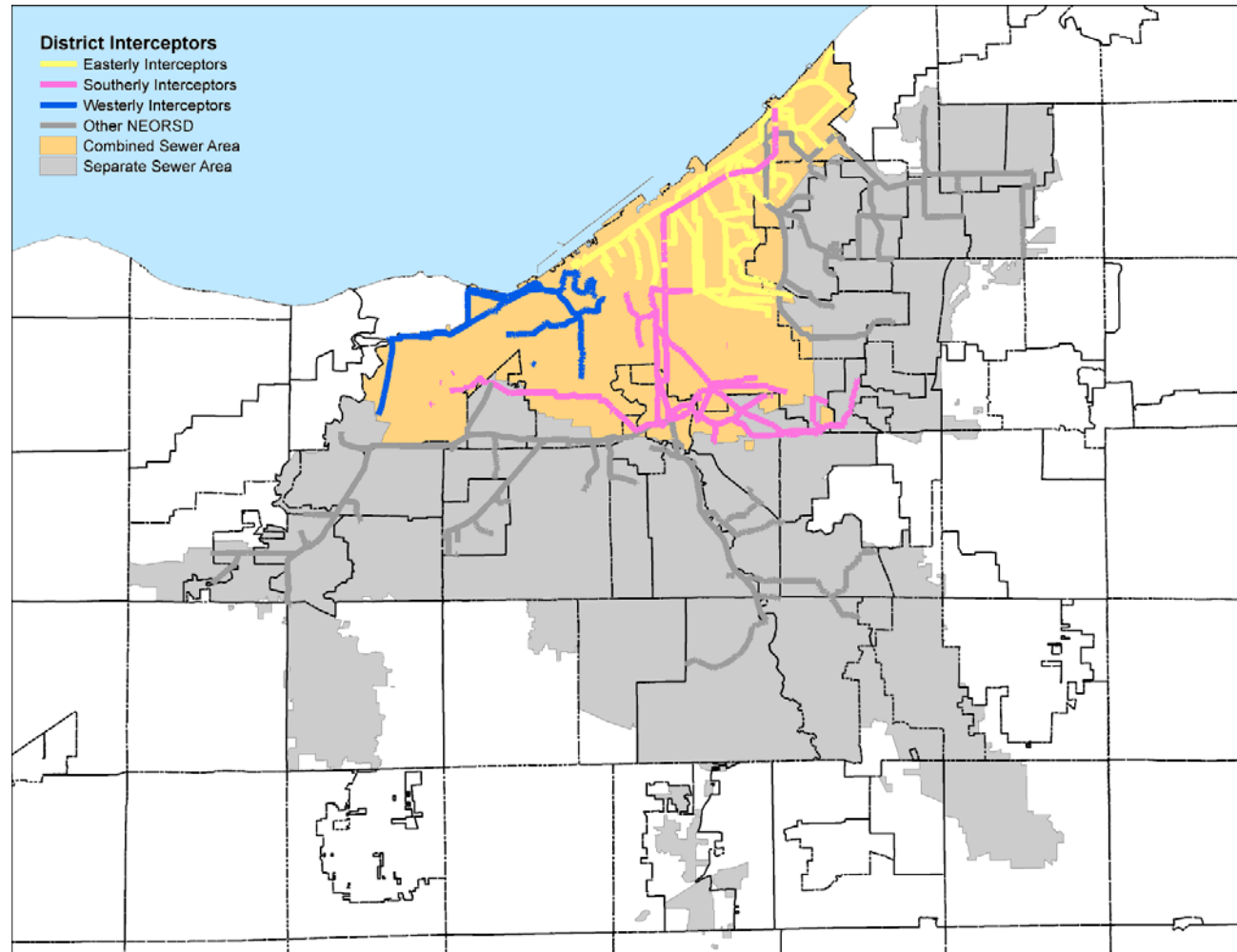
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Introduction

- Large, system-wide sewer system rehabilitation programs can take years to move from planning projects (inspection and condition assessment) to actual design contracts.
- Because of lengthy process and dynamic nature of infrastructure asset deterioration, the design engineer is often faced with decisions as to what previous inspection data can be used for the design, and what additional inspection is needed to complete the design.
- By recognizing these challenges early on, there are approaches to design that make the most efficient use of time and budget on these large-scale projects.

