Newberg
Inflow and Infiltration Study
WES 2017
What is Infiltration and Inflow?

**Infiltration and inflow (I/I) represent extraneous groundwater and storm water runoff that enters the wastewater system.**

Infiltration is groundwater that enters the system through leaky pipes and manholes.

Inflow is storm water that enters the system through direct connections, i.e. roof drains, catch basins, C/O, etc.
Infiltration

- Groundwater that enters the wastewater system through leaky pipes and manholes.
Inflow

- Storm water runoff that enters the wastewater system through direct connections.
  - Roof drains
  - Holes in manhole lids
  - Catch basins
  - Broken or open cleanouts
  - Foundation drains
Why should you care?

- Infiltration and inflow increases the flow to your wastewater system
  - Accelerates and increases size of capital improvements
  - Increases conveyance, treatment, and mitigation costs
  - Increases risk of sanitary sewer overflows (SSOs) and NPDES violations
Existing EPA Guidance

If the average **dry weather** flow (DWF) is **less than 120 gallons per capita per day** (gpcd), then the amount of infiltration is considered non-excessive\(^1\).

If the average **wet weather** flow (WWF) is **less than 275 gpcd**, then the amount of inflow is considered non-excessive\(^1\).

Components of an I/I Program

- Collect data
- Identify I/I sources
- Identify appropriate rehabilitation approach
- Focus on areas where you get greatest return on investment
  - Look for smoking guns
  - Perform cost/benefit analysis
- Develop budget and capital improvement plan
- Monitor improvements
Collect Data

A good program requires good data.

- **Basic, Ongoing Data**
  - Daily lift station pump run time data
  - Precipitation data
  - Hourly SCADA data (at WWTP and lift stations)
  - Regular CCTV data
  - GIS (material and condition data)

- **Periodic, Supplementary Data**
  - Flow monitoring
  - Night-time monitoring
  - Smoke testing
  - Dye testing
Identify I/I Sources

- Pump run time analysis
- Flow monitoring
- Smoke testing
- Night time monitoring
- Video inspection
- Dye testing

- Narrows down worst basin/s
- Narrows down worst areas
- Smoking guns
- Narrows down flow monitoring results
- Pipe conditions and indicators
- Tracks I/I sources
**Identify I/I Sources**

Use the data to quantify I/I and focus efforts.

- Compare flows in basins to wintertime water consumption
- Look at seasonal changes
- Look at responses to storm events (may need to get out in the rain)
- Look at night-time flows
- You may need help gathering and processing the data
Identify Appropriate Rehabilitation Approach

- **Pipeline rehab**
  - Open trench
  - Trenchless
  - Spot repairs
- **Lateral rehab**
  - Full replacement
  - Grouting
  - Liners
- **Manhole rehab**
  - Full replacement
  - Grouting
  - Lining
Identify Appropriate Rehabilitation Approach

OPEN CUT
- Appropriate when surface repair is minimal, when pipe sags need to be repaired, when pipe needs to be upsized more than one nominal size, and when there are many lateral repairs

PIPE BURSTING
- Appropriate trenchless technology; typically allows upsizing of one nominal size
- Open cut still required at lateral and near insertion/extraction pits; special considerations for some pipe types, soil materials, and shallow bury depths

CURED-IN-PLACE PIPE (CIPP)
- Appropriate trenchless technology when host pipe is desired size and grade
- Lateral repairs possible, but costly

OTHER METHODS
- Directional drilling, bore, slip lining, host of spot repair options
Rehabilitation Options

Spot repairs
Rehabilitation Options

Lateral rehabilitation
Rehabilitation Options

Manhole rehabilitation
Rehabilitation Options

Disconnect direct connections
After You Have the Data

- Risk considerations
- Cost / benefit analysis
- Prioritizing improvements
- Developing annual replacement plan and budget
- Maintaining I/I reduction program
Risk Considerations

- Risk = likelihood of failure (x) consequence of failure

- Consequence considerations
  - Trunk line
    (size, number of connections)
  - Schools, hospitals, etc.
  - Risk of SSO’s
    (proximity to waterway)
Prioritizing Improvements

• Prioritize based on multiple criteria
  – CCTV reports
  – Pipe age and material
  – Observed infiltration
  – Consequence of failure

