Lessons Learned During Sewer Rehabilitation on Public and Private Property City of Westlake, Ohio

Presented by:

Scott E. Belz
Project Manager- URS Corporation

Robert P. Kelly, P.E.
Director of Engineering-City of Westlake

James J. Smolik, P.E.
Engineer-City of Westlake

City of Westlake Facts

- Founded in 1811
- Suburb of Cleveland, Ohio
- Mostly residential with light industrial and retail areas
- Population- approximately 34,000
- Daytime population exceeds night time.

City of Westlake Facts

- 16 Square Miles in Area
- 124 Miles of Storm Sewer
- 142 Miles of Sanitary Sewer
- Sanitary sewer is maintained by the City's Service Department.
- Projects are funded by Sewer Bill

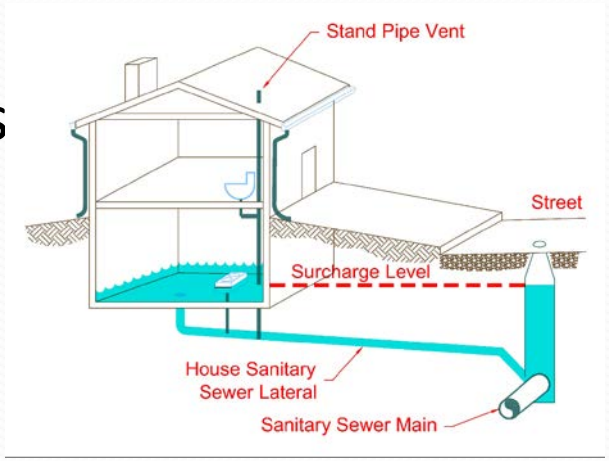
  Residential- Flat Fee- $35.00 Quarter

  Commercial- Rate based on usage

  Industrial- Rate based on usage

Westlake Flooding History

- Topography is flat with Storm Mains installed at minimum slopes
- Surface water flooding of streets and yards during intense rainfall events
- Surcharging of sanitary sewers within basements
- Flooding follows flood plain maps for area



I/I Program General Characteristics

- All homes within the project areas were built between the 1950's and 1970's
- Homes had separate Storm and Sanitary Sewers
- Many of the homes had septic tank conversions
- The majority of homes have downspouts connected to storm sewers that are not splash blocked.
- All areas experienced basement flooding.
- Areas of rehabilitation were initially based on complaints.

I/I Program Introduction

- In 1992, City implemented Inflow/Infiltration (I/I) Removal Program based on flooding and other sewer problems
- Since 1992, Eight (8) Study Areas have been investigated
- I/I Investigations were conducted for each project area by Contractors or Engineering Consultants
- In 2012 a City Wide Flow Metering Project was performed to help direct future I/I programs

Sewer Rehab. Project Areas

	Homes Tested	Homes Rehab.
King James Subdivision		
• $340,000 Lateral ($340,000 Total)	130	50
Salem-Radcliff Subdivision		
• $100,000 ($300,000)	103	46
Berkeley Estates		
• $545,000 ($630,000)	177	89
Canterbury Area		
• $870,000 (1,160,000)	261	136
Westhill,Allen & Melrose Area		
• $300,000 ($550,000)	97	57
Cornwell,Bonny Bank & Arthur		
• $180,000 ($330,000)	48	36
Total		
$2,335,000 ($3,310,000)	816	417

I/I Investigations

- I/I Investigations consisted of some or all of the following:
  - Smoke Testing
  - Mainline Dye Testing
  - Manhole Inspection
  - Residential Dye Testing
  - CCTV Inspection
  - Wet Weather CCTV Inspection
- Each Area had similar defects and similar recommendations to cure.

Project Evolution

- Lessons Learned from previous projects
  - Flow Monitoring
  - Testing (I/I Investigations) and Design Phase
  - Construction Phase
- Created an opportunity to improve efficiency and reduce cost.
- Building Blocks for future projects

Lessons Learned

- Each sewer rehabilitation project provided valuable information in all areas of the program:
  - New testing techniques
  - Field data research
  - Product selection
  - Engineering specifications
  - Value Engineering
  - Engineering controls
  - Rehabilitation methods and means

King James Subdivision

Project Scope

- Work performed in 1992
- Initial I/I Investigation was performed with smoke testing by a contractor.
- Rehabilitation performed
  - Manholes Sealed
  - Sanitary mainline was lined by CIPP from MH to MH

King James Subdivision

Project Issues

- Still had flooding problems after project was completed
- No flow monitoring pre or post
- Only sanitary mainline and manholes were rehabilitated
- No rehabilitation work was performed on the laterals
- Initial smoke testing did not indicate significant problems with sanitary laterals.

King James Subdivision

Projects Issues

- Revisited area since problem was not solved
- Flow monitoring was performed that indicated I/I was still a problem.
- Since the sanitary main was rehabilitated-laterals need to be explored.
- So all houses were dye tested from the downspouts by a contractor.
- All homes with positive dye transfer were rehabilitated
  - Cleaned and televised both laterals
  - Point repairs were performed
  - Sanitary connection were grouted from Main to House

King James Subdivision

Who Pays?

- City Council agreed that Residents would pay for:
  - Structural repairs outside the ROW
- City Council agreed that the City would pay for:
  - All work performed in the ROW
  - Lateral grouting outside the ROW
- Result:
  - Only $5,000 of the $338,000 rehabilitation fell under the owner's financial responsibility. 1.5% of the Contract

King James Subdivision

Project Setbacks

- Attempted to solve problem by addressing the mainline only
- The assessment to the homeowners was insignificant and caused more aggravation then good.
  - So the home owner fee was waived.
- Initial phase of project had no flow monitoring

King James Subdivision

Project Successes

- Post flow monitoring performed indicated a drastic decrease in I/I
- No flooding problems since

King James Subdivision

Lessons Learned

- Both the private and public side of the sanitary sewer needs to be addressed to eliminate I/I
- Work on the private side was more beneficial than originally thought.
- Pre and Post Flow monitoring is critical in determining success of the project
- These types of projects are now funded 100% by the City

Salem-Radcliff Subdivision

Project Scope

- Work performed in 2001
- The I/I Investigation was performed by a contractor
- All homes were dye tested from downspouts (one at a time).
- Homes that had dye transfer to the sanitary were rehabilitated:
  - Both storm and sanitary laterals exposed
  - Cleaned and televised both laterals
  - Point repairs were performed
  - Sanitary connections were rehabilitated by CIPP
  - New cleanouts installed
- No testing or work occurred for the sanitary mainline.