NEORSD Background

- ~ 61 municipalities served
- ~ 1 million customers
- 1995-2001: comprehensive inspection and condition assessment program
- ~ 1.2 million feet of sewer



Background

Rehabilitation Divided into 4 Contract Types	
Spot Repairs	Structural Rehabilitation/Replacement
Sewer Cleaning	Manhole Rehabilitation

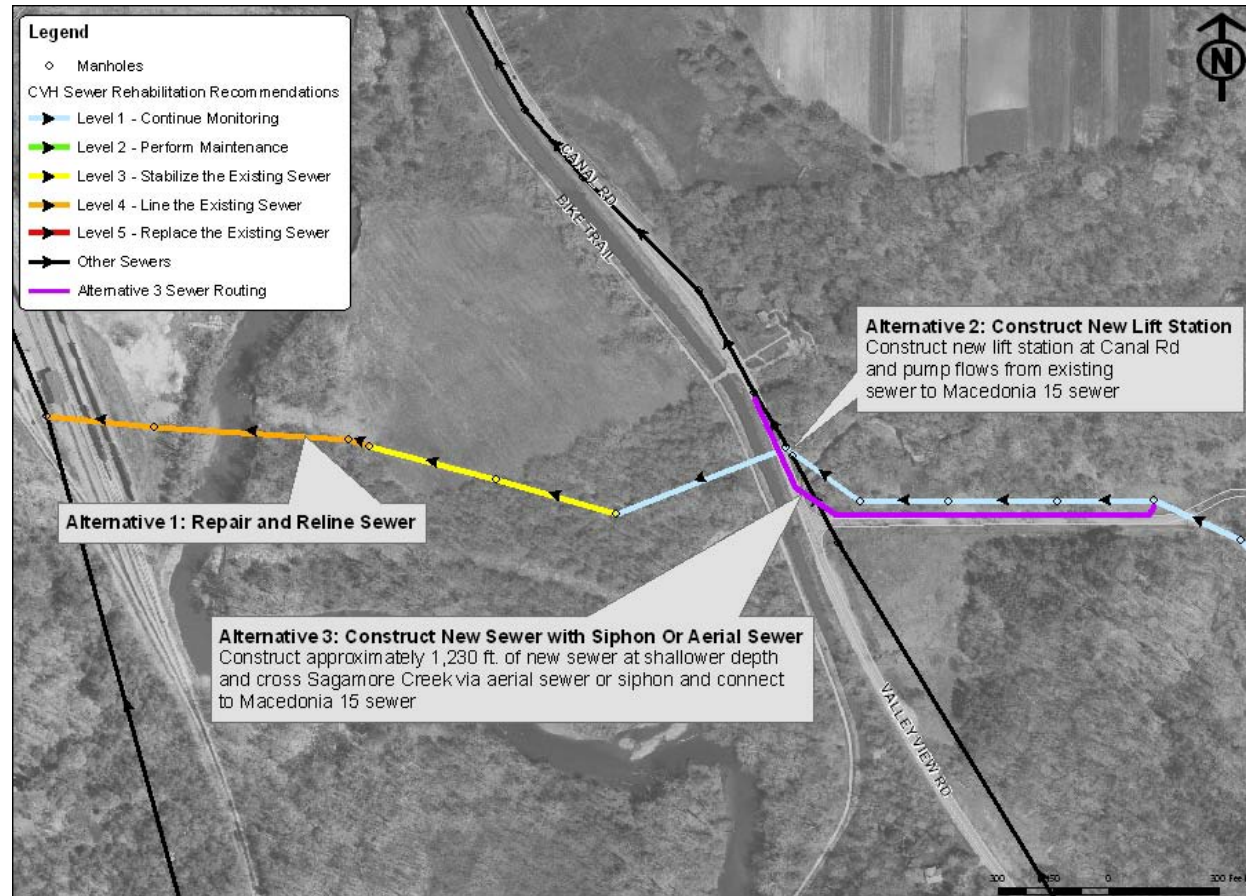
Project	Project Type	Total No. Reaches / Manholes	Total Footage	Engineer's Estimate of Cost	Bid Date - Construction Date
Easterly District Interceptors Service Agreement Contract (EDISAC)	Spot Repairs	153	56,756	\$ 2,300,000	2003 - 2005
Easterly District Interceptors Hydraulic Improvement Contract (EDIHIC)	Cleaning	276	69,200	\$ 4,713,000	2004 - 2005
Easterly District Interceptors Reline and Replace Contract (EDIRARC)	Lining/ Replacement	56	14,997	\$15,640,000	2005 - 2007
Southerly Westerly District Interceptors Hydraulic Improvement Contract (SWDIHIC)	Cleaning	94	29,700	\$ 2,750,000	2006 - 2007
Southerly Westerly District Interceptors Reline and Replace Contract (SWDIRARC)	Lining/ Replacement	56	11,400	\$13,765,000	2006 - 2008
Southerly Westerly District Interceptors Service Agreement Contract (SWDISAC)	Spot Repairs	207	49,669	\$3,935,000	2010 - 2011 (est.)
Manhole Rehabilitation Contract (MR-10)	Manhole Repairs	186	N/A	\$1,727,900	2007 - 2009
Total		1,028	231,722	\$44,830,900	2003 - 2011