• Grouped projects
  – Separate lists for cross connections and spot repairs, organized by $/gpm
Cost / Benefit

- Estimated cost of rehabilitation
- Estimated cost to convey and treat wastewater
- Calculated annual replacement budgets
Cost / Benefit Analysis

• Compares cost to convey and treat versus cost of rehabilitation

• Challenges
  – Quantifying flow reduction
  – Assigning conveyance and treatment cost to an incremental increase/decrease of flow
  – Assessing impacts for offsetting / delaying capacity-required capital construction costs
Rehabilitation Costs

- Traditional pipe replacement (8” line) – $180/LF
- Trenchless pipe replacement – Up to 40% savings
- Spot repairs – $2000 for 3 ft spot repair liner
- Lateral rehabilitation – $50/LF open trench
  – $3500/lateral trenchless lining
- Manhole rehabilitation – $60/sqft rehab and lining

Costs are variable and function of pipe size and length, material, depth, water table, location, etc.
Sample Cost / Benefit Analysis

- **Cost to convey and treat**
  - Fixed and variable costs

- **I/I inconsistent flow, based on rainfall and groundwater**
  - Variable intensity of rainfall
  - Variable duration of rainfall

<table>
<thead>
<tr>
<th>Wastewater Fund</th>
<th>2012 Budget</th>
<th>2012 Actual</th>
<th>2013 Budget</th>
<th>2013 Actual</th>
<th>2014 Budget</th>
<th>2014 Actual</th>
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<tbody>
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<td>Administrative</td>
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<td>$998,541</td>
<td>$1,015,456</td>
<td>$1,009,070</td>
<td>$1,198,528</td>
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<td>Operations (WWTP)</td>
<td>$1,718,746</td>
<td>$1,489,899</td>
<td>$2,053,923</td>
<td>$1,941,149</td>
<td>$2,044,137</td>
<td>$1,964,612</td>
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<td>WW Collection (Maint)</td>
<td>$981,379</td>
<td>$653,889</td>
<td>$817,337</td>
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<td>$1,017,266</td>
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<td>Debt Service Payments</td>
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<td>$736,877</td>
<td>$729,408</td>
<td>$729,430</td>
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<td>$1,489,899</td>
<td>$2,053,923</td>
<td>$1,941,149</td>
<td>$2,044,137</td>
<td>$1,964,612</td>
</tr>
</tbody>
</table>

- **Operations (WWTP)**
  - Operating supplies   $144,580  10%  $14,458
  - Utilities            $282,655  40%  $113,062
  - Equipment Repair and Maintenance   $147,680  25%  $36,920
  - Pump Station Maintenance    $6,531  50%  $3,266

| WW Collection | Supplies & Tools | $15,867  25%  $3,967
| Inflow/Infiltration | $4,105  100%  $4,105
| Wastewater Rehabilitation | $58,000  75%  $43,500
| Wastewater System Replacement | $6,417  50%  $3,209
| Manhole Rehabilitation | -  50%  -
| Lateral Replacement | $16,012  70%  $11,208
| Equipment Repair and Maintenance | $4,510  25%  $1,128
| Pipe and Materials | $20,541  25%  $5,135

- **Dry Season flow**
  - 1.7 mgd
  - 1181 gpm

- **Wet Season flow (avg)**
  - 5.1 mgd
  - 3542 gpm

- **Wet Season flow (peak)**
  - 17.6 mgd
  - 12222 gpm

- **Cost per gpm removed**
  - $0.82/gpm/day
  - $1,180.92/gpm
  - $342.20/gpm

- **Average Daily Flow**
  - 3.4 mgd
  - 3542 gpm

- **Cost per gpm removed**
  - $101.63/gpm
  - $1,016.29

This does not account for potential to offset treatment plant or other capital improvements.
Focus on Areas Where You Get Greatest Return on Investment

1) Look for smoking guns

2) Utilize cost/benefit analysis
Smoking Guns

- Manhole “gushers”
- Disconnect direct connections
- Often highest return for lowest cost:
  - Roof drains
  - Catch basins
  - Open/broken C/O caps
  - Storm system connections
Sample Cost/Benefit Analysis – Smoking Guns

- Cross Connections
  - Rational Method
  - Cost to remove
  - GPM benefit
  - Relative comparison