Salem-Radcliff Subdivision

Project Scope

- Rehabilitation of the laterals was done with CIPP
  - Installed from excavated entry pits and liner inserted with rods, not pressure
  - Steam Curing
  - CIPP provided structural improvements over grout.
- Testing
  - Pre and Post flow monitoring
  - Pre and Post dye testing
- Manhole Rehabilitation
  - Manhole Sealing was sprayed-on Polyurethane Liner from invert to casting.

Salem-Radcliffe Subdivision

Project Successes

- Post dye testing verified infiltration was mitigated
- Rehabilitation reduced basement flooding and service calls
- Similar rain events for pre and post flow monitoring indicated the surcharge depth reduced from 50” to 12”
- Provided the knowledge and expertise to establish direction for future I/I projects:
  - I/I Investigation (testing)
  - Design
  - Construction

Salem-Radcliffe Subdivision

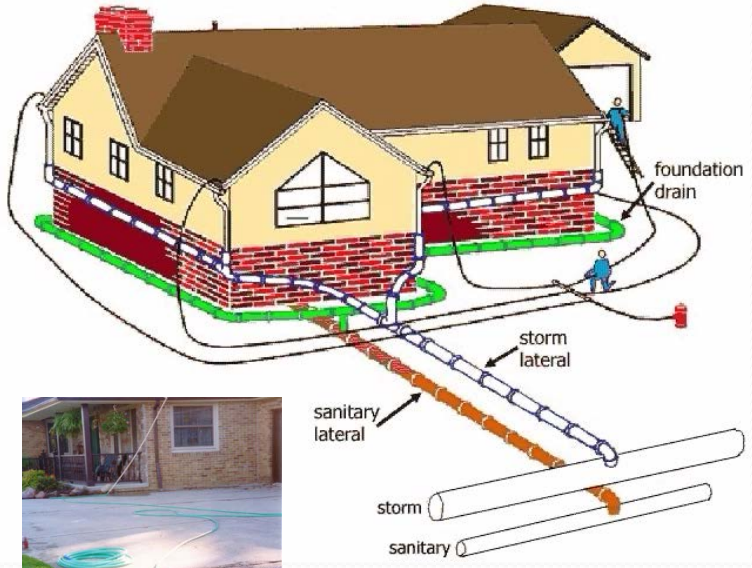
Lessons Learned

- More data needs to be gathered from the I/I Investigations
- Field reconnaissance of homes to be rehabilitated should be done during design
  - Size of connections
  - Pipe layout
- The sanitary main needs to be evaluated during the I/I Investigations
- CIPP was added to the methods of rehabilitation since we had success using it.
- The pre and post flow monitoring established a good benchmark of success.
- Grade ring area of the manhole needs to have a flexible product installed.

Berkeley Estates Area

I/I Investigation Reformed

- It became clear to the City that accurate and detailed pre-testing was essential to identify homes contributing I/I to the sanitary sewer.
- So a professional consultant was chosen to perform the initial testing as opposed to a contractor.
- URS performed the initial testing and analysis of data
- Residential dye testing was performed with a garden hoses and a manifold connected to a fire hydrant.
- Simultaneous testing of multiple downspouts could be performed as opposed to one.



Berkeley Estates Area

I/I Investigation Reformed

- Mainline sanitary dye testing was performed by initiating a surcharge within the storm main with dye.
- The sanitary main was televised to locate infiltration of dye from the above testing and non-conforming issues.
  - Joints
  - Laterals
- If clear water was seen at the sanitary connection it was also noted. Homes were checked to verify no water was being used.

Berkeley Estates Area

Project Scope

- Work performed in 2004
- CIPP Lateral rehabilitation was done in the same fashion as previous project with the following changes
  - A pressure launching vessel was used for inversion
  - The lateral to mainline interface was grouted with a lateral packer
  - Ambient cure was used
- Sanitary Mainline
  - Sectional chemical grouting of joints
- Sanitary Manhole Rehabilitation
  - Cementitious coating
  - Flexible urethane product was used at grade ring

Berkeley Estates Area

Project Setbacks

- Some failures of the CIPP lining occurred. Probably from ambient cure in cool weather
- A carpet roller was used in lieu of a nip roller to wet out the liner. This could have resulted in some failures of the lateral CIPP
- The majority of the storm and sanitary laterals were more then 10’ apart. So an additional excavation had to occur since both could not be exposed in the same pit
- The storm main was not inspected prior to project and many point repairs had to occur

Berkeley Estates Area

Project Successes

- Rehabilitation reduced basement flooding and service calls
- Similar rain events for pre and post flow monitoring indicated a reduction the surcharge depth reduced from 24” to 4”
- Manhole sealing was more cost effective than previous project (Salem-Radcliffe)
- Previous experience made this project easier to prepare specifications and manage project

Berkeley Estates Area

Lessons Learned

- Testing requirements need to be established to verify that the CIPP liner has meet the performance strength requirements in the contract documents.
- Vacuum testing of the sanitary manholes needs to be implemented
- Laterals with mineral deposits at main were not addressed even though they showed signs of infiltration

Berkeley Estates Area

Lessons Learned

- A method needs to be established on how to deal with branch connections
- The storm main needs to be televised prior to bid to locate the laterals and determine the condition as similar to the sanitary main
- Air testing needs to occur to verify a tight seal at the lateral to mainline interface
- Value engineering of products is essential for maintaining budgets.
  - For example MH Rehab. with cementitious coating

