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Conventional DAF Meets Site-Specific Requirements

Antiquated equipment, elevated DBP levels, and capacity constraints led a New York utility to analyze two DAF treatment processes.

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THE CITY OF PEEKSKILL, N.Y., faced major challenges. The city's slow sand filtration facility, the Peekskill Water Treatment Plant, was built more than 100 years ago; the city's distribution system had elevated disinfection by-product (DBP) levels; and capacity and hydraulic constraints limited expansion. Any plan to update the facility had to consider building height restrictions because of a nearby residential neighborhood, minimizing excavation because of underlying bedrock, and limited space, as the old plant needed to remain operational during construction.

TECHNOLOGY SELECTION

Wiccopee Reservoir, Peekskill's supply source, is eutrophic with seasonal algae blooms, but the water supply to the treatment plant has low raw-water turbidity and low-to-moderate total organic carbon (TOC).

The first step—technology evaluation—identified processes that would meet existing and anticipated drinking water regulations:

- Membrane treatment for particle removal, followed by free-chlorine and chloramine residual
- Chemical coagulation and flocculation applied directly to membrane filtration, with free-chlorine residual
- Chemical coagulation, ballasted flocculation, and high-rate settling, followed by rapid granular filtration and chlorine disinfection
- Chemical coagulation, flocculation, and dissolved air flotation (DAF) clarification, followed by rapid granular filtration and chlorine disinfection

Based on comparative cost estimates and considering a raw-water supply that's subject to seasonal turnover and algae problems, DAF was selected as the best treatment option. DAF process optimization and selection of design criteria were evaluated during pilot testing.

PILOT STUDY

The pilot study assessed two types of DAF processes—conventional DAF treatment and a proprietary high-rate DAF technology—followed by filtration. Pilot trailers were located adjacent to the plant's proposed location, about 25 ft uphill from Campfield Reservoir, the equalization reservoir for Peekskill's pumped supply.

Raw water was pumped from mid-depth of the reservoir and directed to the conventional DAF pilot trailer and the high-rate pilot trailer. Influent to the conventional DAF trailer followed a single process train, consisting of in-line static mixers, two-stage flocculation, and DAF, followed by filtration. The high-rate DAF trailer was equipped with a single process train consisting of a mechanical mixer, three-stage flocculation, and DAF. Because the high-rate DAF trailer wasn't equipped with filters, two of the four filter columns located in the conventional DAF were used to filter the high-rate DAF-floated water. Waste flow from each pilot trailer was discharged by gravity to a sewer connection.

Two loading rates were tested for each DAF process—6 gpm/ft^2 and 7.5 gpm/ft^2

TREATMENT OPTIONS

WHAT IS DISSOLVED AIR FLOTATION?

A proven water treatment technology, dissolved air flotation (DAF) offers significantly lower capital costs than most other clarification processes. The DAF process separates flocculated particles and contaminants from water by floating them to the surface for removal. Flotation is achieved by injecting a pressurized, air-saturated recycle stream. This recycle stream, injected into the inlet of the DAF units, results in a sudden reduction in pressure, triggering the release of air in the form of micro-bubbles that attach to flocculated particles, form a dense foam, and float the particles to a tank's surface where they're removed by a skimmer.


The new Peekskill Water Treatment Plant faced several design complexities, including connecting the new facility and high-service pumps to the existing clearwell without interrupting service; installing a new intake; and managing a project site underlain with bedrock, requiring costly excavation. An award-winning approach was used to optimize the conventional DAF process and include a pump station that allowed the plant to be constructed at grade, minimizing excavation.

PHOTOGRAPH: HAZEN AND SAWYER

for conventional DAF and 12 gpm/ft^2 and 16 gpm/ft^2 for high-rate DAF. The lower loading rates (6 gpm/ft^2 and 12 gpm/ft^2) averaged lower floated-water turbidities; filtered water quality parameters varied.

The pilot data confirmed that both DAF processes, followed by filtration, provided high-quality finished water (low filtered-water turbidity and high particle removal) and maintained adequate filter-run lengths. Filtered-water turbidity was consistently less than 0.1 ntu. Log particle removal ranged from 1.1 to 2.8 for optimized runs. Unit filter run volumes consistently exceeded the 7,500-gal/ft^2 pilot goal.

Iron and manganese in the filtered water were frequently undetectable and reliably less than the 0.02-mg/L pilot goal. Organics removal ranged from 40 percent to 50 percent for specialized TOC testing, and ultraviolet analysis indicated removal greater than 75 percent. These high removal rates would help the city meet federal standards regarding DBP formation.

The pilot data confirmed both processes provided high-quality, low-turbidity finished water and high particle removal, with adequate filter run-lengths. Therefore, further evaluations were conducted to determine which technology was best suited for the site's space, height, and depth requirements. Conceptual building and site layouts were prepared for both processes, and comparative cost estimates were developed.

DESIGN AND CONSTRUCTION

Computational fluid dynamics (CFD) was used to optimize facility design and minimize plant footprint and excavation depth and extent. Flocculation tanks of the same width were dedicated to the respective DAF–filtration tanks. This innovative layout enabled pinpoint floc to form and be removed in less time, allowing for more compact flocculator layout and decreased structural and excavation costs. CFD modeling confirmed that this arrangement wouldn't result in uneven flow distribution to the DAF saturator zone. CFD modeling was also used to refine spacing of the transition baffles between the flocculation basins and DAF tanks, providing efficient layout.

Although high-rate DAF resulted in a smaller flotation area, it required a deeper tank and larger flocculation area than conventional DAF. Evaluations demonstrated that the conventional DAF process was cost-effective and required less space than high-rate DAF. Therefore, conventional DAF was selected for design and construction.

Because the high-rate DAF process operates at much higher loading rates than conventional DAF, it seems intuitive that the high-rate process would save money because of its smaller footprint. However, analysis demonstrated that, after optimizing the flocculation basin arrangement, there was little difference in overall footprints of the two processes, and the high-rate process didn't meet the owner's footprint or cost–benefit criteria.

SYSTEM BENEFITS

The new plant began serving customers in May 2010. The cost-efficient treatment process effectively removes organics, producing finished water that consistently meets DBP limits, which the old plant had seasonally exceeded. The quality of water from the new plant significantly improves public health for Peekskill residents.

The American Council of Engineering Companies recognized the new facility with a 2011 Gold Award because it exhibits the successful evaluation of alternate treatment processes, pilot-scale studies of options within the selected process, optimization of the selected treatment, and life-cycle cost analysis. The approach established the most cost-effective treatment alternative and optimized plant design, taking into account considerable site constraints and the need to provide continuous service throughout construction.