Table H.1 – Estimated Inflows and Improvement Costs for Cross-Connections

<table>
<thead>
<tr>
<th>Picture ID</th>
<th>Address</th>
<th>Inflow Source</th>
<th>Area of Inflow, A (ac)</th>
<th>Runoff Coefficient, C</th>
<th>Rainfall Intensity, i (in/hr)</th>
<th>Inflow, Q (gpm)</th>
<th>Inflow, Q (ch)</th>
<th>Estimated Improvement Cost</th>
<th>Cost per GPM</th>
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<tbody>
<tr>
<td>9</td>
<td>3813 Coffey Ln</td>
<td>driveway drain</td>
<td>0.02</td>
<td>0.75</td>
<td>1.85</td>
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<td>1.85</td>
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<td>31</td>
<td>1300 Villa Rd</td>
<td>roof drain</td>
<td>0.04</td>
<td>0.90</td>
<td>1.85</td>
<td>0.07</td>
<td>30</td>
<td>$300</td>
<td>$10</td>
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<td>48</td>
<td>1542 E 1st St</td>
<td>roof drain</td>
<td>0.05</td>
<td>0.90</td>
<td>1.85</td>
<td>0.19</td>
<td>45</td>
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<td>$7</td>
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<td>0.90</td>
<td>1.85</td>
<td>0.18</td>
<td>45</td>
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<td>75</td>
<td>503 N College St</td>
<td>roof drain</td>
<td>0.04</td>
<td>0.90</td>
<td>1.85</td>
<td>0.07</td>
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<td>$300</td>
<td>$20</td>
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<td>107</td>
<td>417 &amp; 419 S Main St</td>
<td>roof drain, driveway drain</td>
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<td>E 1st St and Everest Rd</td>
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<td>43</td>
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<td>45</td>
<td>E 1st St and Everest Rd</td>
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<td>0.55</td>
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<td>271</td>
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<td>66</td>
<td>300 N Lincoln St (K V Milk Storage)</td>
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<td>1.85</td>
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<td>86</td>
<td>E Sheridan St and N College St</td>
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<tr>
<td>87</td>
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<td>0.61</td>
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<td>1.85</td>
<td>0.71</td>
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<td>0.65</td>
<td>0.99</td>
<td>1.85</td>
<td>0.71</td>
<td>320</td>
<td>$45,000</td>
<td>$109</td>
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<td>97</td>
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<td>0.48</td>
<td>0.99</td>
<td>1.85</td>
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<td>0.99</td>
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<td>0.99</td>
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<td>1.85</td>
<td>0.66</td>
<td>295</td>
<td>$9,000</td>
<td>$80</td>
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<td>121</td>
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<td>0.99</td>
<td>1.85</td>
<td>0.77</td>
<td>345</td>
<td>$14,500</td>
<td>$50</td>
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<tr>
<td>123</td>
<td>E 4th St and S Meridian St</td>
<td>catch basin (4x)</td>
<td>0.6</td>
<td>0.99</td>
<td>1.85</td>
<td>0.69</td>
<td>310</td>
<td>$25,000</td>
<td>$64</td>
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<td>126</td>
<td>E 5th St and S Meridian St</td>
<td>catch basin (2x)</td>
<td>0.8</td>
<td>0.99</td>
<td>1.85</td>
<td>0.69</td>
<td>310</td>
<td>$25,000</td>
<td>$64</td>
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<tr>
<td>127</td>
<td>E 4th St and S Center St</td>
<td>catch basin (4x)</td>
<td>0.8</td>
<td>0.99</td>
<td>1.85</td>
<td>0.69</td>
<td>310</td>
<td>$25,000</td>
<td>$64</td>
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<td>137</td>
<td>1215 E 4th St</td>
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<td>0.99</td>
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<td>1.85</td>
<td>0.93</td>
<td>419</td>
<td>$25,000</td>
<td>$54</td>
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Totals: 6000 $342,000 $397
Annual Budgets & Capital Improvement Plan

• Identified projects become part of CIP
• Educate and present budget
• Additional budget elements:
  – Pipeline replacement/rehab
  – Lateral replacement/rehab
  – Manhole replacement/rehab
  – Inspections/monitoring
Replacement Budgets