Determine what is important

- To determine what new information is critical to the design of a specific type of rehabilitation, the first step is to determine what information is **most useful** and what information can be **reasonably assumed** or based solely on historical data.
- Each type of rehabilitation contract requires **varying types** and **levels of accuracy** of information. Therefore, each contract type is evaluated separately.
- The timing of the 7 construction contracts generated from the NEORSD Interceptor Rehabilitation Project was such that in some cases the second rehabilitation contract of any type was typically not bid until a significant portion of the first contract's construction was completed.

Interpret and Incorporate Historical Data

- Original inspections
 - 3 separate inspection contracts
 - 6 years
 - 9 different inspection contractors
 - 12 years old
- Rehabilitation recommendations
 - Provided planning level detail for pipes and manholes needing repair
 - Divided into: cleaning, spot repairs, lining, or replacement



Interpret and Incorporate Historical Data

Because of the large gap in time from inspection to design, plus the varying quality of previous inspections, several points must be considered when deciding what data is used in rehabilitation design:

Pipe Segment Refere...		City	Street	Material	Location C...	Sewer Use
WLA00065_042611		STRONGSVILLE	SPRAGUE	REINFORCED CONCRETE...	EASEMENT/R...	SANITARY
Upstream MH		Total Length	Year Laid	Shape	Location Details	
WLA00065		1366.7		CIRCULAR	@ MARKS	
DS Manhole		Length surveyed	Year Renew...	Height	Width	Pipe Joint...
WLA00060		1366.7		78	78	8
SPR	470	MPR	112	PO Number		Customer
SPRI	2.4	MPRI	1.1			BROWN AND CALDWELL
QSR	5A4C	QMR	2A1P	Work Order		Purpose
		G				ROUTINE ASSESSMENT
OPR	582	Surveyed By	Direction	Date	Media label	
OPRI	2.0	Dan_Zaffle	DOWNSTREAM	20110426	WLA	
		Certificate Number	Pre-Cleaning	Time	Weather	
		U-804-1527	NO PRE-CLEANING	11:11	SATURATED	
		Date Cleaned		End Time	Additional Info	
				11:58		

Distance	Condition	Cont. Dfct.	Values			Joint	Clock Position		Grade
			1st	2nd	%		AV/From	To	
0.0 ft.	Access Point Manhole					<input type="checkbox"/>			
Remarks: WLA00065									
0.0 ft.	Water Level				20	<input type="checkbox"/>			
0.0 ft.	Surface Reinforcement Visible Unknown	S01				<input type="checkbox"/>	7	5	5
0.0 ft.	Surface Reinforcement Visible	S04				<input type="checkbox"/>	7	5	5
28.4 ft.	Surface Reinforcement Visible	F04				<input type="checkbox"/>	7	5	5
28.4 ft.	Surface Aggregate Missing	S05				<input type="checkbox"/>	7	5	4
28.4 ft.	Surface Reinforcement Visible Unknown	F01				<input type="checkbox"/>	7	5	5
37.8 ft.	Deposits Settled Fine	S07			5	<input type="checkbox"/>	5	7	2
37.9 ft.	Alignment Right	S06			5	<input type="checkbox"/>			1
103.2 ft.	Deposits Settled Fine	F07			5	<input type="checkbox"/>	5	7	2
134.9 ft.	Surface Aggregate Missing	F05				<input type="checkbox"/>	7	5	4
134.9 ft.	Surface Spalling	S08				<input type="checkbox"/>	7	5	2
253.4 ft.	Water Mark				40	<input type="checkbox"/>			
423.7 ft.	Alignment Right	F06			5	<input type="checkbox"/>			1
765.7 ft.	Alignment Right	S09			5	<input type="checkbox"/>			1
805.6 ft.	Alignment Right	F09			5	<input type="checkbox"/>			1
805.6 ft.	Alignment Left				5	<input type="checkbox"/>			1
948.1 ft.	Surface Spalling	F08				<input type="checkbox"/>	7	5	2
1366.7 ft.	Access Point Tee Connection		24			<input type="checkbox"/>	8		
Remarks: WLA00060 BLIND JUNCTION									

- Sewers are dynamic environments where defect severity can increase unexpectedly over time.
- Repair quantities can be computed using inspection defect quantities but there are issues to consider.
- Original inspection data does not necessarily provide all the information needed for detailed design.

