Water System Operations Made Easier

Enriching SCADA Data through Hydraulic Modeling

A Bentley Technical Paper

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Introduction

Traditionally, water system operators have relied on SCADA systems to provide insight into their networks. Though SCADA systems have many benefits, they also have limitations. For example, they do not enable operators to clearly foresee the consequences before making any changes in operations. Additionally, installing a sensor for every system attribute at every location can be prohibitively expensive.

Hydraulic models, on the other hand, can calculate any status at any point in a system without a sensor by filling in gaps between measured points with sound mathematical models. They can also test various operational alternatives, which can be useful for planning, design, and operations-based projects. But hydraulic models don't report the system status in real time, such as the current pump status and tank levels.

Today, water system operators aren't stuck having to choose one over the other. They can integrate hydraulic modeling and SCADA data and combine each one's strengths to overcome any limitations. By using 3D modelingsoftware, including SCADA-hydraulic modeling integration, operators and engineers have new methods to improve water system operations, from boosting energy management to enhancing shutdown planning and emergency response.

Hydraulic modelers, planners, and operators can use a network model to identify safe, effective options for addressing pipe bursts, power outages, fires, and other urgent events.

Benefits of Full SCADA and Hydraulic Modeling Integration

Benefits for Engineers

Integrating SCADA data within hydraulic models allows engineers to create accurate models that reflect real network conditions. These models become a true digital twin that looks and performs like the real-world system at all times and helps water system engineers make more informed decisions.

Differences between the SCADA and model data enable forensic studies of the system.

Improved Model Calibration

SCADA data can provide the initial conditions for hydraulic modeling, including the initial levels in water tanks and status of pumps. With the SCADAConnect® application included in real-time modeling and optioneering solutions, SCADA data is automatically integrated into the modeling software. This allows the designer to view a comparison between field data and the model to create a fully calibrated digital twin of the water system in which the status matches the measurements taken by SCADA sensors.

Live SCADA data continuously calibrates the hydraulic model, ensuring model results match real-world conditions. At any time, engineers can recalibrate the model manually if conditions change. Strong visualization capabilities empower operations engineers to monitor SCADA signals as they change and are notified about issues that need immediate attention. Engineers can then respond quickly to minimize downtime and keep the water system operating at maximum efficiency.

Forensic Studies

These visualization capabilities enables users to view both real-time and historical SCADA data, then pinpoint the difference between SCADA and model results. The process allows historical SCADA data to be used for forensic studies or operator training. For instance, the operator can review a past main break by viewing the SCADA data from the when the break occurred and examining the state of the system at the time. The operator can then identify conditions that caused the break so they can anticipate and plan maintenance and operations in the future.

Benefits for Operators

Filling Information between Sensors

Most SCADA systems only monitor a small fraction of the real system. Those that can integrate hydraulic model results with SCADA can fill in the information between SCADA monitoring points, such as the expected pressure at a pressure zone boundary, and provide operators with properties that can't be measured directly including water age or velocity. Doing so provides a more comprehensive overview of the water system.

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Forecasting Operations

While the SCADA system only measures the current conditions in the water network, integrating hydraulic model results shows operators how the network will respond to any changes that occur in the future or what will happen if the network operates with no changes. The unified model can test alternative ways to operate the system to save energy and improve efficiency, or examine operational responses to nontypical events such as fires, pipe breaks, power outages, and extraordinary demand.

This can be used at the end to tell readers the capabilities of our solution. White papers should describe the pains and then offer what our solution helps to resolve these pains.

Seamless Integration for Easy Visualization

Viewing results in OpenFlows WaterGEMS and WaterOPS does not require special training. The software enables the visualization and manipulation of hydraulic results directly within the SCADA control room using the system's existing human machine interface (HMI) screen. The SCADAConnect Simulator in OpenFlows WaterGEMS uses the industry-standard OPC communication protocol, which allows system operators to visualize model results in a familiar interface.

