Case Study: City of Carlsbad Municipal Water District

SCADA system for water transport, distribution, and treatment

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THE CHALLENGE

The scenic beach town of Carlsbad, California, just north of San Diego, is known for its beautiful beaches, upscale homes and quaint shopping district.

Technician Tom Pagakis oversees the SCADA systems that monitor and control all water and reclaimed water for the city. The key components for these systems are SNAP-brand controllers manufactured by Temecula, CA-based Opto 22.

"We started using Opto as an experiment," Pagakis explains. "Years ago, we were using outdated technologies like tone telemetry and later, a mix of I/O modules and systems from Grayhill and other vendors.

Pagakis' responsibilities center on two distinct areas of operations: sourcing, transport, and distribution of purchased water from lakes and reservoirs to the city; and reclamation of treated water.

"Special drivers had to be created to make everything communicate, and it had become very complicated and unwieldy."

Racks of analog and digital I/O regulate many of the City of Carlsbad's water-related activities.

The SNAP systems—which communicate with each other and back to the control center through a combination of radio, serial, and Ethernet links—are used to monitor, control, and acquire data from all of the city's water and reclaimed water systems.

Pagakis regulates all water transport, monitors an independent water treatment plant, and controls the chemical dosing of ammonia and chlorine that cleans the water. In total, these activities incorporate more than 1000 I/O points distributed across the city's command and control center and numerous remote sites.

WATER TRANSPORT & DISTRIBUTION

Water purchased from the San Diego County Water Authority is transported through piping to Carlsbad, where it's then distributed to businesses and residences. Delivery of the potable water requires little to no pumping, as the water travels via a gravity feed that brings it from large storage tanks (as large as 9 million gallons) located at

Pumps and valves at lift stations and booster stations are key parts of the city's infrastructure.

higher elevations (around 700 feet) all the way down to sea level.

The SCADA system has been carefully configured to control various equipment and monitor the water throughout this entire process. Specifically, analog and digital input and output modules connect to:

- Level transducers that track water levels in large reservoirs and tanks.
- Pressure transducers in pipes that measure pressure in pounds per square inch (psi) within each zone and ensure that water is pumped and is flowing efficiently as it's being delivered.
- Flowmeters that measure how many gallons of water per minute are being delivered.
- Pressure-sustaining, pressure-reducing, and other valves that open and close incrementally to adjust the rate at which the water flows.

All of the monitoring and data acquisition functions are performed not by a single (or even multiple) central controllers, but by three local I/O processors (or "brains") distributed at pump stations and several other points across the city's infrastructure.

"Currently, the SCADA system encompasses 3 large reservoir impounds, 14 reservoirs, and 20 pressure-reducing stations used to monitor more than 500 miles of distribution pipeline," says Pagakis

Significantly, all of the monitoring and data acquisition functions are performed not by a single (or even multiple) central controllers, but by three local I/O processors (or "brains") distributed at pump stations and several other points across the city's infrastructure.

These brains communicate to I/O located on the same rack and perform functions normally reserved for an expensive PLC. For example, the brain takes valve readings from the analog input modules and performs scaling calculations to convert a voltage measurement into a percentage. (So, for a typical 4-20 mA analog input module, a measurement of 12 volts would result in a reading of 50%.) To have this scaling and engineering unit conversion take place locally, at the I/O level, relieves the main controller from extra processing, while also giving Pagakis and other control center personnel the convenience of being able to view and interpret easy-to-understand units of measure (for example, percentages as opposed to voltages.)

Distributing intelligence in this manner also provides a safeguard in case there's an interruption in the operation of one of the main controllers. The brain can be instructed to continue to record measurements and perform calculations, and operators can continue to view this data from the control center's HMI.

WONDERWARE HMI

Pagakis' HMI is a Wonderware InTouch system that integrated neatly with the Opto 22 hardware and allows Pagakis and other control center personnel to view operational variables and conditions relating to pressure, flow, levels, equipment status, and more.

Pagakis also uses his Wonderware system to generate bar and line graphs (indicating such things as tank levels, pump status, and valve positions) and also for performance and historical trending. Pagakis, for example, generates a 24-hour trend for each storage tank, along with reports for the city on how much water he's pumped each day, week, and month.

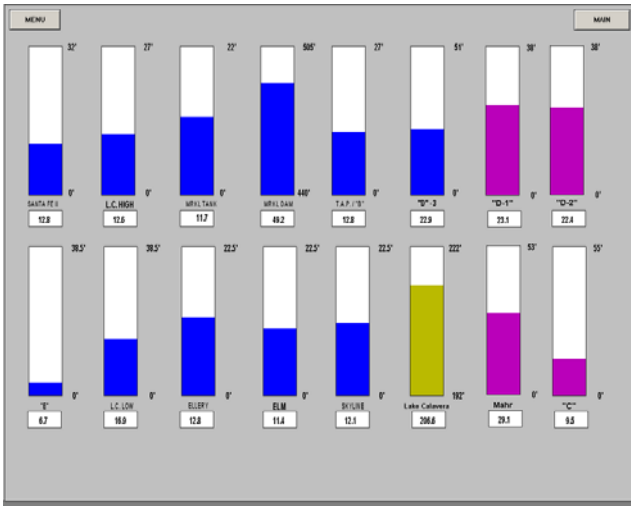
The HMI is configured to alarm on a number of I/O point readings. By defining "normal" or "safe" operational states for specific I/O points, if conditions ever deviate from those parameters, the control center receives a visual alarm. The alarms are also integrated into a pager system and an on-call operator receives a cell phone message that they acknowledge and handle appropriately.