Annual asset replacement quantity for sustainable system:

\[
\frac{\text{Quantity of Asset}}{\text{Life Cycle of Asset}} = \text{Quantity of Asset per Year to be replaced}
\]

Example:

\[
\frac{75 \text{ miles of mainline}}{100 \text{ year life cycle}} = 0.75 \frac{\text{mile}}{\text{year}} (3,960 \frac{\text{ft}}{\text{year}}) \text{ to be replaced}
\]
Monitor Improvements

- Continue to collect data
  - Flow monitoring
  - Pump run times
  - SCADA
- Monitor rehabilitation for improvements
  - Results of rehab can be used to plan future I/I elimination projects
  - NPDES requirements
- Share your successes!
Case Studies

Newberg, OR

Stayton, OR

Ashland, OR
Case Study: Stayton, OR

- Seasonal (shallow groundwater) infiltration
- Storm response
Case Study: Stayton, OR

- Pump run time analysis
- Flow monitoring
- Night-time monitoring
- Dye tests
- Reviewed CCTV logs
Case Study: Stayton, OR

- Identified basin with highest I/I
  - Subsequently, narrowed down worst sub-basin and largest contributors in sub-basin
- Developed list of priority improvements
- Suggested flow monitoring program similar to CCTV program
- Continue CCTV program and repairs

- Demonstrated I/I improvement through historic data
  - Routine CCTV schedule and subsequent repairs

[Graph showing Winter-Summer Factor with data from 2008 to 2010 for different basins.]
Case Study: Ashland, OR

Initial considerations:

- Older pipes (clay and concrete)
- New construction
Case Study: Ashland, OR

- Pump run time analysis
- Flow monitoring
- Night-time monitoring
- Smoke testing

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>Peak Day Factor*</th>
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<tbody>
<tr>
<td>Grandview P.S.</td>
<td>2.32</td>
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<tr>
<td>North Main P.S.</td>
<td>1.95</td>
</tr>
<tr>
<td>North Mountain P.S.</td>
<td>1.93</td>
</tr>
<tr>
<td>Ashland Creek P.S.</td>
<td>1.52</td>
</tr>
</tbody>
</table>

*Peak day divided by average day for Nov. 2012 - Jan 2013 period.
Case Study: Ashland, OR

- Focused on basin with highest I/I
- Narrowed down sub-basin with highest contributions
- Cost/benefit analysis
- Compiled list of cross connection inflows
  - Estimated rehabilitation costs
- Proposed areas for CCTV inspections and ongoing flow monitoring
Case Study: Newberg, OR
Determining Newberg’s Sources of I/I

- WWTP influent data
- Pump run time analysis
  - Narrows down worst basins**
- Flow monitoring
  - Narrows down worst areas
- Nighttime monitoring
  - Narrows down worst segments
- Smoke testing
  - Smoking guns
- Video inspection
  - Pipe conditions and indicators
Start with WWTP influent data

- Seasonal groundwater infiltration patterns
- Storm response
Review other Available Data

- Lift station flow metering and pump run time data
Target Flow Monitoring Sites

- Consider best time of year to capture high flow events
Use Smoke Testing to Find Low Hanging Fruit
Nighttime Flow Monitoring
CCTV Inspection

- Use standardized PACP rating criteria
Risk Considerations

- Risk = likelihood of failure (x) consequence of failure
- Consequence considerations

Table 9 — Consequence of Failure Factors

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>If commercial zone</td>
<td>x 1.1</td>
</tr>
<tr>
<td>If next to school or creek</td>
<td>x 1.1</td>
</tr>
<tr>
<td>If interceptor ≥18”</td>
<td>x 1.2</td>
</tr>
<tr>
<td>If interceptor ≥12”</td>
<td>x 1.1</td>
</tr>
</tbody>
</table>

Legend
- City Limits
- WWTP
- Diversion Chamber
- Pump Station
- Dry Pump Station
- Manhole
- Gravity Line
- Force Main

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>0</th>
<th>&gt;0-2</th>
<th>&gt;2-4</th>
<th>&gt;4-6</th>
<th>&gt;6-8</th>
<th>&gt;8-10</th>
<th>&gt;10-12</th>
<th>&gt;12-13.2</th>
</tr>
</thead>
</table>

Prioritization

- **Pipe Condition**
  - CCTV reports
  - Structural and O&M defects
  - Pipe age and material
  - Night-time monitoring

- **Risk**
  - Risk = Consequence of failure x Likelihood of failure
  - Location: service to school, hospital, etc.