Interpret and Incorporate Historical Data

- One important advantage of collecting new inspection data during rehabilitation design is ability to compare past defect data to newly collected information
- Evaluate the rate of deterioration of certain defects.



East Wall 1997



East Wall 2006



West Wall 1997



West Wall 2006

Relining and Replacement Contracts

- 112 sewer reaches were identified as requiring complete structural rehabilitation or replacement and were broken into two separate construction contracts by area (EDIRARC and SWDIRARC).
- Relining contract for the NEORSD Easterly District (EDIRARC) was completed first and was comprised of approximately 15,000 lineal feet of lining in sewers ranging from 12 inches to 120 inches in diameter.
- Second relining contract for NEORSD Southerly and Westerly District systems (SWDIRARC) and was bid approximately 1-year into construction of EDIRARC. SWDIRARC was comprised of approximately 11,000 lineal feet of lining in sewers ranging from 8 inches to 141 inches in diameter.

Project Highlights

112 reaches

2 separate contracts

EDIRARC

15,000 LF

12-in to 120-in diameter

SWDIRARC

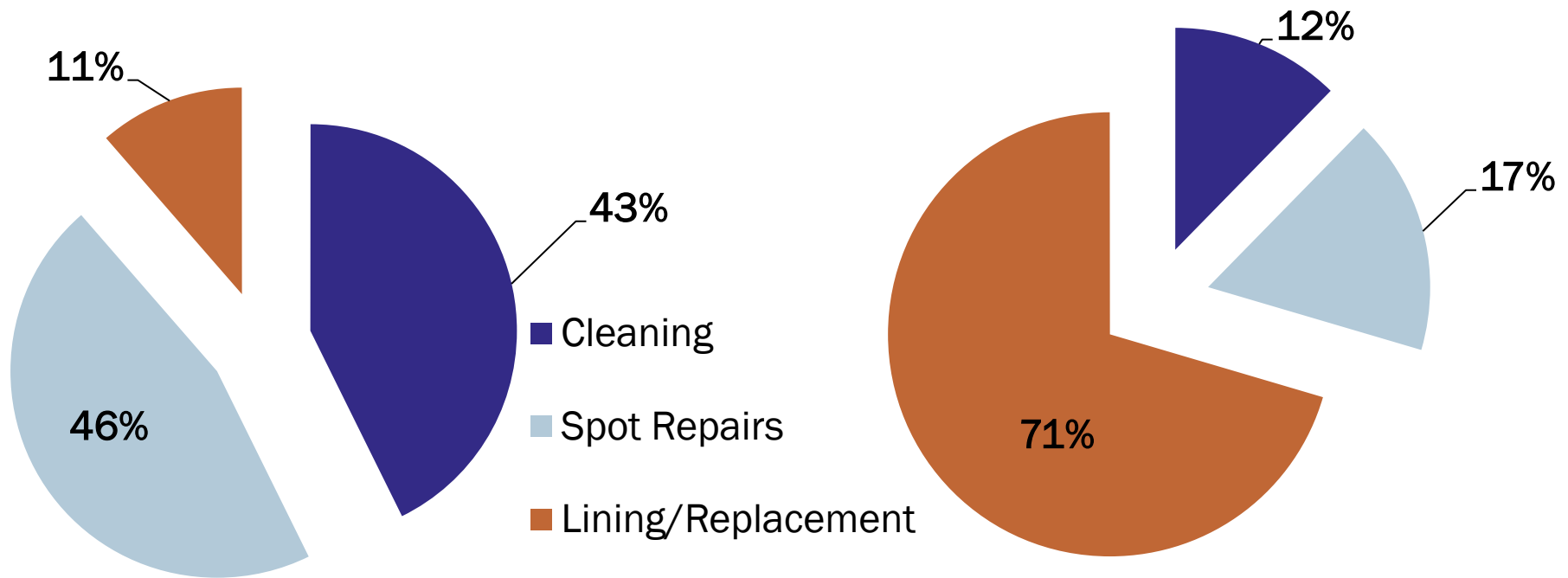
1 year later

11,000 LF

8-in to 141-in diameter

Relining and Replacement Contracts

- The amount of field information required for a successful sewer lining project is the most extensive and the accuracy of the data is the most critical.
- The relining and replacement contracts made up ~71% of the overall rehabilitation construction costs, but accounted for only ~11% of the overall rehabilitation footage.
- The amount of re-inspection was relatively small in the overall Interceptor Rehabilitation Project but considered to be well worth the cost.

