Sunburned: West Palm Beach Water Treatment Plant Digs Deep to Make Room for Ultraviolet Disinfection Process

Heath Wintz and Dr. Poonam Kalkat

The West Palm Beach Water Treatment Plant (plant) site is a living time capsule, with improvements that have progressed through the ages of steam, electrification, and telecommunication. For the team constructing an ultraviolet (UV) treatment process building on the site, the project has been more than just an excavation; it's been an archeological dig through water treatment history and a race against the clock to meet a regulatory deadline.

Objective and Challenges

When the City of West Palm Beach (city) embarked on a capital improvement program for its historic water treatment plant nearly nine years ago, the plant staff looked for cost-effective processes to meet regulatory requirements. Working closely with the local health department, the city selected UV disinfection treatment to provide a 100 percent redundant disinfection process for inactivation of pathogens and viruses. City staff subsequently selected Stantec to provide design and engineering services for a new UV treatment process building.

Unfortunately, the most feasible portion of the site for this addition happened to be in the most congested area of the 100-year-old water plant, requiring removal of a historic in-ground 1 mil-gal (MG) clearwell constructed in 1926. The connections to this clearwell, which have evolved iteratively over the years, presented a number of technical challenges for the design team and the contractor.

The city's fast-track approach to meet this regulatory requirement required important questions to be addressed early in the process, including:

- What are the required power and cleaning requirements for the UV system?
- How would finished water be rerouted to the high-service pumps?
- How will water be bypassed from the filters to the existing transfer pump station during construction?

Alternatives

These questions would be addressed by conducting pilot-scale testing, in parallel with the review of over 90 years of record drawings. While the questions of water quality would be directly answered by pilot testing, the latter issues related to bypassing and repiping would require hands-on workshops and thoughtful collaboration with operators and city staff.

Ultraviolet Technologies

The first technical memorandum (TM) outlined the UV piloting process using reactors from two manufacturers that were available during the window of the study. The pilot study was conducted over a 30-day period during which filtered water would be pumped to a low-pressure high-output reactor (Trojan) and a medium-pressure reactor (Calgon). Engineers monitored ultraviolet transmittance (UVT) of process water over this period of time to establish design criteria and collect samples of foulants from quartz UV bulb sleeves for characterization and estimation of operation and maintenance costs. After evaluation, the city chose to proceed with a low-pressure high-output UV reactor design. This technology will provide a second barrier to pathogens and viruses prior to chlorine disinfection, essentially giving microbes the worst "sunburn" of their lives.

Clearwell Removal

As the plant was expanded over the years, aboveground storage tanks were added. Finished water from these tanks was directed to two high-

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Figure 1. 1926 Pump Station Panoramic *(photo: City of West Palm Beach)*

service pump stations (designated east and west). The east station (built in 1985) was fed via direct suction from these tanks; however, finished water feeding the west station (established in 1926) continued to flow through an underground clearwell. Removing the aging underground clearwell, which supplied four vertical suction-lift high-service pumps, would be necessary to make room for the UV building. Therefore, a second TM was designed to evaluate alternatives for bypassing and removing the underground clearwell by directly connecting the high-service pumps to the ground storage tanks. After evaluation, the city opted to proceed with new direct-suction split case horizontal centrifugal pumps, which it chose over the reuse of the existing suction-lift pumps.

Flume Bypass

A third TM was established to determine how water could be bypassed from the filters to the existing transfer pump station during construction. The project team would need to remove the filter effluent flume, which is an underground concrete channel built in 1926 and then added onto in 1947 to create a 5-ft-by-5-ft box culvert. Functionally, this structure combined water from the 16 north filters and the 16 south filters, directing filtered water to the existing transfer pump station. A bypass pipe would be needed to redirect a maximum flow of 40 mil gal per day (mgd) to maintain operation of the facility and demolish the filtered water flume. Working closely with maintenance staff, a sequencing approach was developed to divert flow and maintain operation of critical disinfection systems adjacent to this structure, while minimizing downtime.

