You Call That Good Data? How to Survive a Consent Decree Flow Monitoring Program

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Project Team

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HRSD Service Area

- Serves Southeast Virginia
- 1.6 million people
- 430 miles of force mains
- 80+ PS
- 50 miles gravity pipe
- 9 major treatment plants
Background

• Previous Consent Orders
  • Norfolk
  • Hampton

• Master Metering Program contracts
  • Boundary meters
  • Treatment plants
  • Some pumping stations
  • Data collected through SCADA

• Miscellaneous gravity flow monitoring
HRSD Flow Monitoring Program

- New Consent Order and Consent Decree
  - Regional Hydraulic Model
- Expand existing network
  - 117 pressure monitoring sites
  - 137 flow monitoring sites
  - 64 rain gauge sites
  - 21 groundwater monitoring sites
  - 39 IWD sites
- Significant installation effort
  - Negotiated schedule
- Standardized equipment
Program Changes

- Pressure-side to gravity flow metering in some locations
- Meter selection
- Location changes
- Policy changes
- Schedule delays

- Kept regulators in the loop
Data Collection

- 12 month program
- Utilizing Telog® system
- Developed Data Quality Standards and Procedures (DQSAP)
- Reliability requirements:
  - 75% for each individual meter during each monthly monitoring period
  - 90% data reliability for all data for each sensor type during qualifying wet weather events
DQSAP

- Additional measurements recorded for QA/QC purposes:
  - wet well levels
  - pump run status
  - pump speed
- ~190,000 data points go through a daily QA/QC process to ensure data reliability
Data Review Process

• Increased staff based on amount of data to review
  • HRSD Data Analysis Section (3+ FTEs)
  • Consultant staff (2+ FTEs)
  • Flow monitoring vendors

• Manual reviews and automated reviews

• Automation made process more efficient
Automated Alerts

• Utilized Telog® Enterprise software
• Data stored in SQL server database
• Deviation measured as compared to “normal” conditions
Automated Alerts (continued)

• Alert automation using SQL functions that were programmed within the software as well as the data server by Telog®

• Added calculated measurements in which the alert SQL statements would calculate from

• More than 3,000 alerts programmed for the QA/QC process
## Alert Definitions

<table>
<thead>
<tr>
<th>Alert</th>
<th>Potential Anomaly</th>
<th>Regime</th>
<th>Time Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow, sensor</td>
<td>Potential sensor fouling and/or failure as indicated by flat lining and where there is insufficient difference between minimum, average, and maximum values.</td>
<td>Wet and dry weather</td>
<td>Hourly</td>
</tr>
<tr>
<td>Flow, deviation</td>
<td>% deviation from a 4-week dry weather rolling average</td>
<td>Dry weather</td>
<td>Hourly, Daily</td>
</tr>
<tr>
<td>Flow, upstream</td>
<td>Upstream flow exceeds downstream</td>
<td>Wet and dry weather</td>
<td>Daily</td>
</tr>
<tr>
<td>Flow, downstream</td>
<td>Downstream flow less than upstream</td>
<td>Wet and dry weather</td>
<td>Daily</td>
</tr>
<tr>
<td>Flow, wet weather peak</td>
<td>Peak factor outside of expected range</td>
<td>Wet weather</td>
<td>Daily</td>
</tr>
<tr>
<td>Pressure, dry weather peak</td>
<td>Peak pressure compared to a 4-week dry weather rolling average</td>
<td>Dry weather</td>
<td>Hourly</td>
</tr>
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<td>Pressure, sensor</td>
<td>Potential sensor fouling and/or failure as indicated by flat lining and where there is insufficient difference between minimum, average, and maximum values.</td>
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</tr>
<tr>
<td>Pressure, wet weather peak</td>
<td>Peak pressure outside of expected range</td>
<td>Wet weather</td>
<td>Daily</td>
</tr>
<tr>
<td>Rainfall</td>
<td>Rainfall 25% greater than adjacent gauge</td>
<td>Wet Weather</td>
<td>Hourly</td>
</tr>
</tbody>
</table>
Flow/Pressure Deviation Alert

• Useful in identifying:
  • Inflow/Infiltration (I/I) effects
  • Recent calibration
  • System diversion
  • System bypass
  • Instrument fouling or failure
Flow Deviation Alert
Pressure Alert
Automated Alert Exceptions

- Pump station flows do not always produce a “typical” diurnal curve and daily manual reviews may be necessary
Automated Work Orders

- Telog® SQL alerts can be sent by SMS text, email, or paging system
- Email alerts are routed into the Numara Track-It!® software to create automated work orders
- Generated continuously (overnight, weekends, and holidays) and are ready for the analysts to analyze upon their return
- Automated work orders are reviewed daily and deemed either valid or invalid
Track-It! Work Order SOP

• Data analyst reviews automated alert work orders (or generates work order based on manual review) and forwards to supervisor with sufficient documentation

• Supervisor reviews and issues to HRSD Instrumentation or Interceptor Operations staff for field investigation

• Upon resolution, Track-It! work order is closed

• Dashboard and reporting useful for management
## Data Reliability

<table>
<thead>
<tr>
<th>Invalid due to:</th>
<th>Valid due to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Maintenance</td>
<td>Data Adjusted</td>
</tr>
<tr>
<td>Sensor Drift</td>
<td>Normal Trend</td>
</tr>
<tr>
<td>Sensor Failure</td>
<td>Operational Change</td>
</tr>
<tr>
<td>Networking Issue</td>
<td>Seasonal Trend</td>
</tr>
<tr>
<td>Power Failure</td>
<td>User Specified</td>
</tr>
<tr>
<td>Site Constraint</td>
<td></td>
</tr>
<tr>
<td>Unknown Causes</td>
<td></td>
</tr>
</tbody>
</table>

Approximately 2,000 alerts received and resolved through the Numara Track-It!® software on a monthly basis.
Flagging Invalid Data

- Need to close the loop on data reliability
- Analyst identifies start and end times for the invalid data
- From the timestamp highlighted in Telog®, analyst can report the percent of valid/invalid data for the selected timeframe
- Standard report was created by Telog® software engineers
Flagging Invalid Data
Change in Requirements

• Original data reliability requirements impractical

• Intent was to provide sufficient dry weather data for model calibration

• Worked with regulators to explain issue

• Adjusted requirement to 75% reliability at 90% of all sites each month AND 90% of model calibration sites
Other DQSAP Changes

- Alerts have been adjusted due to certain site specific conditions
  - Gloucester Line
- Specific alerts may need to be adjusted as operational changes are made to the interceptor system
  - Rerouting flows for CAP
Final Results

• Collected and reviewed more than 70,000,000 points of raw data

• Captured FPR data from 19 wet weather events

• Met updated reliability standards for all 12 months of program

• Regional Hydraulic Model calibration events had aggregate data reliability between 95% and 100% for all three required events
Reporting

- Interim Report
  - After first 5 months of data

- Final Report
  - Overall Summary
  - Program Changes
  - Data Reliability
  - Tabular Data
  - Graphs/Scatterplots
  - Raw data
Report Figures

Dry Weather Average Flow = 18,875 gpm
Wet Weather Average Flow = 26,561 gpm
Rainfall Derived I/I = 62,269,299 gal
Total Rainfall = 2.22 in
Lessons Learned

- Spend lots of time identifying best places for metering
- Allow schedule float for permanently installed meters
- Plan staffing based on level of data review efforts
- Automate alerts
- Utilize alert tracking system
- Keep regulators in the loop
Questions?
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