Canterbury Area

Project Scope

- URS performed the I/I Investigation
- Work started in 2007
- CIPP Lateral rehabilitation was done in the same fashion as previous projects with the following changes for homes that failed the dye test.
  - Specification changes for additional entry pits for storm
  - Both epoxy and polyester resins were used for the felt liners
  - The contractor used ambient, hot water and recirculating hot water cure
  - The contractor used a pressure launching vessel and a pressure shooter for inversion
- Sanitary Mainline and Manhole Rehabilitation
  - No change from previous project

Canterbury Area

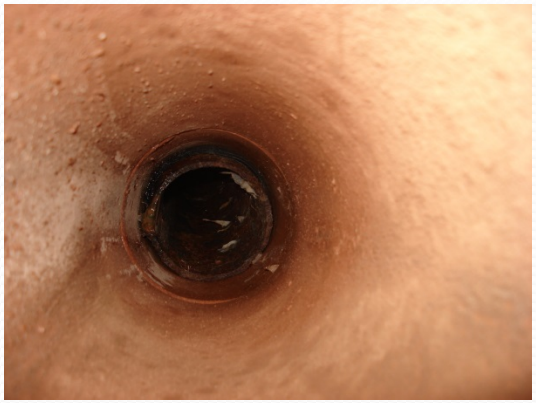
Project Scope

- Laterals with mineral deposits at main were not addressed.
- New Testing Procedures
  - Vacuum testing of rehabilitated sanitary manholes
  - Air testing from CO to main of lined laterals to verify lateral to mainline interface is water tight
  - Physical testing of CIPP samples to verify strength parameters
- Storm Main
  - Prior to bid all the storm mains were cleaned and televised. This aided the contractor in locating the storm cleanouts from the CCTV reports.
  - Storm point repair also were performed

Canterbury Area

Project Setbacks

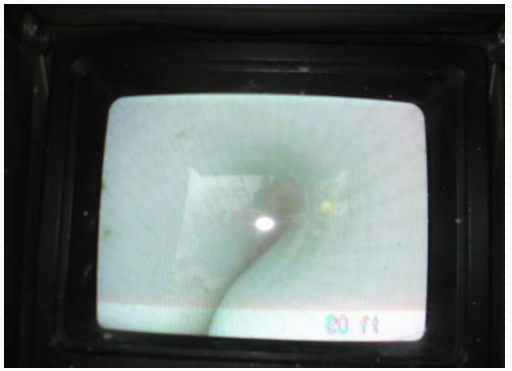
- The majority of the homes had branch connections due to septic tank conversions that could not be lined
- Some homes failed the post dye test
  - The unlined branch connection had infiltration from a compromised DS leader
  - The liner had to end short of the foundation due to a 4” reducer



Canterbury Area

Project Setbacks

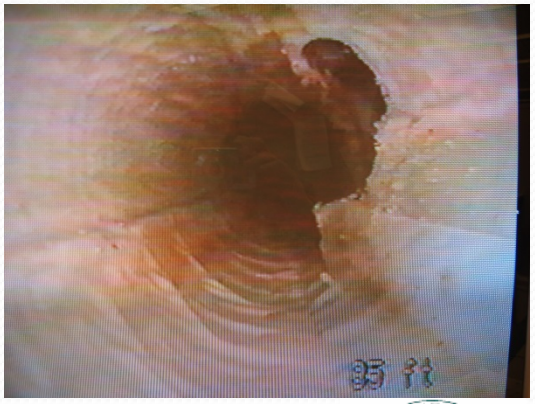
- Some CIPP laterals failed due to workmanship
  - The resin was not cured properly
  - The resin was not properly measured due to faulty equipment
  - The calibration bladder was pulled prior to cure
  - Calibration bladder was installed to short
  - The liner was installed to short from pit to main



Canterbury Area

Project Setbacks

- For some homes the downspout leaders were compromised from roots and or broken pipe
- Some of the sanitary laterals wrapped around the rear of the house with footages beyond 100’
- Reinstatements of branch connections by open cut with a saw yielded frayed edges.



Canterbury Area

Project Successes

- Rehabilitation reduced basement flooding and service calls
- Similar rain events for pre and post flow monitoring indicated the surcharge depth reduced from 111” to 28”
- The changes in the specifications minimized change orders

Canterbury Area

Lessons Learned

- The status of the existing downspout leaders and storm connection is critical.
- If the storm connection is compromised then eliminating I/I on the private side will be difficult
- More research needs to be done during the design to verify the estimated footages of the sanitary connections and the number of possible branch connections by reviewing basement plumbing

Canterbury Area

Lessons Learned

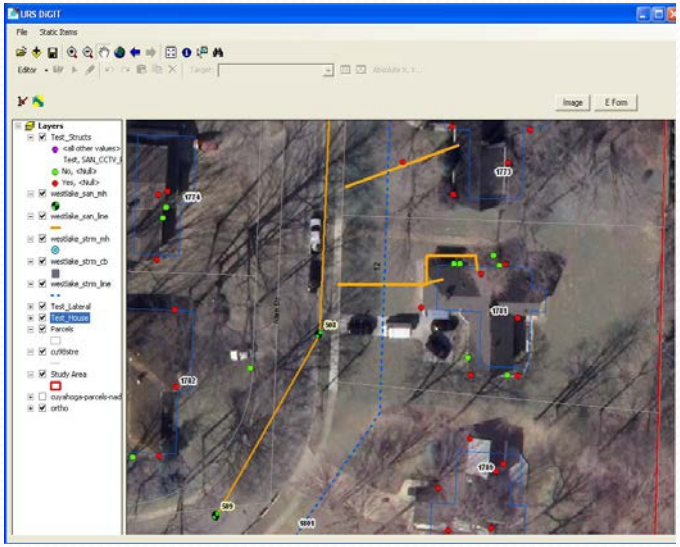
- Testing of the CIPP liners indicated drastic changes between methods