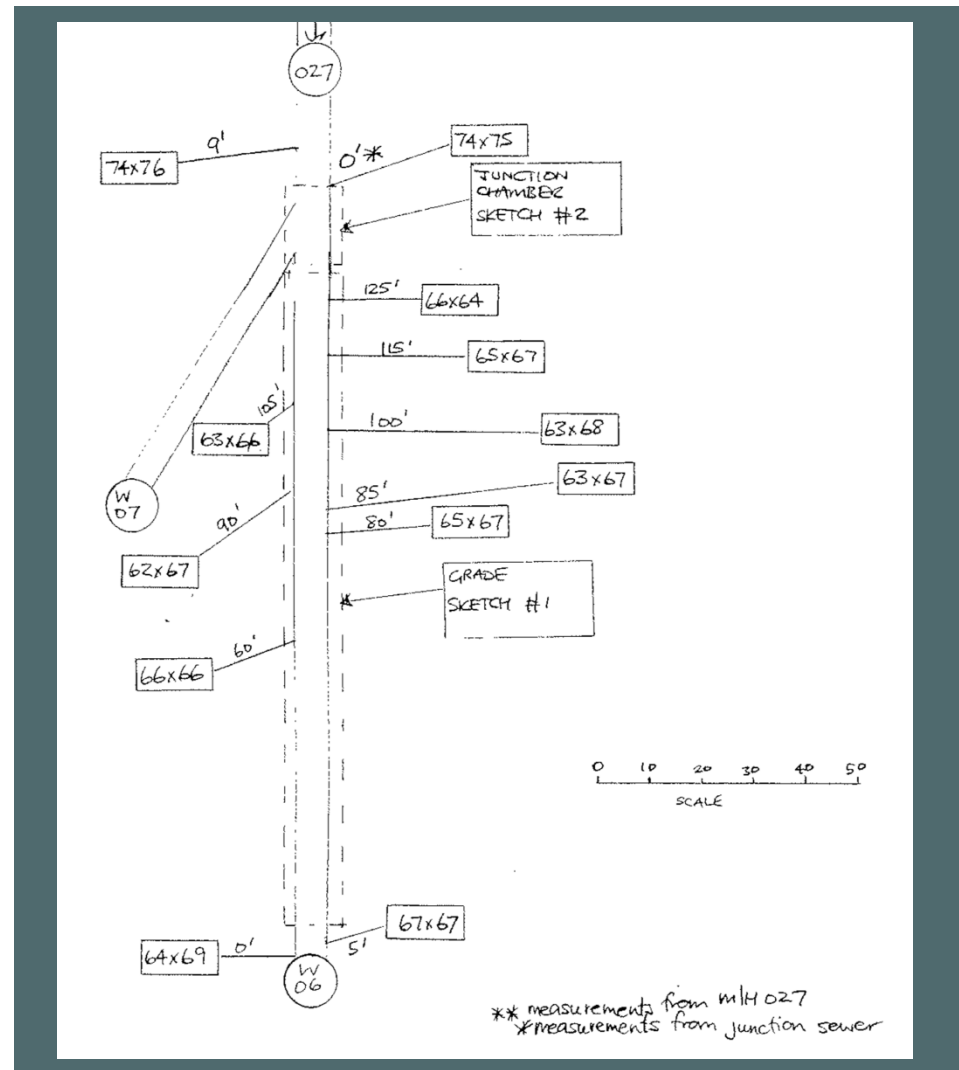


Project Types by Total Footage

Project Types by Construction Cost

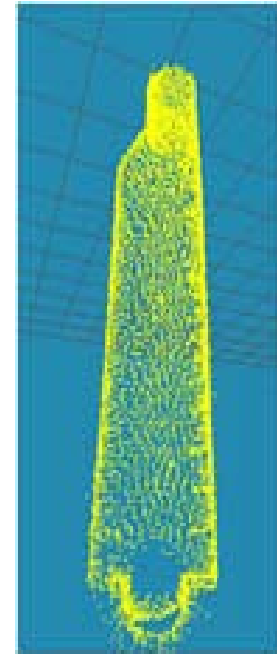
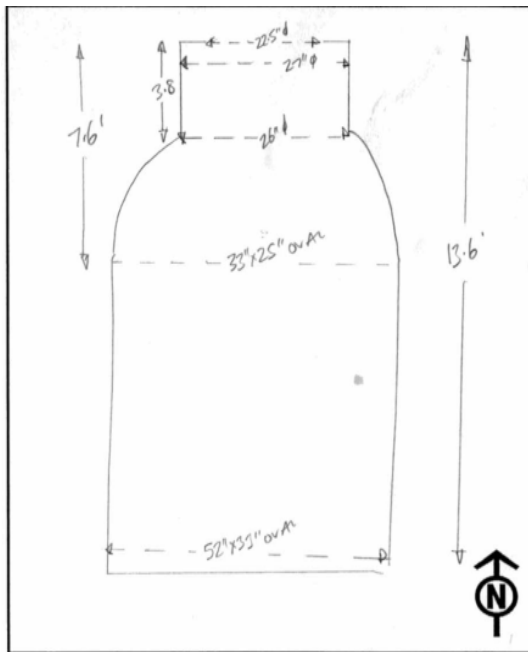
Relining and Replacement Contracts Design Approach – Pipe Inspections