Design and Sequencing

As answers to design questions and alternatives began to crystalize, it became clear to city staff and Stantec engineers that carefully considered sequencing constraints were going to be critical in order for a contractor to bid and build the design.

Transfer/Ultraviolet Building

The cornerstone of the design was a new transfer/UV building. The wet well of the existing transfer pump station was undersized, and in the event of a power failure, could flood in under seven minutes. Therefore, a new transfer pump station based on Hydraulic Institute (HI) standards with four new variable frequency drive (VFD) pumps would be colocated with the UV reactors.

The transfer/UV building wet well would include an emergency overflow spillway to protect electrical gears on the operating floor level and would also include sodium hypochlorite day storage and pumping facilities. Due to the city's ambitious schedule, a conventional equipment preselection process for UV disinfection equipment was not feasible; therefore, to provide for flexibility and a competitive procurement process, the transfer/UV building layout was designed to fit either of the named UV vendors specified.

High-Service Pumping

A direct-suction line with new 500-horsepower (hp) and 700-hp pumps would allow for

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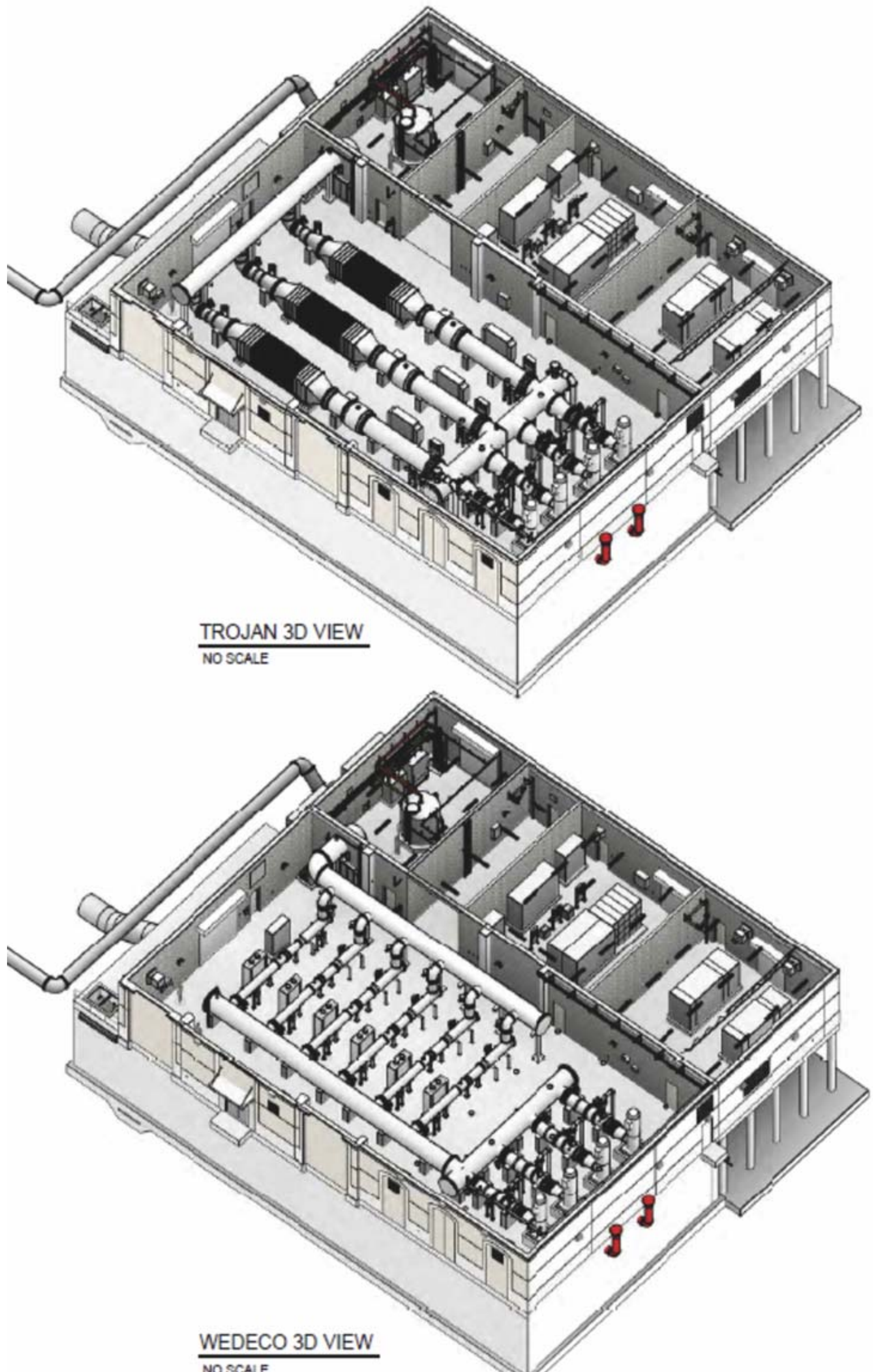