For example, as the control center monitors downstream and upstream water deliveries, it receives alarms on any dramatic changes in pressure due to factors such as a fire hydrant being used or damaged—something that occurred regularly when the San Diego area recently experienced a number of large wildfires.

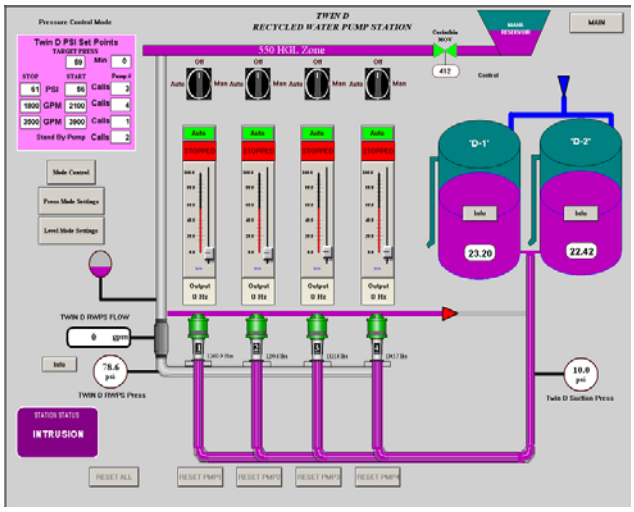
The Opto 22-based SCADA system was also programmed to trigger an alarm when valves malfunction, or when any of the variable frequency drives that regulate any of the pumps fails.

"The VFDs we use are driving pump motors with large power loads, and these are subject to voltage spikes and unusual waveforms," says Pagakis. "We wired up to analog inputs to continuously monitor our VFDs' hertz and motors' RPMs. That way, if either one of them goes, we know right away."

Pagakis explains that the strict monitoring and alarming is due in part to the city's negotiated contract for how much water can be sourced, as well as when and how fast it can be pumped. The city is contracted for a specific seasonal amount of reclaimed water per day. Therefore, the Opto 22



HMI screens display the water levels of tanks, lakes, and reservoirs that supply the city.



Pump station status is monitored via a WonderWare Intouch HMI.

control programs call for the controllers to shut down pumps as soon as this volume is reached.

Furthermore, due to rates imposed by the local power company (San Diego Gas & Electric), the optimal time of day to pump the water is late at night. So although the system has been programmed to monitor the city's water supply levels and begin automated pumping whenever readings drop below a certain point, a condition written into the program delays that pumping until 10:15 PM and always stops operation at 5:50 AM.

WATER RECLAMATION

Water reclamation is a process by which water and sewage from homes and businesses is brought to a treatment plant, where it's cleaned using biological and chemical processes, and then returned to the environment.

"All the sewage for six nearby cities goes to an independently operated treatment plant that we monitor from our control center," says Pagakis.

Using the SCADA system, Pagakis can monitor the treatment plant's operations—particularly wet well levels in lift stations. Via level transducers, the system also monitors reclaimed water storage tank levels and tracks how much clean water has been output and is currently available. The control program was designed so that whenever the city's water supply starts to dwindle, and tank readings reach a certain level, the SCADA system

controllers send analog and digital output signals to partially and fully open valves and start pumps so reclaimed water can be brought from the treatment plant, combined with other sourced water, and then distributed.[1]

Pagakis says his system has been carefully configured to pump and "mix" water from different sources this way so that all the stored water in lakes and storage tanks can be circulated, and water never stands in any one place for too long without being refreshed.

Finally, Pagakis says his SCADA system is also used for a small amount of water treatment. Hach brand sensors and analyzers monitor water properties, and the system regulates chemical dosers that inject chlorine and ammonia into the water as needed.

MOVING FORWARD

The Opto 22 system currently receives input signals from assorted infrared devices, motion detectors, and reed switches outfitted on door frames—all of which are used to ensure there is no unauthorized entry into lift stations, booster stations, or any other facility.

Pagakis has plans to add video surveillance to these intrusion monitoring activities and is also closely tracking the development of a proposed desalinization plant that could provide an additional 50 million gallons of drinking water per day for distribution.[2]

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

In early 2013 Opto 22 introduced *groov* View, an easy-to-use IoT tool for developing and viewing mobile operator interfaces—mobile apps to securely monitor and control virtually any automation system or equipment.

Famous worldwide for its reliable industrial I/O, the company in 2018 introduced *groov* EPIC® (edge programmable industrial controller). EPIC has an open-source Linux® OS and provides connectivity to PLCs, software, and online services, plus data handling and visualization, in addition to real-time control.

All Opto 22 products are manufactured and supported in the U.S.A. Most solid-state SSRs and I/O modules are guaranteed for life.

The company is especially trusted for its continuing policy of providing free product support, free training, and free pre-sales engineering assistance.

For more information, visit opto22.com or contact **Opto 22 Pre-Sales Engineering**:

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1. Because the treatment plant resides at sea level, the reclaimed water has to be pumped to its final destination.
2. Connecticut-based Poseidon Resources Inc. is in discussion to build a 50 million gallon-per-day ocean water desalination plant in Carlsbad. If approved and completed, the "de-sal" plant would be the state's largest and would tap a nearby lagoon filled with ocean water, force that water through filters to remove solids, and, through reverse osmosis, create 50 million gallons of drinking water per day.

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