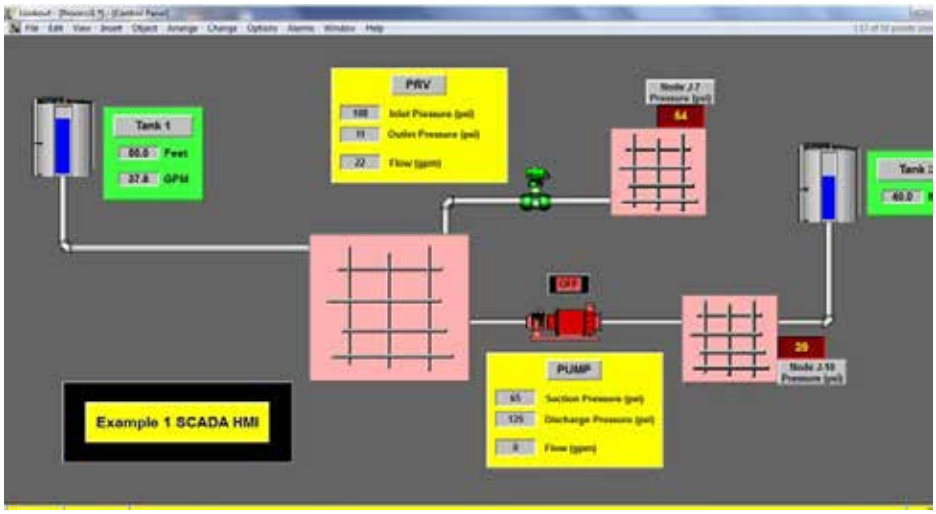

Figure 1: Any prediction is viewable on the HMI screen.

The software also provides operators with simplified control over the hydraulic model results. Operators can easily and rapidly test the network response to specific events or operation changes in a familiar format.

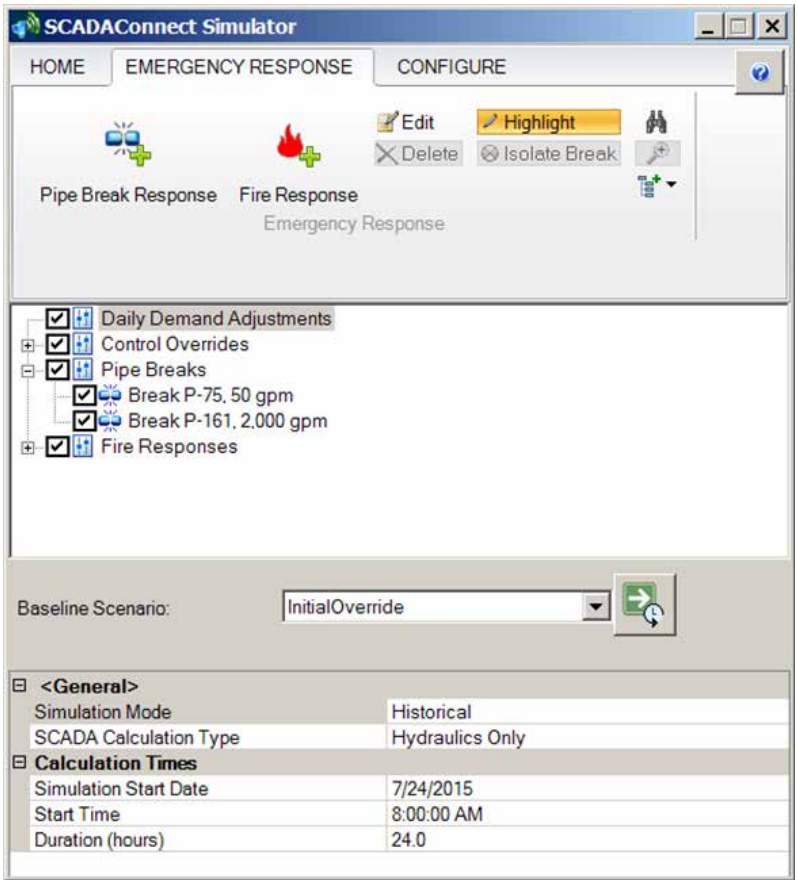

Figure 2: SCADAConnect Simulator provides an interface that operators can easily use to test various scenarios.

Using Digital Twin Models in Operations

Atypical Days

Operators can use hydraulic models to visualize how the water network would respond to unusual conditions or events.

Unusual Demands

Atypical demands include any scheduled events that cause a significant increase or decrease in the number of people using the water network, such as concerts, festivals, sporting events, strikes, spring breaks, and more.

Using real-time modeling applications, operators can easily adjust the typical water demands and override standard controls in the model to test various alternatives and visualize how their water network would behave under atypical conditions.

Operators can use hydraulic models to visualize how the water network would respond to various unusual conditions or events, such as a sudden increase in demand or an emergency shutdown.