Figure 2. Flexible Building Design for Competing Ultraviolet Manufacturers ***(graphics: Stantec)***

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the elimination of an energy-wasting hydraulic-braking valve assembly, which previously protected the clearwell from overfilling or surcharging as it was fed from aboveground storage tanks. This direct-suction line and associated horizontal centrifugal pumps would eliminate repumping and could save the city nearly $100,000 a year in energy costs.

Due to the deep excavation for the transfer/UV building next to the historic high-service pump station, a temporary direct suction header had to be constructed inside the pump station. Because of tight space constraints, a temporary suction header had to be constructed very close to the pump intakes, which did not meet HI standards. Stantec staff communicated the design constraints to the named pump manufacturers during the design phase in order to ensure that there would be no impact on warranty for the owner until the permanent suction header could be constructed outside the building in accordance with HI recommendations.

Flume Bypass

To remove the concrete filtered-water flume structure, a temporary 54-in. high-density polyethylene (HDPE) bypass pipe was designed to divert water to the existing transfer pump station. Integrally fabricated injection points would provide the city with the ability to maintain a free chlorine and corrosion inhibitor as currently operated. With a valving change, flow would need to be redirected from the bypass to the new UV pump station wet well as part of the permanent piping arrangement.

To meet these needs, a custom fabricated double-tee assembly was designed by Smith-Blair. This assembly would intercept two 36-in. pipes with only 11 in. of separation. The assembly was designed with telescoping fittings and a series of restrained dresser couplings that provided vertical and horizontal adjustment to meet field conditions. Additional sleeve fittings would eventually be cast into concrete walls as part of a new end wall for the filter piping gallery. On either end of the assembly, 54-in. butterfly valves would redirect water to the transfer/UV building during start-up.

Construction

Making room for a new 50-mgd transfer pumping and UV process (transfer/UV) building onsite required delicate exploration, assessment of undocumented utilities, and rerouting of the control infrastructure to allow for sheeting

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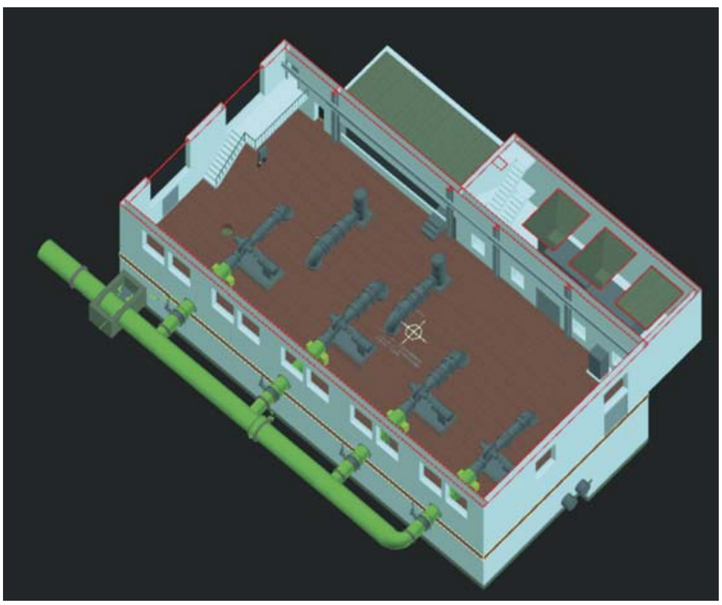

