Outta sight, outta mind...
Our underground infrastructure goes unnoticed……until its too late

- Serves vital and basic human needs
- Can be dangerously deadly
- Costly to fix if allowed to degrade
- Most have long surpassed useful life
- Finding money is time consuming (and can cost money-outsourcing)
- Raising rates is inevitable, and unpopular
A logical, systematic evaluation of the sewer system is necessary to determine the cost-effectiveness of any sewer system rehabilitation to eliminate infiltration/inflow (I/I).

A **Sanitary Sewer Evaluation Survey** is a systematic examination of the sewer system to locate all I/I sources which were previously determined to be possibly excessive, determining the flow rate from each source and estimating the costs required for the rehabilitation of the system **versus** cost of transportation and treatment.
First things first...

- I/I study and rehabilitation is not a one-time event.
- A regular maintenance program is critical to maintain the integrity of a sewer system, including:
  - regular pipeline/manhole inspections
  - scheduled cleaning, root treatment
  - routine I/I source identification/removal
- Prior to an SSES, an initial I/I Analysis is performed to document the extent of I/I in the system, identifying the presence, flow rate, and type.
- At the conclusion of the I/I Analysis, enough data should have been gathered and analyzed to develop the preliminary recommendations and associated costs to implement the follow up sewer system evaluation survey (SSES).
After initial analysis

- The Sewer System Evaluation Survey (SSES) is performed as a follow up to the I/I Analysis to locate, identify and correct specific I/I sources.
- Sewer system drainage areas where I/I is found to be excessive are included in the SSES.
- Appropriate rehabilitation methods are determined based on type of I/I sources and the flow from that source.
- Data collected during the SSES may confirm the findings of the I/I Analysis.
- Determine extent of additional investigation, rehabilitation, and/or system improvements.
Obligatory definition of I/I

- **Inflow**
  - Stormwater discharged directly into sewers
- **Infiltration**
  - Groundwater that enters the sewer through defective pipes, joints, connections & manholes
- Both overload collection systems & reduce treatment efficiency
  - Function of age
- **We can SEE Inflow!**
Inflow - Illegal Stormwater Connection

Infiltration

Just stinkin’ cute
SSES Components- there are 5

1. Physical Survey

Aboveground inspection:
- investigate the general condition of the study area
- locate potential problem areas
- select the key manholes for additional flow measurement and groundwater monitoring

Flow monitoring:
- locate and isolate where I/I problems exist
- target efforts to areas with highest volumes
- further reduce the number of areas to be investigated

Extensive Manhole inspection:
- determine the actual physical condition of manhole (size, construction, condition, pipe size)
- document visually identifiable infiltration/inflow sources
- provide information on the configuration of the sewer system and subsystem boundaries
SSES Components

2. Rainfall Simulation
   - Smoke testing
   - Dyed water testing

3. Preparatory Cleaning
   - Clean inside of sewer pipes to prepare for video inspection

4. Internal Inspection
   - CCTV NASSCO rating of pipes (PACP), manholes MACP) and laterals (LACP)
   - Record pipe diameter, length; type, depth; cleaning method used
   - Record defects- observed leakage (type, location and flow rates); recommended corrective action
SSES Components

5. Survey Report and Cost Effectiveness Analysis

- A summary of all the results gathered during the investigation
- A cost-effectiveness analysis to determine the portion of sewer sections which can be cost effectively rehabilitated
- A proposed sewer system rehabilitation program and its related costs

- A documentation of all the field data gathered during the investigation (and how it was gathered)
- Clarification of the results, conclusions and recommendations
Why do it?

- State Revolving Loan Fund (SRF) applicants are generally required to evaluate the impacts of I&I on their overall system.
- To comply with a consent order/administrative order.
- Your community is unable to bear the cost of upsizing capacity.
- Extraneous water from I/I sources reduces the useful life of equipment.
- Mitigation of I/I is essential to protect the environment (where there is infiltration there can be exfiltration).
- To protect your capital investment in the system and reduce insurance rates.
- **The elimination of I/I by sewer system rehabilitation reduces the cost of wastewater collection and treatment.**
Shifting gears....is I/I a thing?

