

Infiltration and Inflow

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Inflow and Infiltration

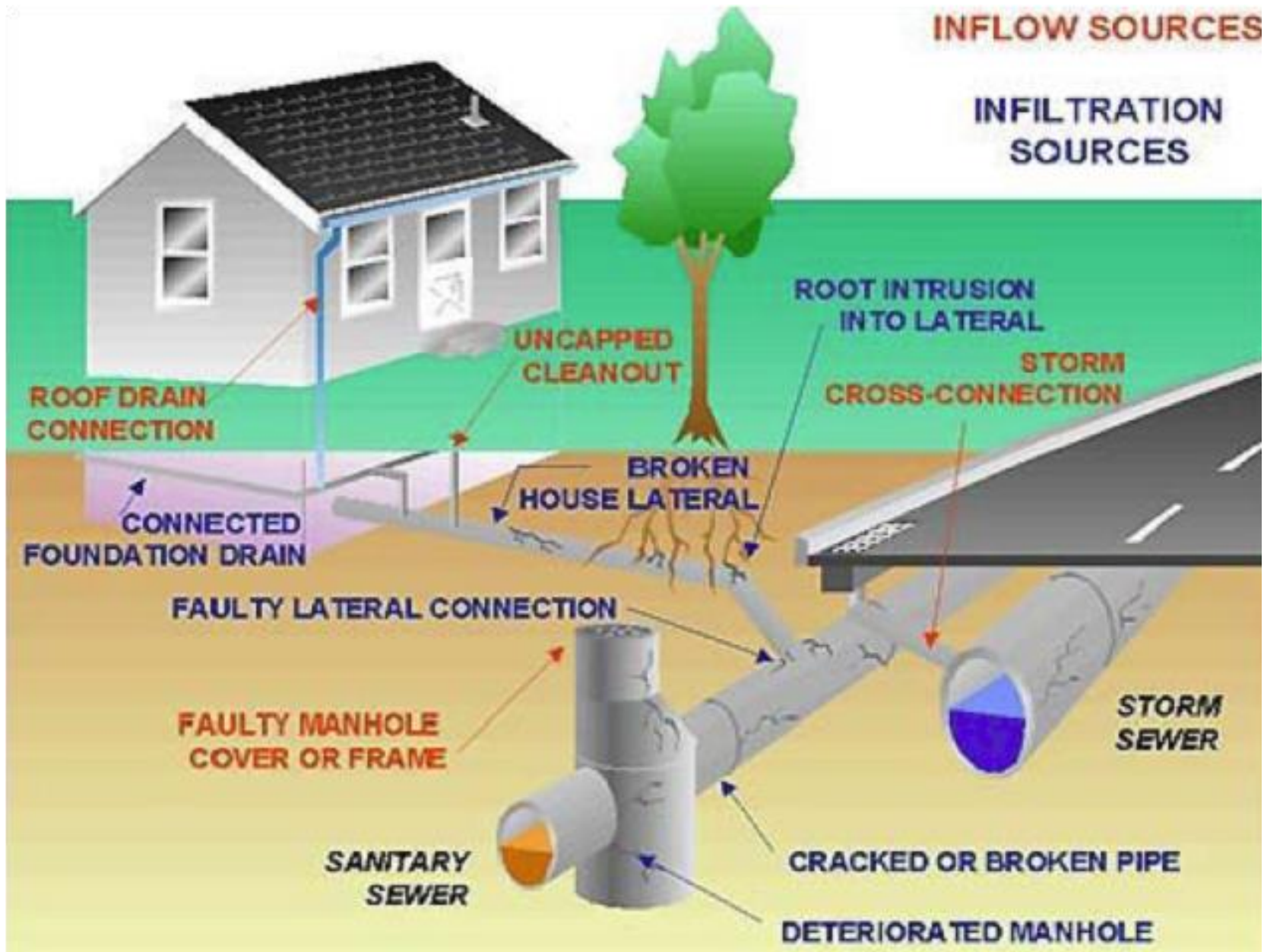


Learning Objectives

- Do you have Excessive I/I ?
- Sources of Inflow and Infiltration
- I/I abatement programs
- Sewer Rehabilitation Methods

INFLOW SOURCES

INFILTRATION SOURCES



Is your I&I Excessive?