- **Separate list of cross connections**
- **Separate list for spot repairs**
  - Grade 4 or 5 structural defect in PACP report
Cost / Benefit

- Cross connections (smoking guns)
  - Rational method: estimated $/gpm removed
- Estimated cost of rehabilitation
- Estimated cost to convey and treat wastewater
- Calculated annual replacement budgets
Sample Cost / Benefit Analysis

- Cross Connections
  - Cost to remove
  - GPM benefit
  - Relative cost per GPM comparison

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<tr>
<th>Picture ID</th>
<th>Address</th>
<th>Inflow Source</th>
<th>Area of Inflow, A (ac)</th>
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<th>Rainfall Intensity, i (in/hr)</th>
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<td>0.93</td>
<td>419</td>
<td>$42,000</td>
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</table>

Totals: 6000 $342,000 $57
Sample Cost / Benefit Analysis

- Cost to convey and treat
  - Fixed and variable costs
- I/I inconsistent flow, based on rainfall and groundwater
  - Variable intensity of rainfall
  - Variable duration of rainfall

<table>
<thead>
<tr>
<th>Operations (WWTP)</th>
<th>COST</th>
<th>VARIABLE COSTS</th>
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<tr>
<td>Operating supplies</td>
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<td>Utilities</td>
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<tr>
<td>Equipment Repair and Maintenance</td>
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<td>Pump Station Maintenance</td>
<td>$6,531</td>
<td>$3,266</td>
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- WW Collection

| Supplies & Tools                  | $15,867 | $3,967         |
| Inflow/Infiltration               | $4,105  | $4,105         |
| Wastewater Rehabilitation         | $58,000 | $43,500        |
| Wastewater System Replacement     | $6,417  | $3,209         |
| Manhole Rehabilitation            | $-      | $-             |
| Lateral Replacement               | $16,012 | $11,208        |
| Equipment Repair and Maintenance  | $4,510  | $1,128         |
| Pipe and Materials                | $20,541 | $5,135         |

- O&M Savings $102 / gpm

- Average daily flow: 3.4 mgd
- Average daily flow: 2361 gpm

This does not account for potential to offset treatment plant or other capital improvements.
Priority Improvements

- Prioritize based on multiple criteria
  - CCTV reports
  - Pipe age and material
  - Observed infiltration
  - Consequence of failure

- Grouped projects
  - Separate lists for cross connections and spot repairs, organized by $/gpm
Case Study: Newberg, OR

Deliverables

- Prioritized list of rehabilitation projects
- List of spot repairs – major pipe defects
- List of cross connections

Utilization

- Allows “smart” planning of rehabilitation projects
  - Can group with other utility work
- Can budget rehab work annually
- Update and re-prioritize list as additional data is collected (living document)
- Prioritized projects if extra money is awarded or surplus budget
Round 2 / Lessons Learned

- **Newberg Wastewater Master Plan**
  - Building on previously completed I/I Study
  - Incorporating collected data from then to now
    - Standardize methods of data collection
  - Collecting new data in different areas
    - Extents of data are important
  - Updating prioritized projects and lists
Building on Initial Study
Keep Records & Standardize Process

- Highlights trends over time
- Facilitates ability to track condition changes

<table>
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<tr>
<th>I/I Flow (MGD)</th>
<th>Andrew</th>
<th>Charles</th>
<th>Chehalem</th>
<th>Creekside</th>
<th>Dayton</th>
<th>Sheridan</th>
<th>Fernwood</th>
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What can you do about I/I?

• Start with what you have
  – Collect data (daily pump run times, CCTV reports, etc.)
• Educate political leaders & commit to an I/I program appropriate for your community
• Identify & correct the low hanging fruit (and share your success!)
  – Cost/benefit
  – Prioritized plan
• Don’t be afraid to ask for help to jump start or enhance your program
QUESTIONS?

Peter Olsen, P.E.
polsen@kellerassociates.com
Salem, OR  (503) 364-2002

Emily Flock, E.I.
eflock@kellerassociates.com
Salem, OR  (503) 364-2002