Figure 3. Revit 3D Model of Flooded Suction to High-Service Pumps *(graphic: Stantec)*

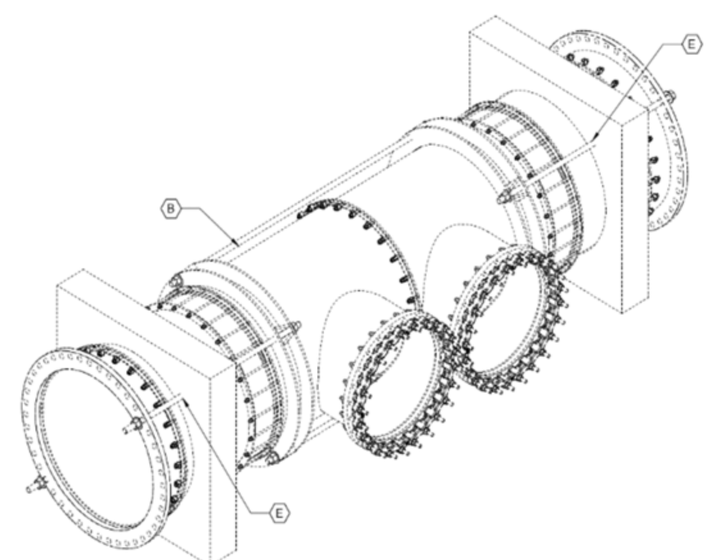

Figure 4. 3D Model of Double-Tee Assembly *(graphic: Smith-Blair)*

Figure 5. Push-Sheeting Installation Around 3-MG Tank *(photo: Stantec)*

Figure 6. Custom 48-in.-by-36-in. Reducing Tee Fitting Installation

Figure 7. Bottle From the Palm Beach Bottling Works *(photo: Stantec)*

Figure 8. Clearwell Roof Demolition *(photo: Stantec)*

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and deep excavation to make critical tie-ins during limited shutdown windows. A "potential" sequence was provided with a construction constraints technical specification, which provided the contractor with a road map to plan and execute work in the following stages:

1. High-service pumps and 3-MG tank tie-in
2. Flume bypass
3. Clearwell demolition and UV building construction
4. Civil paving, grading, and drainage improvements

High-Service Pumping and 3-MG Tank Tie-In

Early submittals were prioritized for the 500- and 700-hp split case pumps to meet an aggressive project delivery schedule. In order to connect these high-service pumps to a 3-MG storage tank, a new flooded suction header needed to be constructed and an inoperable 48-in. valve replaced; however, this valve was nearly 20 ft deep and only 3 ft away from the tank wall. To access this valve without subjecting the tank to excessive vibration, a specialized push-sheeting method was used.

After driving sheets and excavating, the valve was found to be situated beyond the sheeting line under the tank itself. Due to constraining underground utilities, however, the inside distance between sheets was less than anticipated. For these reasons, the assembly design was changed from restrained joint (RJ) fittings to flanged fittings (involving a custom-fabricated 48-in-by-36-in. reducing tee) to minimize lay length.

In February 2017, during the first critical shut-down and tie-in of the project, slight centerline elevation differences prevented a proper fit of this custom-reducing tee and closure of the 36-in. and 48-in. piping. Fast-track procurement of a tapered filler flange to correct this geometry issue enabled the city to resume use of the west high-service pump station with a mere one-week impact.