What is considered Excessive I&I?

Infiltration

Average Daily flow over 120 GPPD (Gals./person/day)

- Divide Average Daily Flow by population

OR

GPD/IDM over 4,000 GPD

- IDM = Inch Diameter/ Mile of pipe
- Determine IDM of your system
- Example – 36 miles of 4" pipe + 36 miles of 8" + 6 miles of 10" + 6 miles of 12"
- $36 \times 4 + 36 \times 8 + 6 \times 10 + 6 \times 12 = 564$ inch diameter miles
- Avg Daily Flow 2 mgd divide by 564 IDM = 3546 GPD/IDM

Is your I&I Excessive?

What is considered Excessive I&I?

Inflow

Average Daily flow over 275 GPPD (Gals./person/day)

- Divide Average Daily Flow by population

OR

GPD/IDM over 9,000

- Determine IDM of your system
- Example – 36 miles of 4" pipe + 36 miles of 8" + 6 miles of 10" + 6 miles of 12"
- $36 \times 4 + 36 \times 8 + 6 \times 10 + 6 \times 12 = 564$ inch diameter miles
- Peak Wet Weather Daily Flow 6 mgd divide by 564 IDM = 10,638 GPD/IDM

Six Components of a Good, Well-Planned, Organized I/I Abatement Program

1. Mapping:

Without a map of your collection system, you cannot implement an I/I program. Mapping involves documenting slopes and invert elevations, and knowing the locations of all of the system's manholes.

2. Metering:

Metering should be at key locations at the bottom of individual sub-basins in order to help coordinate investigative and rehabilitative actions. Both baseline and wet weather flows should be identified during the summer months and February through May, respectively. The wet weather metering should attempt to collect 6–8 inches of rainfall over a 6–8 week period and include 6–8 different storm events.

3. Televising:

The entire system should be televised in order to identify areas that need to be rehabilitated due to structural failure or to identify illicit connections, water main breaks, etc. This is an integral part of the overall program with respect to identifying leaking service laterals.

Six Components of a Good, Well-Planned, Organized I/I Abatement Program

4. System Hydraulic Characterization:

This step should be accomplished in order to identify areas of the collection system that physically do not allow for effective transfer of flow, especially during wet weather conditions. This is of critical importance in areas where the collection system becomes surcharged during wet weather events.

5. System Rehabilitation:

This occurs after the steps referenced above are completed and may include various methods of pipeline repair or replacement depending on site conditions or cost feasibility.

6. Post-Rehabilitation Flow Metering:

This should occur on a sub-basin level to document the effectiveness of the abatement efforts referenced above and to identify areas in the collection system that need further investigation.

Frequent Sources of Inflow

- Loose, open, perforated manholes
- Direct downspout and sump pump connections
- Cross connection of stormwater pipe to sewer pipe