Sample Number	Flexural Strength (psi)	Flexural Modulus (psi)	Curing Method	Resin Type
1	1,364.00	57,845.00	Ambient	Polyester
2	1,278.00	59,451.00	Ambient	Polyester
3	1,441.00	66,497.00	Ambient	Polyester
4	6,228.00	182,610.00	Hot Water	Polyester
5	6,547.00	287,800.00	Hot Water	Polyester
6	7,429.00	260,000.00	Hot Water	Polyester
7	5,697.00	254,186.00	Hot Water	Polyester
8	7,659.00	350,719.00	Hot Water	Epoxy

Melrose Area & Westhill /Allen

Phase 1 Testing (I/I Investigations)

- Dual CCTV cameras were used to assist with the residential dye testing.
- URS performed the initial testing in 2008
- About 170 home were dye tested. Mainline testing did not change
- Residential Dye-Testing was changed from previous studies to evaluate the status of the storm connection as well.
- Testing data stored in a GIS environment



Melrose Area & Westhill /Allen

Phase 1 Testing

- Duel Camera Testing Set-Up
  - 1st Camera monitoring –storm connection
  - 2nd Camera monitoring – sanitary connection

- Advantages with this set-up
  - Both the storm and sanitary are monitored for each house
  - Identify if the storm connection is compromised
  - Provides priceless information to owner in protecting their basement from flooding.
  - Storm main was televised in the process.