- Full re-inspection of all pipe reaches
- Gather the critical data
 - Changes in Pipe Size
 - Changes in Pipe Configuration
- Not included in typical PACP inspection, but is easy and cost-effective for crews to gather

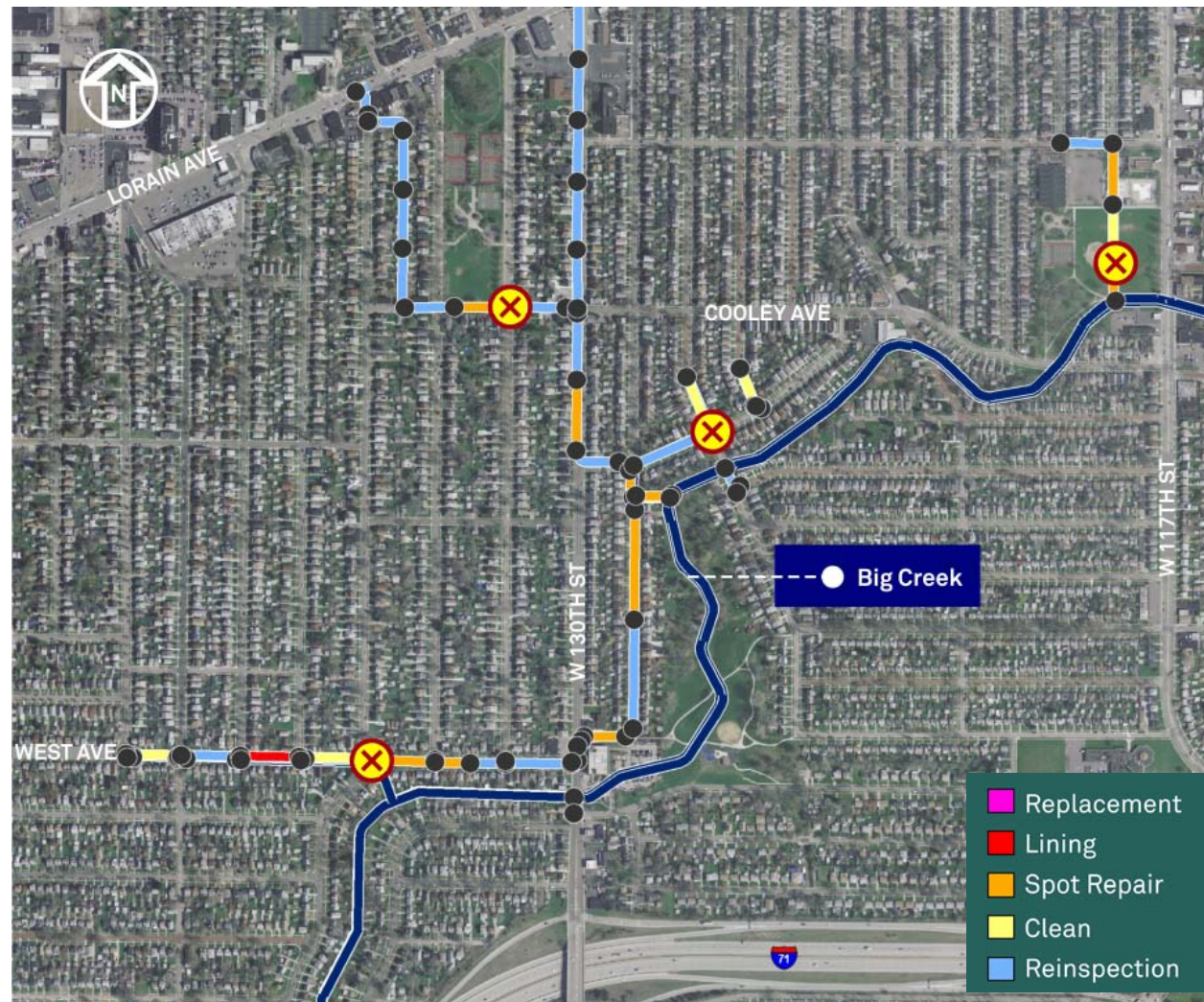


Relining and Replacement Contracts Design Approach – Manhole Inspections

- Where the contractor is using existing manholes to perform the lining work, the size and configuration of the structure is critical.