Frequent Sources of Infiltration

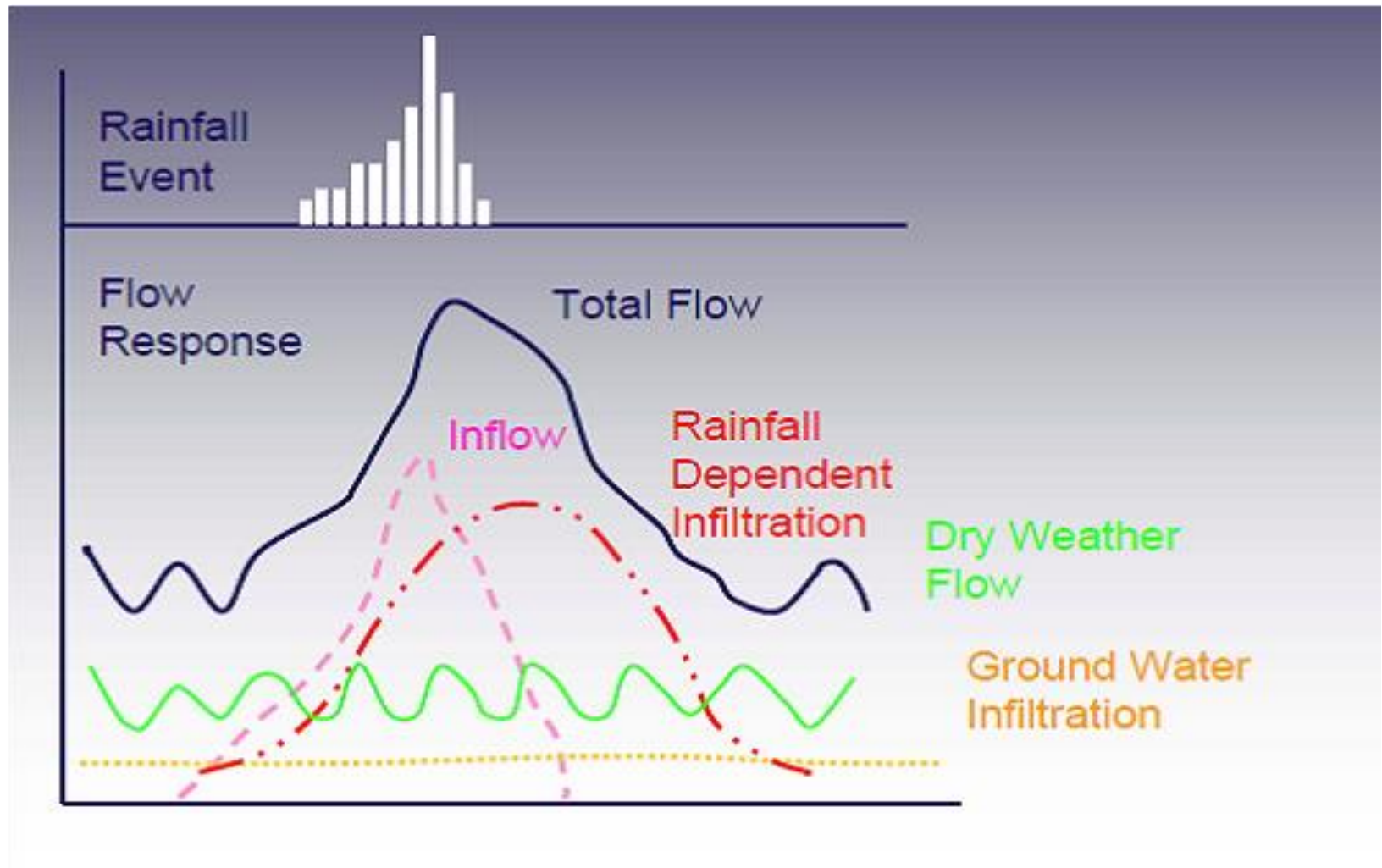
- Cracked pipes
- Loose joints
- Leaking pipe joints or manholes
- Defective Stream Crossings
- Root intrusion



Identifying I&I

- **Inflow:** Metered flow peaks quickly with rainfall and declines rapidly after rainfall ceases.
- **Infiltration:** Generally, metered flow increases steadily and once rain fall ceases, flows steadily decline, usually over the course of days.
- **“RDII”** – Rainfall Derived Inflow and Infiltration

Inflow vs Infiltration



Fix it or leave it???

- Determine if I&I is excessive. >120 GPD/capita or >4,000 GPD/IDM.
- Cost Effectiveness Analysis – To rehab or not?
- Estimate Rehab costs vs treatment costs
- Leaks will often migrate to the next defect
- Prioritize rehab efforts
- Look for structural issues that might not be leaking now

Sewer System Evaluation Survey

- When should we look for I&I ??
- Flow Metering of sub areas
- Inspections – Visual, Smoke Testing, Building Inspections, Manhole Inspections
- Condition Assessment – Cost Effective Analysis?
- Prioritizing Rehabilitation
- Rehabilitation Methods
- Lamping to determine if a sewer is straight or blocked.