- It's really two separate “things” and can be handled that way.
- Inflow is easy (and relatively cheap) to find and fix.
- Infiltration requires more intensive monitoring and internal investigation.
- By tackling inflow first you can determine extent of infiltration.
- By splitting them up you can save time and money on a SSES.
Tackling Inflow first

You probably already have what you need to start-

- Pump run times
- Flow fluctuations to WWTP
- SSOs
- Staff that know where the problems are.....
Inflow = Rainfall

- Inflow accounts for more than 50% of the I&I entering the collection system
- Up to 12,000 gallons of stormwater can enter a single manhole in a 24-hour period
- Sewer flow peaks during rain events
- The size of the storm event matters—larger storm event creates more inflow
- Stormwater wastewater flow is linearly related to rainfall
Sewer Flows V. Rainfall
We Can See ..... INFLOW!!!
Inflow

Flow vs. Rainfall

Flow (Gallons)

Rainfall

INFLOW
Sanitary Sewer Overflow
Start with manholes- big bang for the buck!

Cost in real money:

- 1 gallon per (gpm) minute flow can cost $900 annually
- 5 gpm flow can cost $4,400 annually
- 10 gpm flow can cost $8,900 annually
- In just 10 years 10 gpm will cost a municipality almost 10 million dollars in treatment costs!
Types of Manholes

Doghouse

Precast

Drop

Brick
Manhole Inflow fixes

- Inflow dishes
- Chimney repair/sealant
- Apron repair
- Ring and cover realignment/replacement
Put a Dish in it!
Inflow dish

- Inflow dishes capture stormwater, grit, sand, foreign objects
- Simple and cost-effective
- Generally made of stainless steel or HDPE
- Dramatically reduce sewage treatment costs
- The dish is positioned directly below the manhole cover and is firmly seated around the manhole frame rim
- Water that enters through the manhole opening is caught by the dish and ejected through the manhole cover pick holes

*I have never seen an empty manhole dish - not ever!*
Chimney seal and Inflow dishes
Holey Smokes.....

Grab your shovel!
Smoke testing is a cost effective way to:

- **Locate** inflow and infiltration sources
- **Verify** system connectivity
- **Verify** flow routing/basin boundaries
- **Identify** stormwater cross connections
- **Locate** illicit connections
- **Identify** abandoned connections
- **Regain** system capacity
Smoke The System - Finding It
Dye testing

- Dyed Water Testing can identify/confirm direct inflow sources to the sanitary sewer system, such as catch basins, downspouts, area drains, patio drains, window well drains, stairwell drains, sump pumps, and driveway drains.
- Direct inflow sources may not always be detected through smoke testing due to trapped building service laterals or clogged drains.
- Suspect direct inflow sources can be recorded during smoke testing and/or during house-to-house surveys and targeted for subsequent dye testing.
- Dyed Water Testing is performed by introducing dyed water into a suspect inflow source, and then observing at a downstream sanitary sewer manhole whether dyed water enters the nearby sewer.
- The presence of dyed water in the sanitary sewer would confirm an inflow source connection.
Once you’ve tackled inflow....

- After removing inflow, the remaining flow is baseflow + infiltration.
- Assuming that any increases in baseflow are negligible, any decreases or increases in flow are related to fluctuations in infiltration.
- Based on an analysis of baseflow + infiltration vs. groundwater elevations graphs from pre and post construction activities infiltration reduction will be calculated.
- Separate baseflow + infiltration based on water use, dry days and day of the week
Infiltration Issues

- Broken Pipe/Tree roots
- Broken Laterals
- Extruded laterals
- Bad manhole connections
Collection system infiltration
Broken Pipe = Infiltration...
Infiltration

Baseflow and Infiltration vs. GW Elevation and Rainfall

Flow (MGD)

GW Elevation (ft)

Rainfall (in)

Date

Jan-06 May-06 Sep-06 Jan-07 May-07 Sep-07 Jan-08 May-08 Sep-08 Jan-09 May-09 Sep-09 Jan-10 May-10 Sep-10 Jan-11 May-11 Sep-11 Jan-12 May-12 Sep-12 Jan-13 May-13

- Baseflow and Infiltration
- Groundwater Level
- Rainfall
Groundwater Vs Base + infiltration