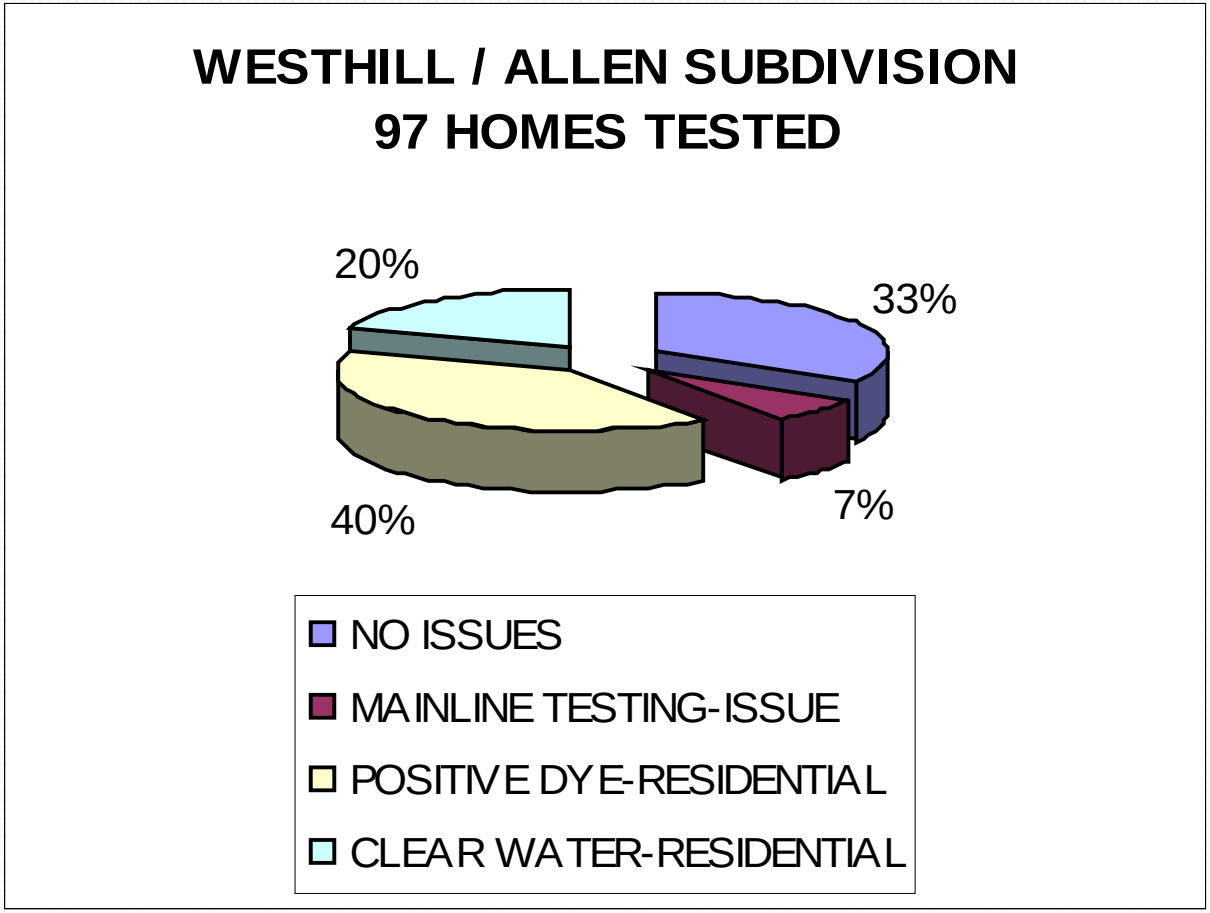
Melrose Area & Westhill /Allen

Address *1248 E Melrose* **General Comment**

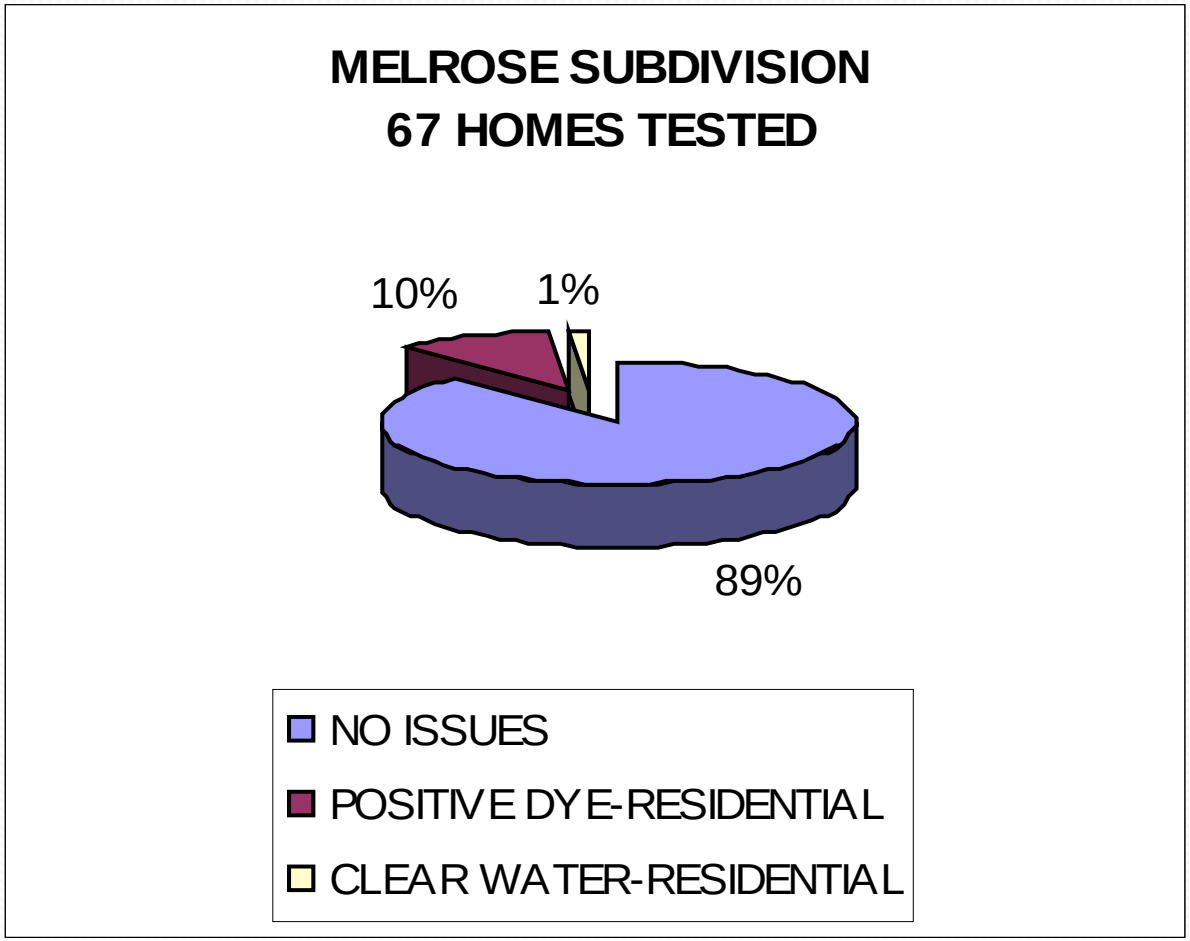
TestID	Structure	Location	Description	Test	Dye Color	Sanitary CCTV Results	Sanitary Est. Flow (GPM)	Sanitary CCTV Section	Storm CCTV Results	Storm Est. Flow (GPM)	Storm CCTV Section
256	Sump pump	In House	Connected	No		Could Not Observe	None	38	Could Not Observe	None	38
	Comments	No one home at time of test									
176	Downspout	Middle Right	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
175	Downspout	Rear Right	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
174	Downspout	Rear Middle	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
173	Downspout	Rear Middle	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
172	Downspout	Rear Middle	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
171	Downspout	Front Left	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
170	Downspout	Front Left	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
169	Downspout	Rear Middle	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
168	Downspout	Front Middle	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										
167	Downspout	Front Right	Connected	Yes	Green	Positive	3-5 gpm	38	Positive	5-8 gpm	38
	Comments										

Phase 1 Testing – Data Example

Melrose Area & Westhill /Allen



Melrose Area & Westhill /Allen



Melrose Area & Westhill /Allen

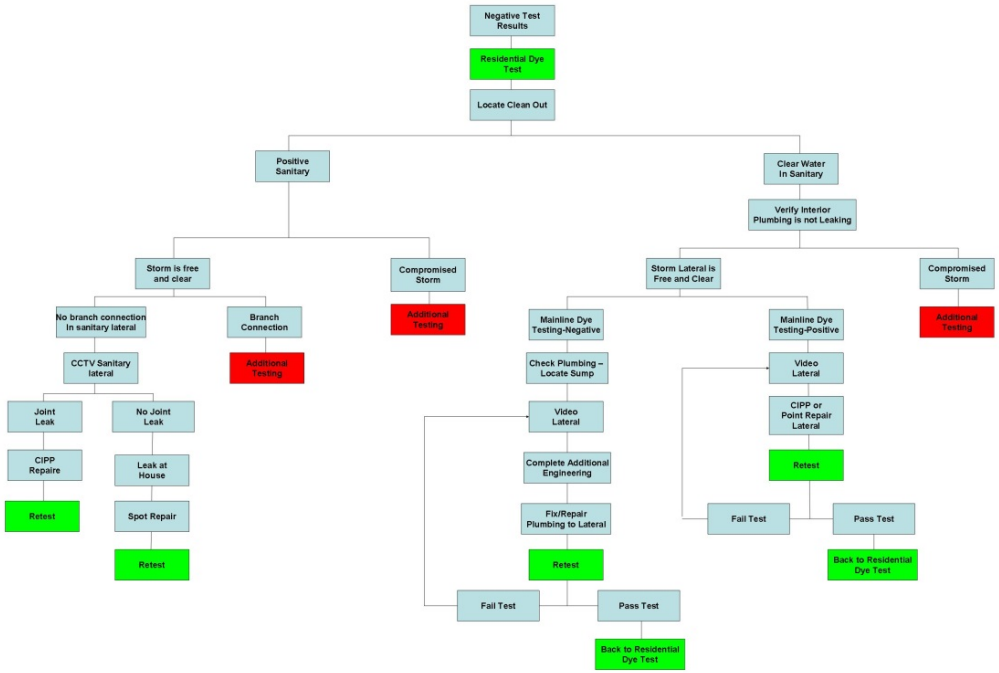
Phase 2 Testing (I/I Investigation)

- Homes that had positive dye transfer or clear water seen in the sanitary sewer were red flagged.
- Homes red flagged in the Phase 1 Testing had both the storm and sanitary cleanouts exposed by the City's Service Department
- Scheduled additional testing for the red flagged homes .
- Phase 2 testing was performed from the cleanouts with the use of a push camera by the City's Engineering Department.
- Re-create positive dye test from URS report
- Testing determined "HOW" infiltration or inflow occurred at each house.