I/I Abatement Program

- Mapping
- Metering
- Televising
- System Hydraulic Characterization
- System Rehabilitation
- Post-Rehabilitation Flow Metering



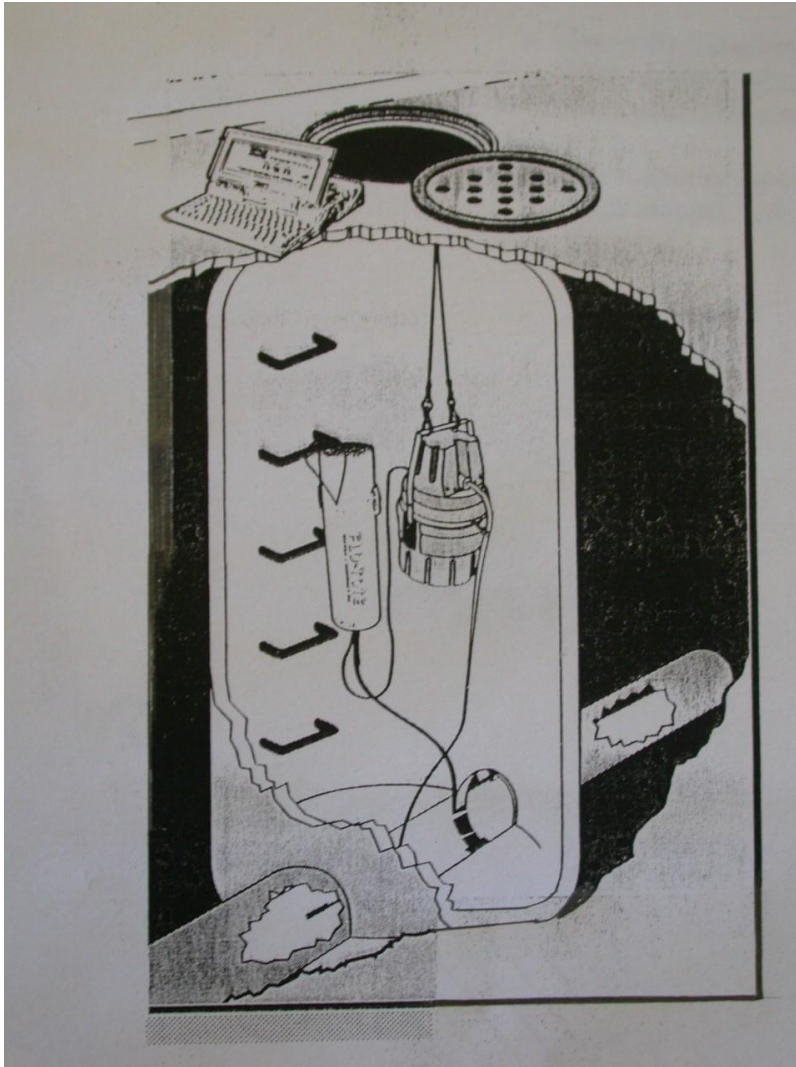
Mapping

- One comprehensive system map including street names, manhole numbers, invert elevations, manhole locations, streams, roads, lateral connections, storm sewers, etc.
- Printed maps, Laminated, or on a laptop in GIS format.
- GIS can be linked to videos, inspection reports, repair records, Maintenance issues, etc.
- This could also be helpful to investigate illegal dumping or to track down other pollutant sources

Metering

- A sub-basin metering program to identify areas with excessive or significant I/I
- Baseline and wet weather flow data collection
- Data should cover 6-8 inches of rainfall over a 6-8 week period and include 6-8 different storm events.

Portable Flow Meter



For metering sub areas.

- Flow sensor
- Battery power
- Data Recorder
- Waterproof housing
- Software for tabulating data

V-Notch Weir



For measuring flows.

Televising

- TV during the right weather conditions
- High Flow conditions, Night work or Bypass Pumping
- Identify Infiltration or Inflow
- Televising entire system ??? Or by Sub-Basin
- Identify areas that need repair, cracked or broken pipes and dislocated joints
- Identify illicit connections (like storm sewer connections or illegal connections)
- Water main break inflow
- Contractor or Municipally owned?