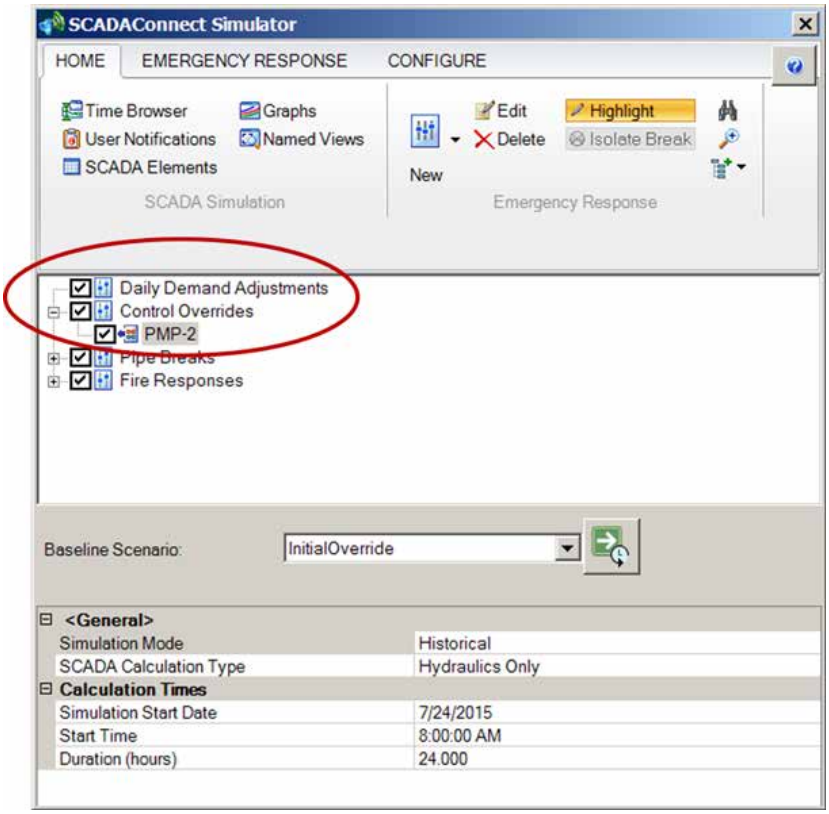

Figure 3: SCADAConnect enables you to easily adjust water demands and controls to predict and visualize network response.

Emergency Response Decision Support

Shutdowns can be scheduled for planned maintenance, or unscheduled as a result of pipe breaks, fires, power outages, or contamination. In these cases, hydraulic modeling can help operators respond appropriately.

By utilizing insight from hydraulic modeling results, system operators can better manage shutdowns by answering the following questions:

- What is the impact of shutting down some valves in the system?
- How does the water get past an area with a shutdown?
- Are there other mains parallel to the one being shut down that can service the system without problems occurring, or will shutting off a valve cut water service?
- How long can downstream tanks support the demands of the downstream customers?