Melrose Area & Westhill /Allen

Phase 2 Testing

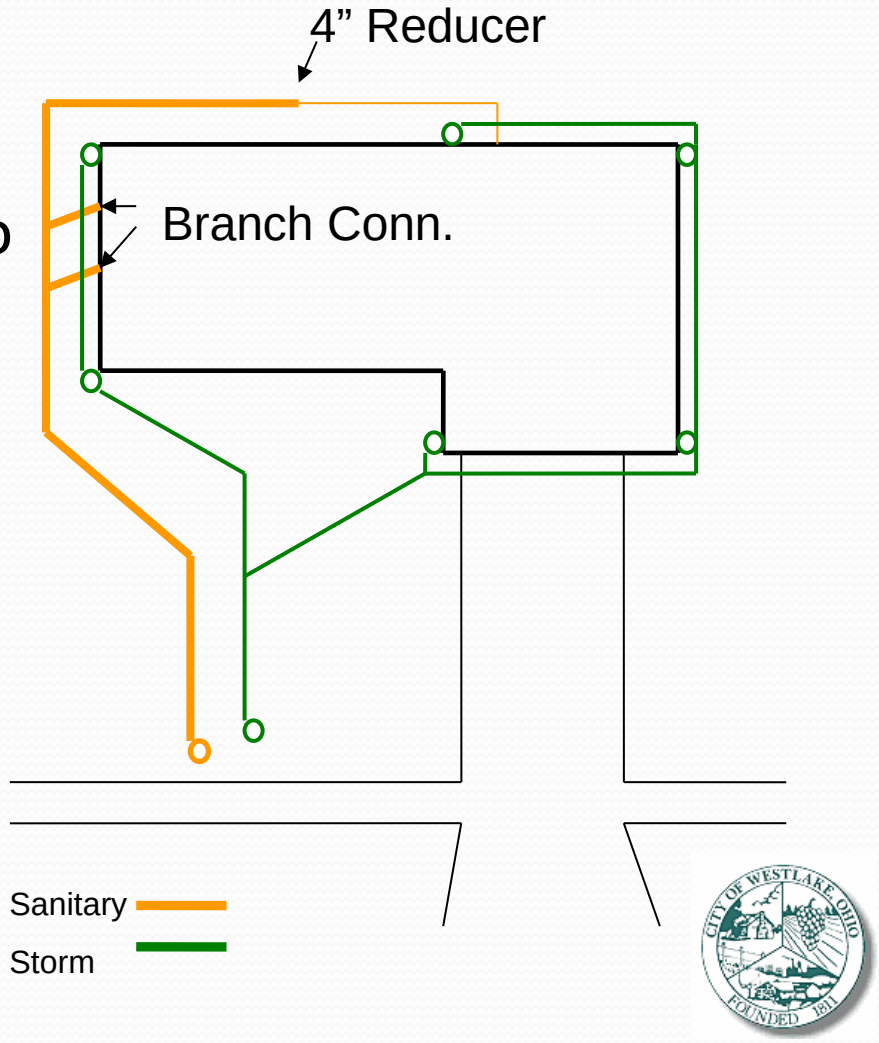
- Locates deficiency in sewer system
- Systematic Flow Chart Used
- Establish budget for rehabilitation
- Determines type of rehabilitation:
  - Point Repair
  - Cleaning
  - CIPP
  - Grouting



Melrose Area & Westhill /Allen

Phase 2 Testing

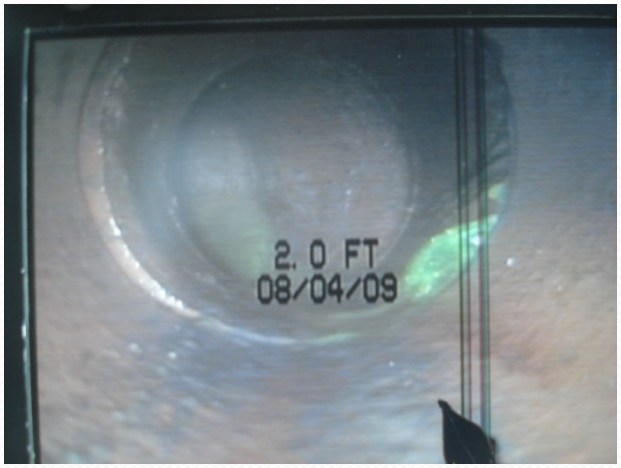
- Identified limitations to CIPP Lining
  - Branch Connections
  - 4” Reducers
  - Long Runs



Melrose Area & Westhill /Allen

Phase 2 Testing

- Common found deficiencies
  - Sanitary Joint Infiltration
  - Compromised DS Leader
  - Storm Connection blocked