Relining and Replacement Contracts Design Approach – Debris Information



- Characterize debris:
 - Identify location and size of solid debris such as mineral deposits, construction material (concrete), and hardened material
 - Identify if any hazardous debris exists
- Because all 7 rehabilitation contracts would include some degree of sewer cleaning, a debris sampling and laboratory analysis effort was developed for the entire rehabilitation area.

Relining and Replacement Contracts

Lessons Learned

- Manhole measurements are important not just for where liners are inserted, but access for other contractor activities, such as bypass pumping, are just as critical
- Even small changes in pipe size, alignment and grade can affect the ability to install a liner



Spot Repair Contracts

- Approximately 104,000 feet of sewer at 360 sites make up the two spot repair contracts (EDISAC and SWDISAC). EDISAC construction was completed in 2005 and SWDISAC is projected to be completed in 2011.
- Open cut repair of the sewer was anticipated for only a small percentage of the 360 sites.
- A majority of the spot defects identified were in large diameter sewers and required trenchless, internal repairs (missing brick repairs, grouting fractures, missing mortar repairs, etc.). It was in these large-diameter, internal spot repair sites that the greatest potential for costly change orders were found and were, therefore, the focus of the field data collection efforts.
- Little design budget for re-inspection

Project Highlights

~ 104,000 LF
360 sites

2 spot repair contracts
2005, 2011

Few open cut sites

Majority defects in large-
diameter sewers

Spot Repair Contracts

Design Approach – Repair Extents

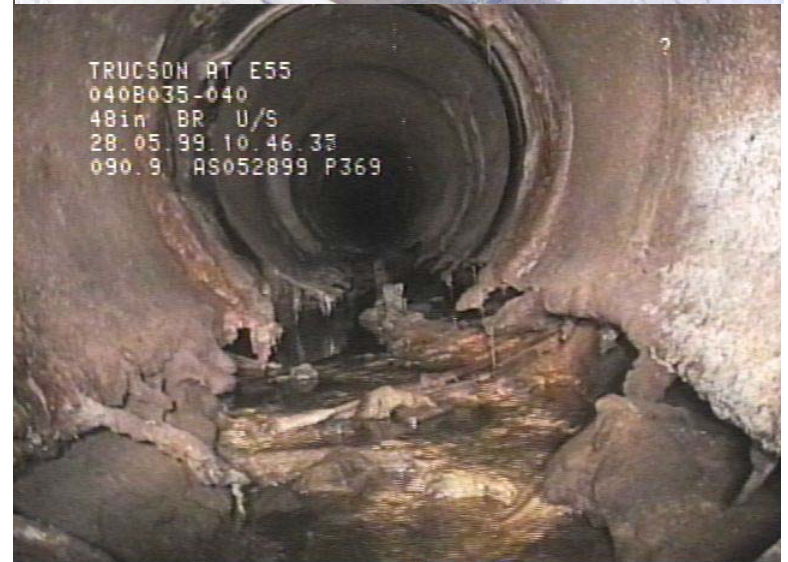
Key Issues

Actual extent of repairs

Unknown repairs

Deterioration beyond
spot repairs

Debris classification

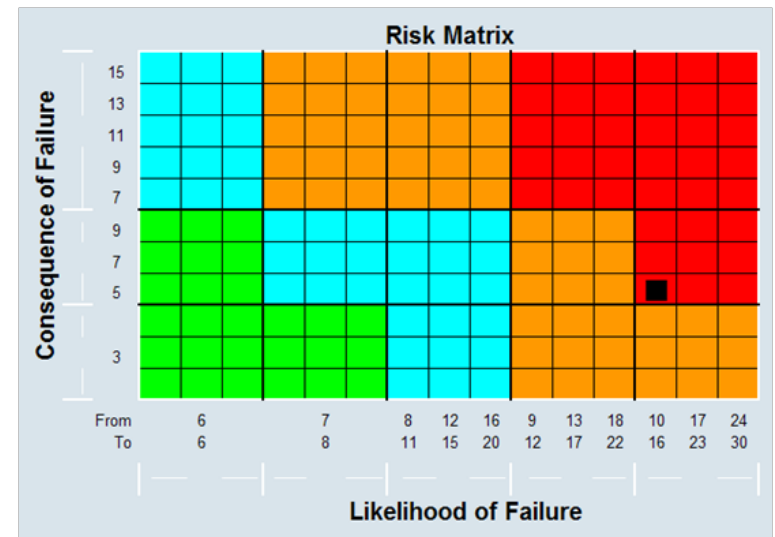


Spot Repair Contracts

Lessons Learned

A methodical approach was developed for selecting spot repair sites for re-inspection, based on a combination of the following :