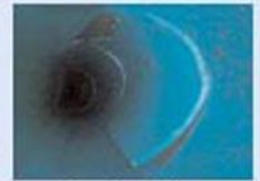
CCTV



Badly Damaged Pipe



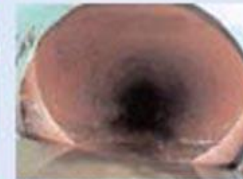
Crushed Pipe



Broken Pipe



Punctured Pipe



Offset Joint



Tree Roots



Just a minor leak: Infiltration

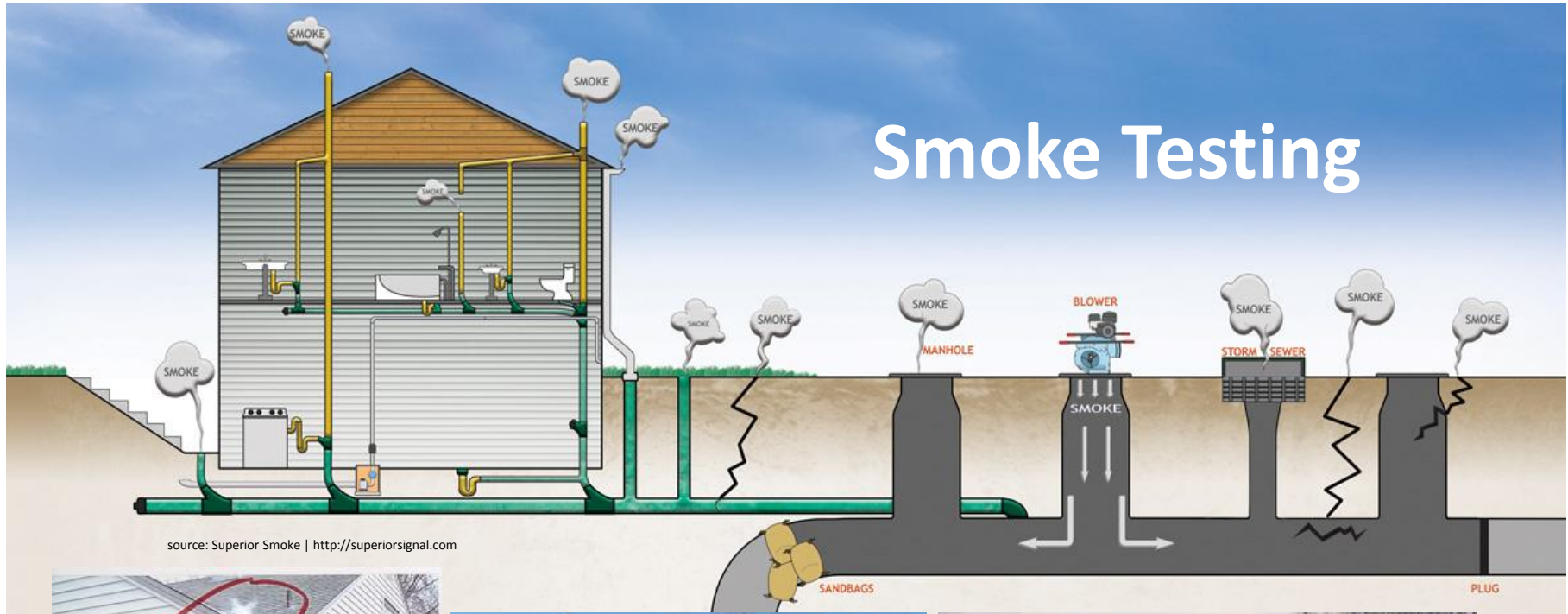


Sewer Testing Methods

- Smoke Testing Procedures
- Dye Testing
- Lamping
- Manhole Inspections



Smoke Testing



source: Superior Smoke | <http://superiorsignal.com>



Dye Testing



source: Tool Experts | <https://www.toolexperts.com/>



source: Drains IOM | <http://www.drainsiom.com/>



Manhole Inspections



Manhole Inspection Form

Customer: _____

Date: _____

Location: _____

MH ID: _____

Present Use: Storm Sanitary Other _____

Surface Cover: _____

Grade to Manhole: Flush Below _____ Above _____

Cover Diameter: _____

Cover Condition: Good Fair Poor

Riser Rings: Number _____ Alignment: _____

Casting Condition: Good Fair Poor

Manhole Type: Precast Brick Block Combination

Manhole Condition: Good Fair Poor

Step Condition: Good Fair Poor

Type: Re-rod Cast Reinf. Plastic Other _____

Apron Condition: Good Fair Poor

Drop Manhole: Yes No

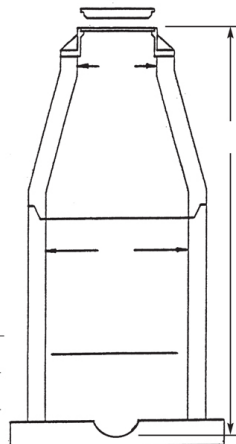
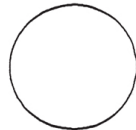
Type: Outside Inside

Infiltration: Yes No

Where: Pipe Invert Casting Walls

Comments: _____

N
↑
Inlets and Outlets
(By Clock Position)



source: USA Ltd | USSR Ltd | <http://www.usa-ltd.ie/>



System Hydraulic Characterization

- Some areas of the collection system may sag and collect debris which affects transfer of flows
- Some areas have slope issues and become the critical condition
- Bends in pipes or missing manholes
- Identifies areas of the collections system subject to hydraulic overloads or surcharges
- Computerized Hydraulic Modeling

Rehabilitation Methods

- Excavate and Replace
- Chemical Grouting – Not a Structural Repair
- Sectional Lining
- Manhole to manhole lining
- Lateral Lining
- Trenchless Technologies

System Rehabilitation

- Repair and maintenance schedule
- Line item in the budget each year
- Coordinate with other municipal activities like road repair, water line replacement
- Nearby Municipalities working together