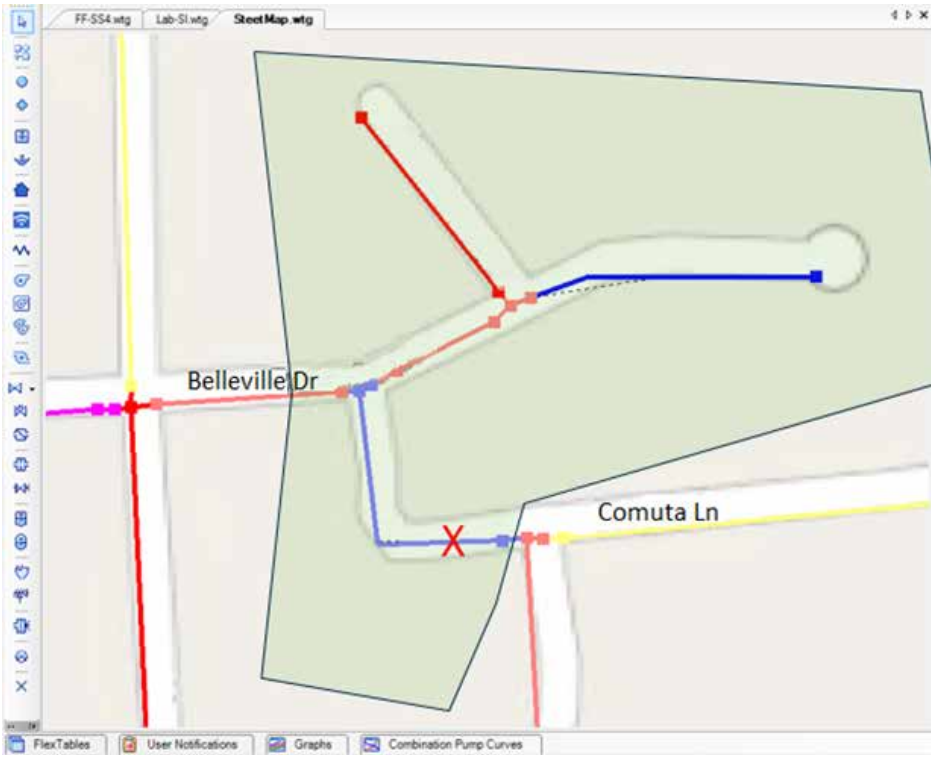

Figure 4: In complex networks, a shutdown map similar to this one can be provided to operators. Because of valving at the intersection of Belleville Dr. and Comuta Ln., all of the customers in the green box would be cut off from water during a shutdown, not just those served directly by the pipe with the "X."

By combining a SCADA system's real-time information with a hydraulic model's ability to interpolate and extrapolate system behavior, decision-makers can obtain a much more comprehensive understanding of potential measures that deal with emergencies, allowing them to respond quickly and effectively to any situation. As a result of Bentley's SCADA-hydraulic modeling integration technology and enhanced collaboration between engineers and operators, response time and customer complaints can be significantly reduced and operational decisions can be improved.

Typical Days

Energy Savings

Water distribution pumps consume a significant amount of energy. However, water utilities can save energy costs by determining where energy is wasted. This helps operators:

- Produce accurate system head curves to size pumps properly.
- Determine if the pumps are operating at inefficient operating points.
- Run compatible pump combinations.

- Evaluate the effects of oversized pumps and display efficiency variations over time.
- Use the best energy rates.
- Identify optimal pump operation schedules.
- Reduce carbon emissions.

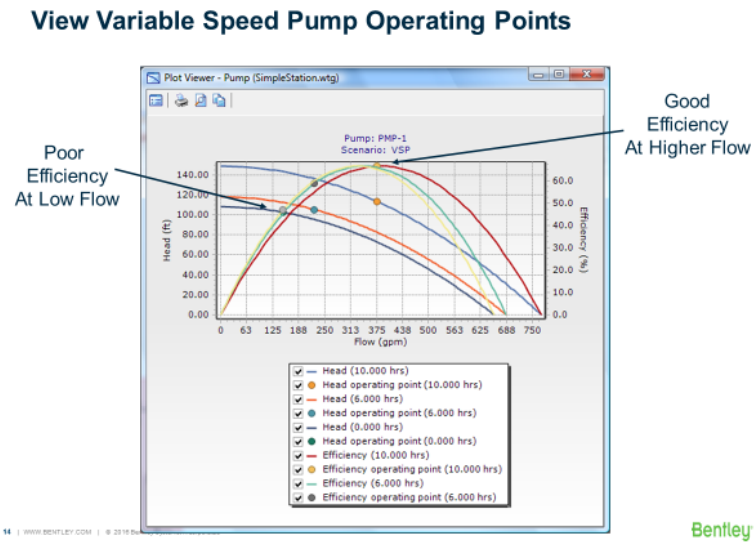

Figure 5: Users can view pump operating points to ensure that they are working at optimal efficiency.

Hydraulic modeling results enable operation teams to determine pump operating costs and modify operations, ensuring that the best energy-saving strategy is implemented.

Flushing

Flushing simulations in hydraulic models and various reporting tools allow operators to determine in advance where flushing will be successful, rather than resorting to a trial-and-error approach in the field.

Useful reporting tools include flushing color-coded maps showing velocity in each pipe, and flushing field reports with drawings and instructions.

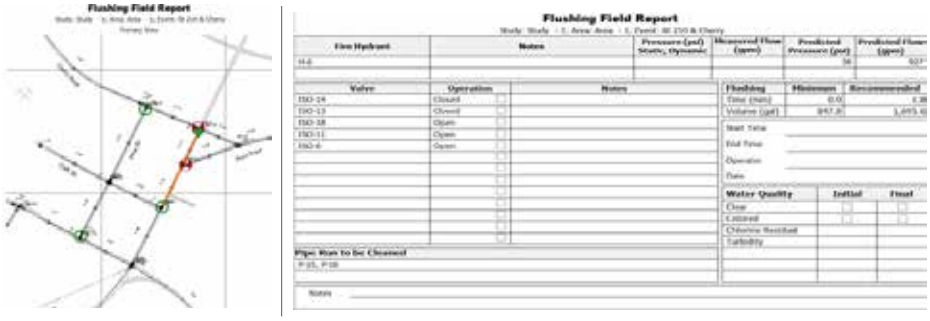

Figure 6: Specific flushing planning reports in WaterGEMS that can be distributed to operators.