- Criticality analysis – Focus on most critical sites
- Proximity to lining sites – Sewers adjacent to lining sites may also need to be lined
- Defects – Certain defects are more likely to progress where spot repairs are no longer feasible
- Wherever possible, flow control or bypass pumping should be performed during CCTV inspections (at least in brick sewers) to avoid surprises in pipe invert



Cleaning Contracts

- A total of 370 sites or 98,900 feet of sewer were included in the two NEORSD interceptor cleaning contracts (EDIHIC and SWDIHIC). EDIHIC was bid in 2004 and completed in 2005. SWDIHIC was bid in 2006 and completed in 2007.
- Like the spot repair contract, little or no additional CCTV inspections were performed during design of either contract.
- A debris sampling program was developed and wherever a sample was taken, debris depth measurements were also taken. This information was used to confirm debris depth estimates based on the original inspections.

Project Highlights

98,000 LF
370 sites

2 cleaning contracts
2005, 2007

Little additional
inspections performed
for design

Debris sampling program

Cleaning Contracts

Design Approach – Debris Characterization

Key Issues

Debris Quantities

Debris Type

Debris Characteristics

Sewer Access



Cleaning Contracts Lessons Learned

- Inaccuracies of estimated debris in the inspections
- Unforeseen conditions
- Estimated quantity of hard debris



Manhole Rehabilitation Contract

Project Highlights

186 manholes

1 manhole contract
(MR-10)
2007 - 2009

Rehabilitation:

- Manhole lining
- Raising manholes to grade
- Partial reconstruction
- Complete reconstruction

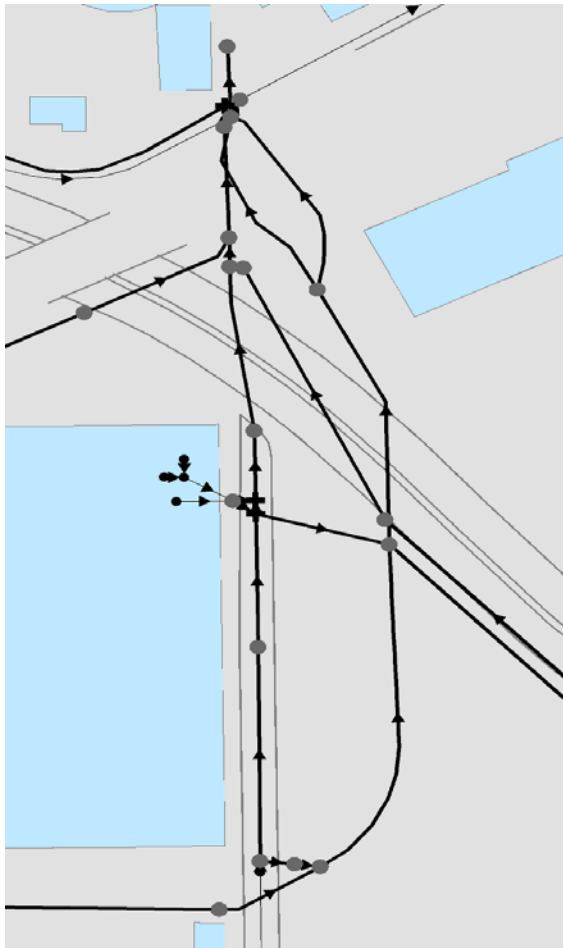


Manhole Rehabilitation Contract Design Approach

- Common work items included
 - Raising manholes to grade
 - Installing cementitious liners
- Minimal advantage to gathering additional detailed information on manhole defects



Manhole Rehabilitation Lessons Learned



- Construction drawings showed GIS mapping of project MHs
- Most common issue during construction was with mapping and access
- In some cases the repair work identified for the project was found to have been completed
- Quick site visits can prevent these issues



Next Phase

- The next round of rehabilitation, on the NEORSD's combined sewer overflow pipes, provides the opportunity to apply lessons learned and improve the design process
- The CSO system was also inspected as part of the system-wide inspection conducted from 1995 through 2001 which means that the inspections being used as a basis for rehabilitation design are up to 15 years old



Conclusion

- One of the key outcomes of the program is realizing the need to streamline the inspection and rehabilitation process thereby reducing the time delay between inspection and rehabilitation.
- Closing the time gap will help to improve confidence in the accuracy of the data available during design, however, some of the same issues will still have to be addressed by design phase field investigations.
- Budgets for additional field investigation during design will still have to be managed and utilized as efficiently as possible.
- Focus must remain on the most critical information required by contract type.

Questions