Mainline Grouting



Unlined Lateral Grouting

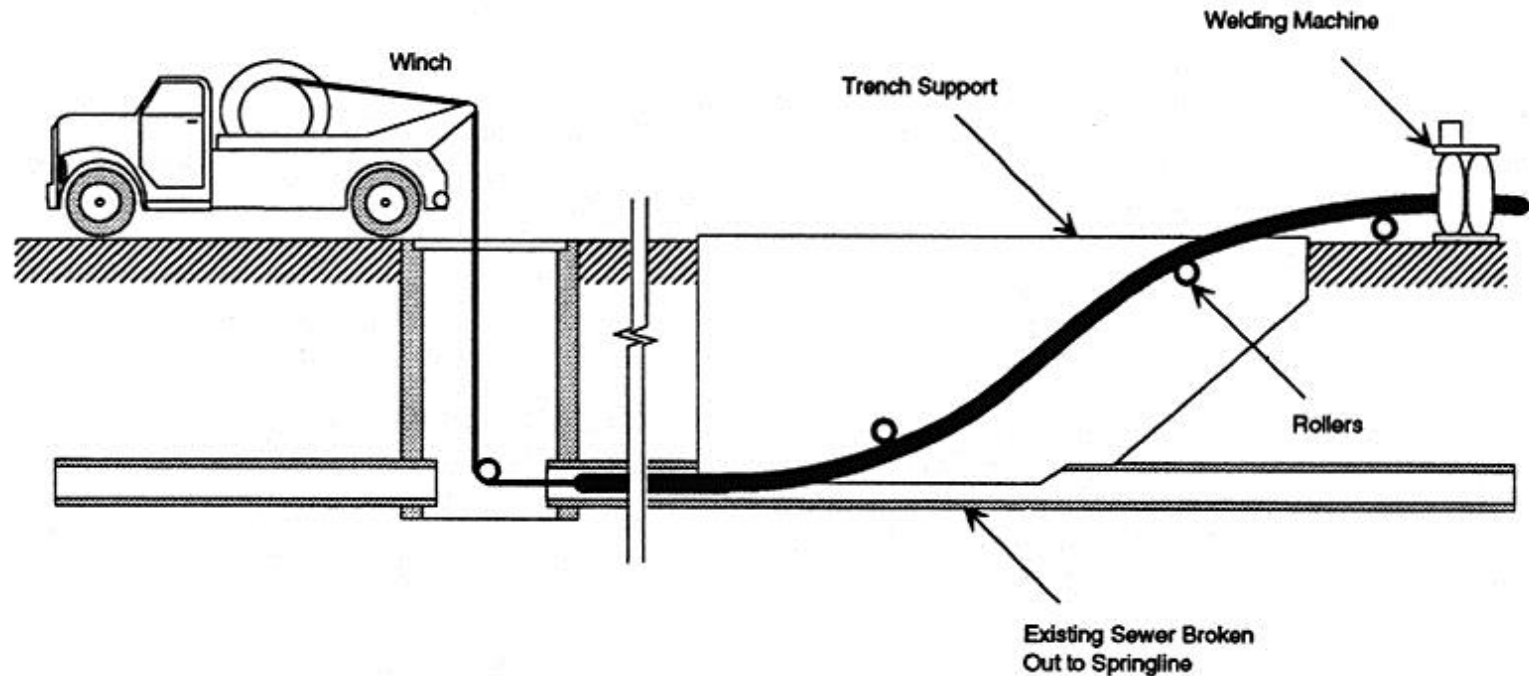


Manhole Horizontal Crack Injection



Lined Lateral Grouting

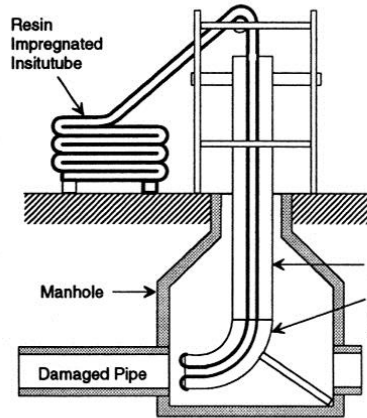
Sliplining



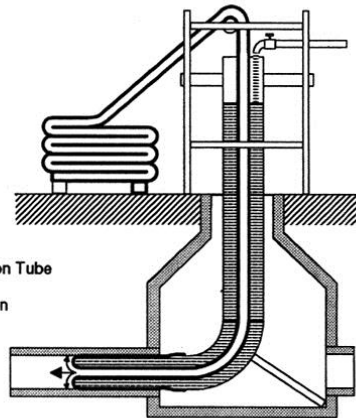
- Sometimes Annular Space leak problems
- Reduces pipe size and capacity