Artifacts

As exploratory excavation continued in the vicinity of the pump station and unforeseen underground utilities were uncovered, interesting artifacts were also brought to the attention of the city and the engineers. Mosaic tiles from the historic pump station and spikes from the Flagler railroad spur were discovered. Most surprisingly to team members, however, were historic bottles from the Palm Beach Bottling Works.

With delays encountered early in the project from unforeseen underground conditions, the schedule for meeting a regulatory deadline was immediately put at risk. For this reason, the project team proceeded with clearwell demolition and UV building foundation work prior to the completion of flume bypass piping. This decision carried risk because the filtered-water flume was an old structure, with cold joints adjacent to a deep excavation. With equal senses of urgency and caution, the contractor and the city decided to proceed with stages 2 and 3 of the project in parallel.

Clearwell Demolition

In March 2017, critical rerouting of finished-water piping, chemical piping, and power and fiberoptic supervisory control and data acquisition (SCADA) network cabling was completed in the vicinity of the clearwell. As the clearwell was pumped out, safe entry was made into this structure for the last time to inspect and prepare for demolition work.

With an eye towards salvaging select key architectural features, a specialty demolition contractor began removing soil from the top of the clearwell with plans to daylight the structure. Section by section, the roof was hammered and steel reinforcing cut. Following removal of the clearwell structure, excavation for the UV building foundation proceeded.

Transfer/Ultraviolet Building

In April 2017, foundation work began for the transfer pump station. The concrete subcontractor worked diligently to make up schedule time by working weekends where possible. By November 2017, the operating floor slab of the transfer/UV building was constructed in two halves (north/south), each requiring a 26-truck continuous pour. As masonry, structural, and electrical work proceeded, the UV process room of the building began to take shape. By January 2018, four 300-hp vertical turbine transfer pumps were installed, allowing process piping to be flown into the location and the roof enclosed.

In May 2018, the UV reactors arrived and were fit to allow process piping to be completed while the building envelope was constructed.

Start-Up and Commissioning

In August 2018, following completion of most owner training requirements, a start-up and commissioning plan for the UV process and new sodium hypochlorite metering pumps was put forward by the contractor. Through a series of review workshops, the plan was refined and developed to set clear expectations for system operation. An eight-day UV system test in an isolated "sandbox" configuration was conducted by recirculating water from transfer pumps, through the UV reactors, and back down into the wet well.

During this shakedown of the UV system, the contractor, operators, and engineers had the opportunity to push the equipment and controls to the point of failure or shutdown to ensure that the safety systems and protective programming functioned as intended.

When opportunities to simplify programming or controls of the equipment arose, the team remained ready to listen to ideas to ensure that this first, large-scale UV drinking water facility installation in the state was a success for the city. Once the testing reached conclusion, a date was set to make the final process water connections to the ground storage tanks and begin sending finished water out the door to customers. In February 2019, residents of West Palm Beach began enjoying their first taste of water from the city's new UV treatment process.

Final Details

Following the commissioning of the new process, the city was able to proceed with the final stage of construction, which involved the demolition of an antiquated chemical building to allow for a driveway access around the new transfer/UV building. This driveway would enable the operators and delivery drivers the ability to navigate a complete looped road around the facility.

In concert with these civil and landscaping final touches, the city's contractor is finishing construction of a new pretreatment powdered activated carbon (PAC) contact basin. By June 2019, utility customers in West Palm Beach will not only be protected by a dual barrier to pathogens and viruses, they will also be assured that its award-winning surface water is free of taste and odor-causing compounds.

Figure 9. Transfer/Ultraviolet Building Construction *(photo: Stantec)*

Figure 10. Ultraviolet Bulb Replacement Training *(photo: Stantec)*

Figure 11. Transfer/Ultraviolet Building Nearing Completion *(photo: Stantec)*