Baseflow and Infiltration vs. GW Elevation
Protocol manhole infiltration rehab

- Grouting (internal and or external)
- Structural lining
- Rebuilding benches/inverts
- Grouting around mains to block XXXXX
- Sealing and or rebuilding the chimney and apron
- Realigning and sealing ring and cover if compromised
- Installing an inflow dish

Voila!
What to look for

- Cracks
- Missing wall
- Roots
- Missing bench/invert
Common manhole lining options

- **Cementitious**
  - 100% pure fused calcium aluminate (CA)
  - Partial CA mixes
  - No CA (portland, mortars and mixes)

- **Inert**
  - Slip lining
  - Cured-in place-lining (CIP)
  - Polymers/Epoxies
  - Fiberglass
Method To Connect Manholes To Mains

Bench and Cone Repairs/ASTM Standard

- For concrete repairs in Manholes – calcium aluminate products only – SewperCoat is a 100% calcium aluminate mortar premix
  - ASTM C 109, 293, 457, 496, 596, 642, 666, 882
- For the manhole pipe seal Dymonic FC – polyurethane sealant – designed to be pressure grouted in place – used it in marine setting.
  - ASTM C 510, 639, 661, 679, 793, 794, 1183, 1246
Before and after with a cementitious lining

Before

After
Approximate costs per manhole

- Grouting active leaks - $100/gal
- Structural lining - $200/per vertical foot
- Rebuilding benches/inverts - $500/ea
- Chimney seal - $300+/ea
- Realign, grout and seal casing - $800+/ea
- Installing an inflow dish - $75+/ea
Main and lateral rehabilitation

Rehabilitation methods for both mainline sewers and service laterals that may be considered include, but are not limited to:

- Air testing and sealing with a chemical grout
- Cured-in-place pipe lining (from manhole to manhole)
- Short liners
- Spot repairs (dig and replace)
- Pipe replacement (dig and replace).
Sanitary Pipe Materials

- Small lines:
  - PVC
  - Vitrified clay
  - Asbestos cement

- Larger lines:
  - Ductile iron
  - Asbestos cement
  - Concrete
1. Leaky Pipe = liner
2. Leaky Liner = repairs
3. Leaky laterals = lateral liner
4. Bad service line = clay, cast iron, orangeburg
   will require digging
Benefits Of Cured In Place

- CIPP remains the method of choice for the last 40 years (84%)
- Steam, Water, air pressure and UV options for curing resin
- U-liner, inversion are examples, but there are others
- Huge improvements with time with remote operations
- Pipe must be clean – biggest issue, but can be wet
- Provides pipe structural integrity
CIPP Standards

- ASTM F1216 (Rehabilitation of pipelines by the inversion and curing of a resin-impregnated tube),
- ASTM F1743 (Rehabilitation of pipelines by pulled-in-place installation of a cured-in-place thermosetting resin pipe), and
- ASTM D790 (Test methods for flexural properties of unreinforced plastics)
Lateral Repairs – LMK T-liner With Gaskets – ASTM F2561
SSES Deliverable - in detail

- An Executive Summary highlighting all tasks performed, a subsection of conclusions and recommendations and approximate costs.
- It should also have summary tables and estimates of quantities of I/I components:
  - Description of existing wastewater treatment and collection system;
  - Description of problems (overflows, bypasses, etc.) within the system, including past studies and rehabilitation work;
  - Delineation of subsystems, gauging locations and sewer size;
  - Outline gauging/internal inspection program;
  - Summary of gauging results. Show how wet weather flows were determined (adjustment to design storm, separate infiltration from base flow). Include rainfall/inflow graphs;
  - Results of inspections and recommendations for rehabilitation;
  - Cost-effectiveness Analysis – demonstrate how transportation and treatment costs are derived and present in a tabular form;
  - Recommendations – list proposed recommendations including cost and schedule.
A C/E/A must be performed for infiltration as part of an SSES to determine whether the I/I in the system is excessive.

- Defined as excessive if the costs for the removal of the infiltration source are less than the costs for transportation and treatment of these flows.

- The C/E/A can be done for inflow sources when/if costs of inflow removal are judged to be extremely high.

- A life cycle evaluation should be performed that considers both capital costs and annual operation and maintenance costs.