Cured-in-Place

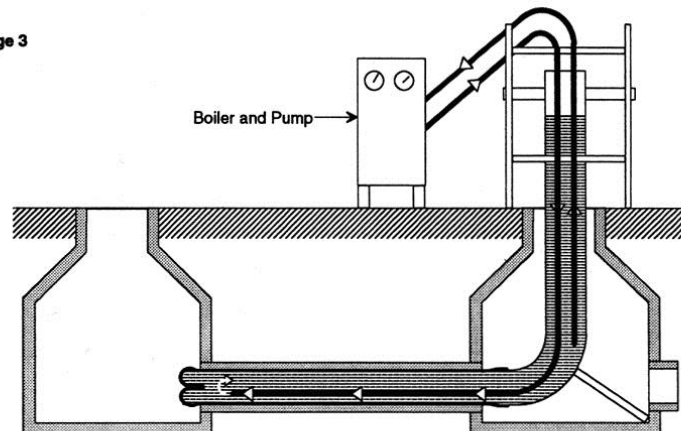
Stage 1



Stage 2



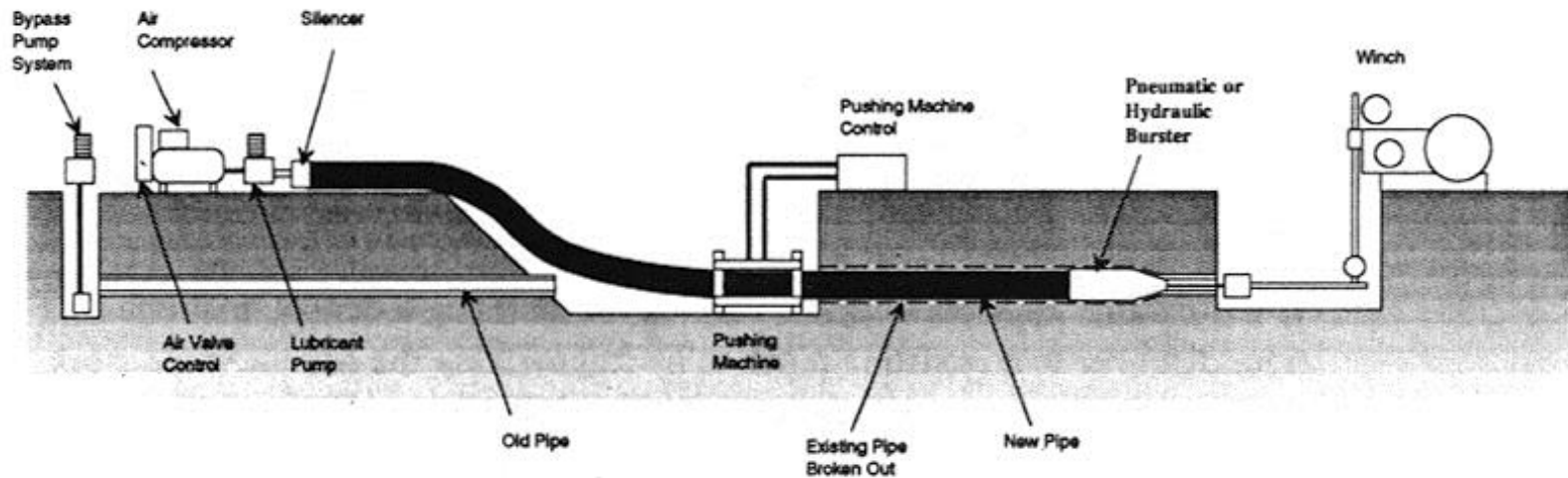
Stage 3



source: Clark Regional Wastewater District | <http://www.crwdd.com/>



Pipe Bursting



Manhole Rehabilitation

- Grouting to stop water flow
- Coating for surface protection, repair or rehabilitation of deteriorated surfaces
- Lining can be installed in manholes by spray on methods, CIP Liners or incorporated in new manhole construction
- Manhole Inserts
- Chimney Seals



source: Parson Environmental | <http://www.parsonenvironmental.com/>



source: Municipal Sewer & Water | <http://www.mswmag.com/>

Post-Rehabilitation Flow Metering

- Meter the same sub-basins to document I/I reductions
- Keep a non-rehabilitated sub-basin for a control comparison
- Prioritize other areas not previously prioritized
- Start the cycle over again

Why remove I/I?

- More I/I water = spending more \$\$, but no more customers
- Hydraulic overload can cause SSOs, effluent violations, NOVs, penalties
- I/I can take up capacity reserved for building projects



Case Study

1. Major pump station overflowed directly to waters of the Commonwealth through a dedicated overflow pipe from the pump station wet well
2. Conducted sub-basin flow metering, both dry and wet weather, in the sanitary sewer collection system tributary to the pump station
3. Discovered high average-to-peak flow ratios at monitoring locations