Melrose Area & Westhill /Allen

<u>Phase 2 Testing Changes Rehabilitation</u>

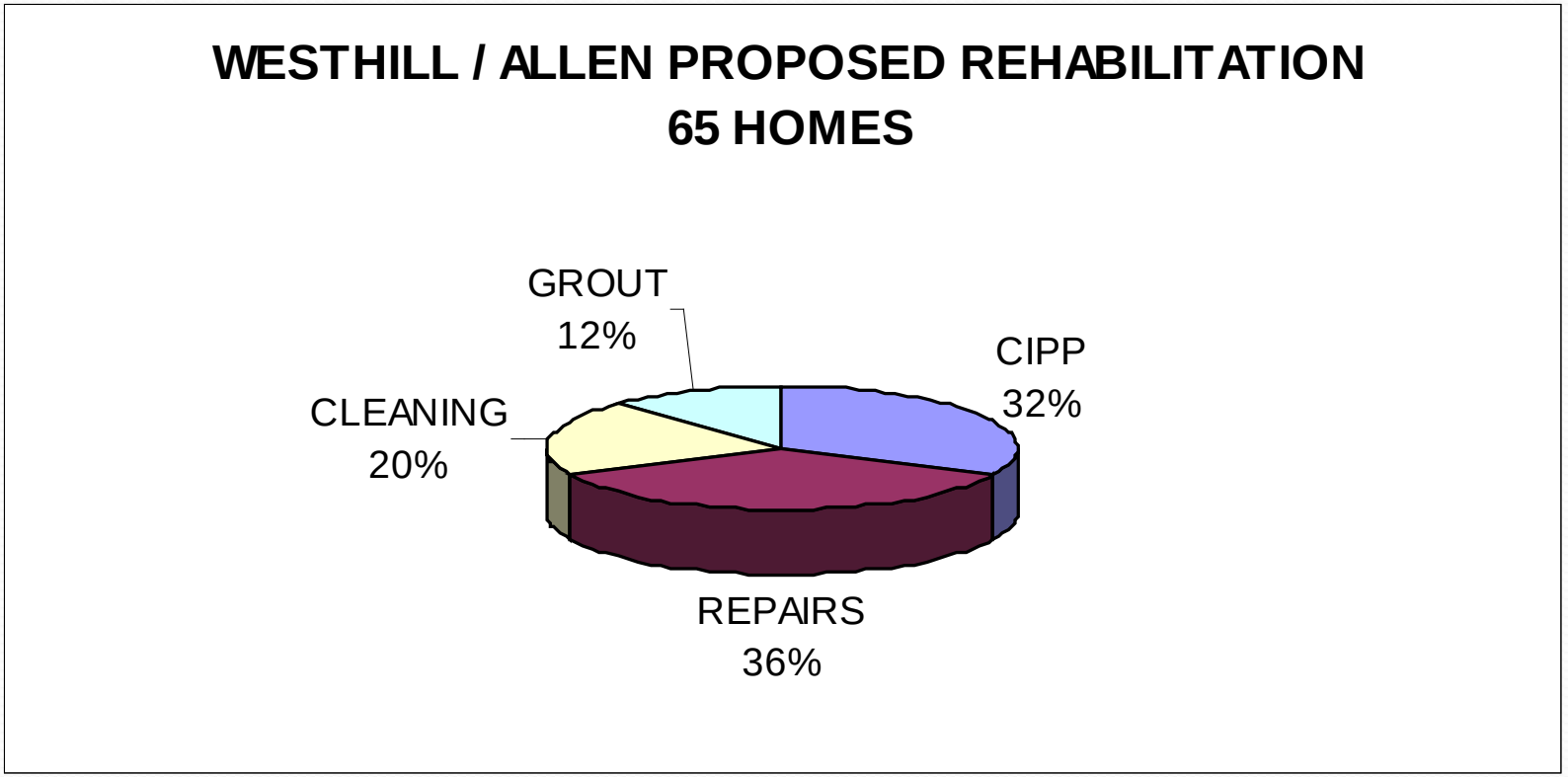
- Historical Method
  - Use CIPP Lining
    - Positive Res. Test
    - Clear Water Infiltration
    - Positive Mainline Test
- New Approach
  - Use all the tools in the tool box
    - Grouting
    - CIPP
    - Cleaning
    - Point Repairs
  - Use appropriate method of rehab.
  - Do not rely solely on CIPP.