- The estimated rehabilitation cost for each 1,000 feet of sewer, including manholes, should be based on the appropriate rehabilitation technique required for the removal of the infiltration sources identified during televising.
Cost Analysis

- Based on information provided by the city of Hollywood, Dania Beach currently pays $2.98/1,000 gallons.
- Assume 850 Manholes, 60 Miles of pipe

<table>
<thead>
<tr>
<th>Assume 800 MH</th>
<th>Inflow</th>
<th>Infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage Reduced (gallons)</td>
<td>18,348,011</td>
<td>72,706,566</td>
</tr>
<tr>
<td>Amount Saved</td>
<td>($55,044)</td>
<td>($216,665)</td>
</tr>
<tr>
<td>Cost</td>
<td>$472,000</td>
<td>$772,000</td>
</tr>
<tr>
<td>Cost/1000 gallon</td>
<td>$22.72</td>
<td>$7.64</td>
</tr>
<tr>
<td>BUT…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoided Cost</td>
<td>($1,200,000)</td>
<td>$0</td>
</tr>
<tr>
<td>Cost/1000 gallon</td>
<td>($42.68)</td>
<td>$7.64</td>
</tr>
</tbody>
</table>
FYI

- A **SSES costs time and money**, either in-house or outsourcing consultant/contractor
- **Upside** - it is less expensive than system expansion
- **Beyond the basics** - should understand:
  - water flow/migration
  - soil conditions/groundwater tables
  - rain event characteristics
- **Compare** wet weather and dry weather infiltration
- **Target** high priority areas for repair, replacement, rehab
Some things you can expect to do post SSES

- **Develop** a detailed asset identification system- including GPS
- **Update/correct** system mapping
- **Sewer line** cleaning, maintenance, rehabilitation program
- **Manhole/wet well** cleaning, maintenance, rehabilitation program
- **Lateral** inspection rehabilitation/replacement program
- **Install** Clean outs in City Rights of Way
- **Develop** a FOG Ordinance (Fats, Oils and Grease)
All your hard work pays off, if you....

- Have or acquire a **CMMS** (Computerized Maintenance Management System) to input your data
- Implement an Asset management (**AM**) Plan
- Begin Predictive (**PdM**) / Preventive (**PM**) Maintenance Programs
- **Delegate** staff to oversee implementation of programs and plans
- **Conduct** a rate sufficiency study to support capital needs
- **Evaluate** your AM annually to stay on track with system improvements
- **FRWA** can assist members with all of the above
Implement SSES findings wisely....

- Improved system performance leads to fewer:
  - Blockages
  - Overflows
  - Costly emergency repairs
  - Pump station failures
  - Insurance claims paid out

- The more effective the maintenance program, the fewer unplanned repairs.
  - Unplanned repairs should be held at 30% or less of annual maintenance activities
  - Unplanned maintenance in excess of 30% indicates need to evaluate causes and adjust strategies
How can the FRWA support your SSES?

- **Member services:**
  - FRWA provides assistance in the identification of problem areas within the collection system.
  - Video Push Camera Inspection System - inspect and troubleshoot collection system lines.
    - FRWA provides camera, expertise; Systems provide sufficient employee support, traffic control and repair of potential problems.
  - Smoke Testing to identify inflow and infiltration areas and collection system integrity.
    - FRWA provides the smoke blower and FRWA Staff expertise in identify potential sources of infiltration and inflow.
    - FRWA has examples of Smoke Testing Notifications to be used before and during smoke testing events.
  - Establishing Ordinances and Fines for illegal connections, such as rain water gutters, storm drains, and using sewer cleanout and manholes for storm drainage.
  - Line and manhole locates using Ground Penetrating Radar (GPR)/ Metal Detectors.
  - Manhole and lift stations inspections - forms, vacuum testing, corrosion and odor needs, etc.
  - Locating line blockages and leakage - utilizing sewer camera and other devices FRWA is able to determine the location and/or cause of the blockages and provide assistance in the clearing of these blockages.
Funding Sources for your SSES

- SRF- will include links
- Need to confirm others
Questions

Laureen Busacca
FRWA
352-279-4989
Laureen.Busacca@frwa.net

Frederick Bloetscher
h2o_man@bellsouth.net

Helpful links:
http://www.frwa.net/frwa-services.html