4. Televised entire sub-basin
5. Identified many faulty sewer lateral connections, mainly at the house side of traps
6. Worked with residents to make the necessary repairs by assisting with funding sources and coordinating the corrective actions
7. Eliminated sewage overflows at the pump station (and an estimated one million gallons of I/I)



Test

1. Three sources of inflow are _____ and _____, _____.
2. Four sources in infiltration are _____, _____, _____, and _____.
3. The six components of an I/I abatement program are: _____, _____, _____, _____, _____, _____.
4. Groundwater entering sewers is _____.
5. Two Testing Methods for sewers are _____ and _____.
6. Rehabilitation methods include _____, _____ and _____.
7. Three benefits of removing I/I are: _____, _____, _____.



Test Answers

1. Three sources of inflow are manholes and sump pumps and downspouts, and cross connections.
2. Four sources in infiltration are cracked pipes, defective joints in pipes, manhole defects, and root intrusion.
3. The six components of an I/I abatement program are: mapping, metering, televising, hydraulic characterization, rehabilitation, post-rehab flow metering.
4. Groundwater entering sewers is Infiltration.
5. Two Testing Methods for sewers are Smoke Testing and Dye Testing.
6. Rehabilitation methods include Lining, Grouting and Manhole Rehabilitation.
7. Three benefits of removing I/I are: save money, less violations, more capacity.