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Pressure Complaints

Low pressure complaints are common in water systems. A digital twin can determine if the complaints are valid and persistent, and what can be done to correct them. Moreover, operators can determine if the complaint was due to a temporary situation such as a pump out of service, a pipe break shutdown, low tank levels, or an ongoing problem such as undersized pipes or attempting to serve customers at the wrong elevation.

On the other hand, customers at lower elevations within a particular pressure zone could receive water at an overly high pressure. This can result from the way boundaries of pressure zones are arranged within the network. By moving pressure zone boundaries by modifying valving, these customers can be moved into a lower pressure zone and still receive sufficient pressure. This reduces energy consumption by requiring less water to be pumped into the higher pressure zone, and potentially reduces the likelihood of leakage. Conversely, customers receiving low water pressure may benefit from adjusting the zone boundaries to place them in a higher pressure zone.

An OpenFlows WaterGEMS model can color-code customers within a pressure zone by the pressure they receive and highlight customers along pressure zone boundaries who are receiving excessive pressure. This shows operators which customers can be moved to a lower pressure zone while still receiving sufficient pressure.[1]

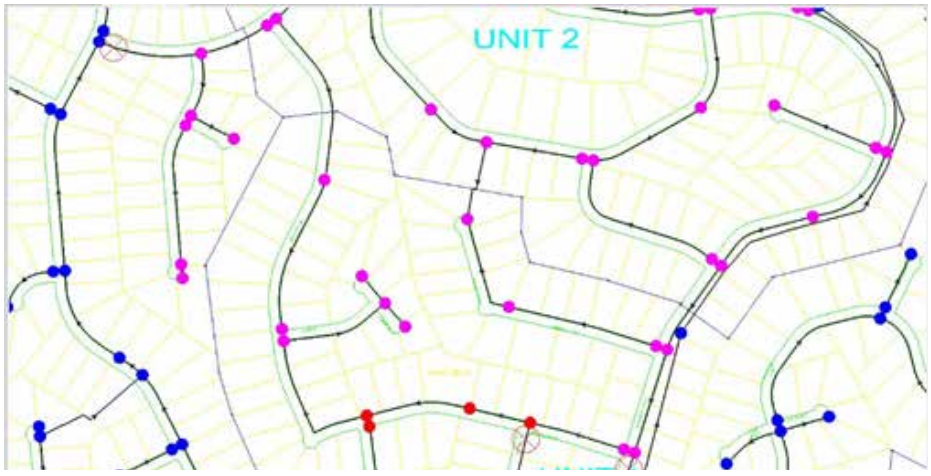

Figure 7: A color-coded map in WaterGEMS, showing customers with excessive pressure along the pressure zone boundary. Magenta nodes are in the higher zone, blue ones in the lower zone, while red ones are in the higher zone but have high pressures and may be better off being moved to the lower zone by adjusting valves.

[1] White Paper: Energy Savings in Water and Wastewater Systems, Dr. Thomas Walski, Tony Andrews, July 2015

Operator Training

Publishing hydraulic modeling results on an HMI screen can help train new operators by showing how the water system will behave in response to certain operations or if a certain event occurred. Providing predictions in a familiar format teaches operators in a way they can easily understand.

Conclusion

Engineering-operation Collaboration Improves Return on Investment

SCADA and hydraulic modeling technologies are both very useful when used independently. However, they also have their limitations. Innovatively integrating SCADA and hydraulic models and setting up true digital twins can benefit planning and engineering departments and operation teams alike. Overall, by leveraging the information made available through engineering-operation collaboration, decision-making can be significantly improved and utilities can realize a greater return on its existing technology investments.

When engineering and operation teams leverage each other's technology and expertise, not only does this improve decision-making for each group, it helps utilities realize a greater return on its existing technology investments.

[2] White Paper: Hydraulic Forces, Randy Rosbury, 2010 Water Environment Federation