Melrose Area & Westhill /Allen

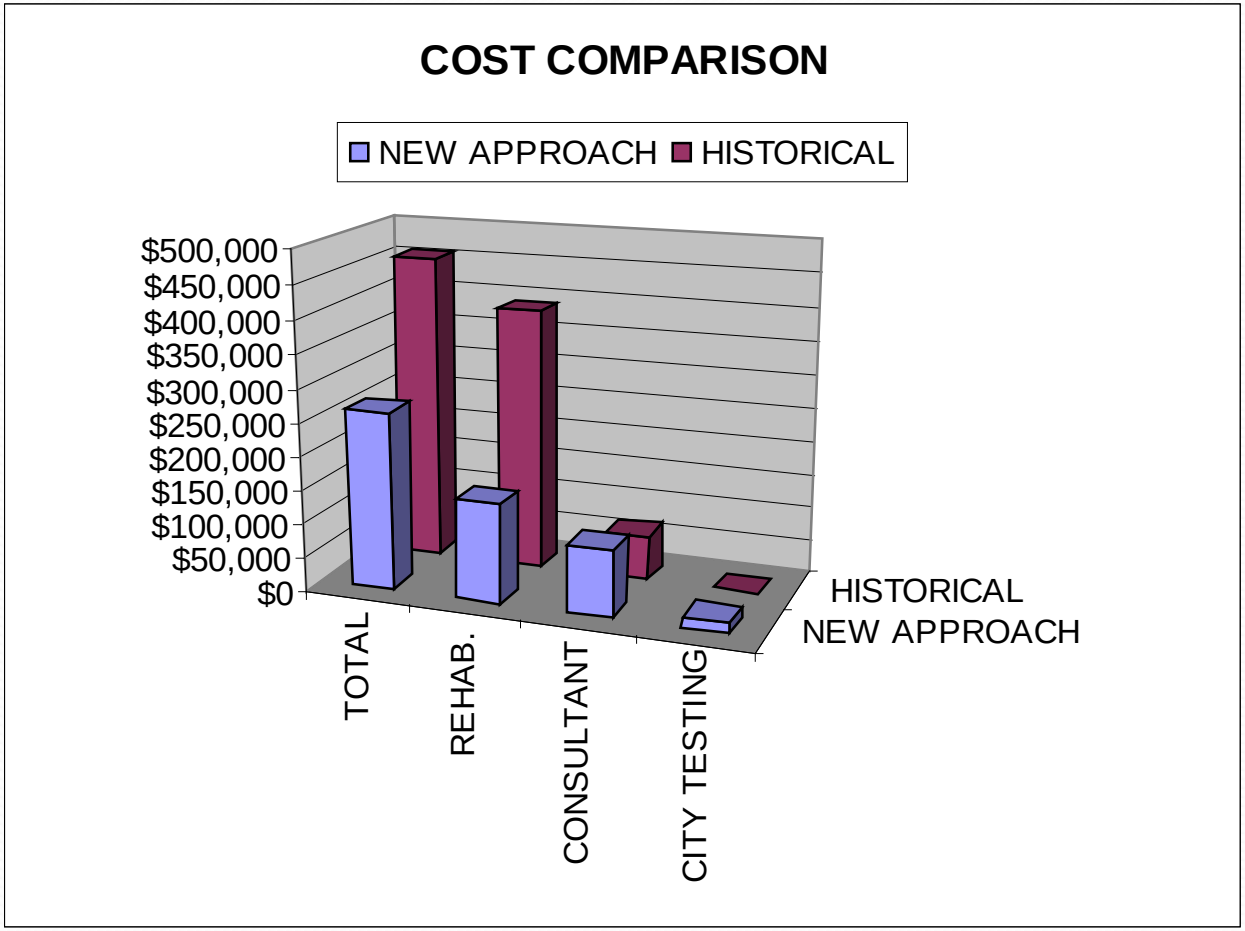
Project Scope

- Work occurred in 2010
- No work occurred for the Melrose area because the amount of homes contributing I/I was low
- Phase 2 testing identified the point specific rehabilitation required for each house on the private side.
  - Grouting
  - CIPP
  - Point Repair
  - Cleaning
- Mainline chemical grouting was done from MH to MH. No sectional grouting
- All sanitary lateral to mainline interfaces were grouted.

Melrose Area & Westhill /Allen



Melrose Area & Westhill /Allen



Melrose Area & Westhill /Allen

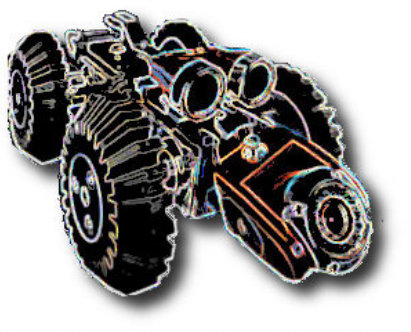
<u>Rehabilitation Savings</u>

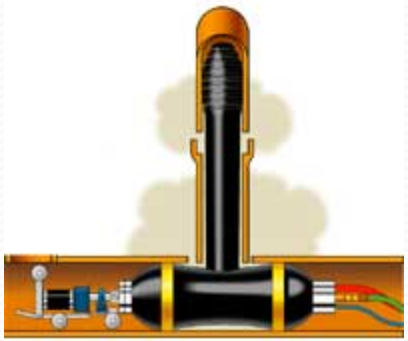
- Total Savings – 43%
  - Historical - $456,000
  - Phase 2 - $264,000
- Rehab. Savings – 62%
  - Historical - $390,000
  - Phase 2 - $149,000
- Testing Increase -77%
  - Historical- $66,000
  - Phase 2- $117,000

Melrose Area & Westhill /Allen

<u>Project Successes</u>

- Additional testing was performed by the means of the following:
  - Duel Cameras for Phase 1- gained information on the storm.
  - Introduction of Phase 2 Testing- learned how I/I occurred so it could be mitigated
- Stopped sectional mainline grouting and performed full run grouting.





Melrose Area & Westhill /Allen

Lessons Learned

- The more effort placed in the I/I Investigation prior to construction the greater likely hood of success.
- Sectional grouting in the past allowed water to migrate to the next failed joint.

Cornwell / Bonny Bank

Project Scope

- I/I Investigation
  - URS-Phase 1
  - Westlake-Phase 2
- New testing approach
  - Wet Weather CCTV with push camera
    - Part of Phase 2 Testing
    - From a Cleanout
    - By City's Department of Engineering
- Performed in 2013 with a waterline and roadway rehabilitation
- Similar sanitary rehabilitation as past.
- All storm and sanitary cleanouts located.

Project Successes

- Wet Weather CCTV provided good results with minimal labor.
- All aspects of the road were addressed
  - Water
  - Storm/Sanitary
  - Pavement

Arthur

Project Scope

- Work was being performed in conjunction with a water line replacement so their was not enough time to perform a full I/I Investigation
- Accelerated I/I Investigation performed by the City
  - Mainline CCTV
  - Wet Weather CCTV of all connections from CO's
  - No Dye Testing
- Wet weather CCTV allowed enough limited info to determine some type of rehabilitation.

Lessons Learned

- For all future waterline and roadway improvement projects allow enough time for sanitary sewer I/I Investigations
- Wet weather CCTV did provide some results.

Overall Lessons Learned

- Cheaper to pay Consultant to test in more detail than to pay Contractor to line laterals where infiltration can be corrected by cleaning or repairing a compromised downspout leader
- Get Contractor with EXPERIENCE in the product specified in the contract
- The sanitary mains are in decent condition due to premium joints and inspection at installation
- The sanitary laterals are the main source of infiltration due to poor construction practices and no inspection at time of installation
- During initial dye testing observe both the storm and sanitary mains for dye to determine the overall functionality of the exterior plumbing of a house

The End

- Thank You
- Questions or Comments?