



ITT

Water & Wastewater Treatment – Clarification Case Story

Leopold® Clari-DAF® System Makes Water Treatment Facility a Plant for All Seasons

Few would dispute that adequate water supply has always been the lifeblood of any community. Entering the last decade, the existing Freedom District Water Treatment Plant, owned by the Carroll County (MD) Bureau of Utilities, had access to plenty of source water in the 3100-acre Liberty Reservoir. However, the service area's steady growth squeezed the 3.0 million gallons per day (MGD) capacity of the county's water plant.

The increase in demand grew from 0.02 to 1.5 MGD from 1970 to 1990. Spikes in peak demand exceeded 70 percent of the plant's capacity by the latter half of the decade. The potential shortfall led to enacting water conservation initiatives and limiting new building permits while the District set in motion the planning for an expansion project. In May of last year (2009), the utility brought into service the largest—and most advanced— surface water membrane filtration plant in the state.

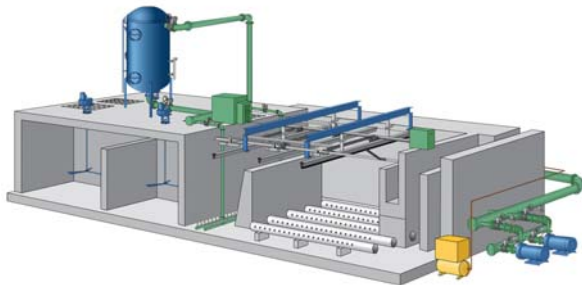
The 4.0-MGD facility incorporates creative design features and treatment technologies that not only improve daily operations but should reduce maintenance and extend the life of the membrane filtration system. Foremost among these is the Leopold® Clari-DAF® clarification system supplied by ITT Water & Wastewater

that works in tandem with the membrane filtration system. The DAF (dissolved air flotation) pretreatment overcomes problems often encountered in surface water sources and improves the efficiency of the 0.02-micron ZeeWeed 1000D membrane filter system provided by GE Water. The filtration membranes safeguard against pathogens that can pass through traditional sand/diatomaceous (S/D) filter systems.

Furthermore, an ingenious integration of new construction and modifications to the original treatment facilities make full use of the DAF system's contaminant removal ahead of the membrane filters. The hydraulic interconnection of the existing plant both upstream and downstream avoided the much higher capital cost of building a larger stand-alone plant to achieve the same 7.0 MGD combined capacity. The Freedom District thereby gained the needed 7.0 MGD capacity, excluding another 1.5 MGD available from two supplementary well systems.

The upgrade has restored development projects in the county while possessing the flexibility to adapt to likely changes in surface water disinfection regulations. While still in the startup phase, the facility already earns high marks from the head of plant operations.

"The design is perfect for our source water," said Greg Wantz, the plant superintendent who has 26 years with the District. "The original plant used a solid-contact clarifier where the sludge always settled to the bottom. Instead, the new plant's DAF clarification system causes the sludge to rise to the top where it can be mechanically skimmed and removed much easier. The overall facility is far more operator-friendly compared to what we had in the past."



Advanced Design and Procurement

From concept through construction and startup, this project offers a prime example of knowledgeable engineering, progressive project delivery and far-sighted solutions to the District's capacity and surface water issues. As is common with many surface water sources, the lake water presents several seasonal treatment considerations. Turbidity, which normally runs less than 5 NTU, is less a problem than the vigorous algae blooms and the lake's pronounced thermocline which induces seasonal mixing of manganese, pH and TOC (total organic compounds) at the intake depth during the onset of the different seasons.

"The DAF system and ultrafiltration membranes are designed to resolve these recurring conditions," Wantz points out. "Our turbidity normally stands at only 2.0 NTU, but we experience significant algae blooms starting in mid-July through October. The top 18 feet of lake can reach 80°F, above a 50°F constant below that depth. Once the algae blooms expire in the fall, the changing temperature conditions start the lake mixing and we contend with challenging manganese levels of 0.3 to 0.5 ppm. This starts in late November as the organics decay and rising manganese levels reach the 8-ft. depth where our intake pumps draw raw water for the plant."

Design / Build Aids Budget Control and Schedule

The county selected Metcalf & Eddy, now operating as AECOM Water, Wakefield, MA, to lead a design/build team assembled for the \$27.5-million-project. Other participants included KCI Technologies, Whiting Turner Construction Company and Construction Dynamics Group, with Arcadis Company serving as the owner's representative. The alternative to a traditional design/bid/build program complemented the fast-track schedule and facilitated up-front pricing and procurement of pre-approved equipment, noted Brian W. Daly, PE, who led the project for AECOM.

"The design/build approach probably saved the District at least three months and cut \$1.5 million off the original budget estimate," Daly believes. "From the time a shovel turned any ground, we brought the plant on-line in less than 18 months.

Given the scope of improvements, the District can be assured of adequate water supply for years to come."

New Solutions to Some Old Problems

The pre-existing plant relied on two, 2100-gallon-per-minute (gpm) variable-speed submersible pumps to advance water drawn from a flexible floating intake system to a vault at the west shoreline of the lake. That original intake was abandoned in favor of a similar flexible floating system but with three, 2700-gpm barge-supported submersibles that draw the raw water to a valve vault and into a common channel where it undergoes two-stage rapid mixing and tapered flocculation ahead of the DAF pretreatment system in the new 4.0 MGD plant. Over the years, the floating intake design had proven itself over a fixed intake because it could adjust the ten-foot-plus swings in lake elevation. Retaining a flexible intake design also improved constructability, sidestepped the higher cost and permitting reviews for a fixed intake, and should be inherently better suited to address the algae and manganese problems than a fixed intake structure.

The total draw from the lake passes through Plant #2's DAF clarification but a flow can be diverted through a 16-in. line and passed through the original 3.0 MGD plant's S/D filtration. The filtered water from Plant #1 is then pumped to a shared 400,000-gallon clearwell to combine with the membrane-filtered water produced by the 4.0-MGD plant. The shared tank was built under a new administration building housing office areas, control and electrical rooms. Superimposing the building over the new clearwell helped both elements fit within the project's limited site.

The combined water in the clearwell receives sodium hypochlorite disinfection, fluoride and corrosion control treatments. Wantz said the adoption of 15 percent bleach disinfection is higher in cost but resolves the risks and discharge residuals associated with the former chlorine gas. In addition, AECOM designed the plant to readily accept ultraviolet (UV) disinfection in the future.

The hydraulic integration of the two facilities extended the useful life of the existing plant while providing the additional capacity sought from the expansion. The design solution was far more cost-effective than totally abandoning the original plant

and building a standalone 7.0-MGD plant. Engineering provisions and equipment sizing also will allow incremental expansions to achieve a total flow up to 12 MGD.

Pilot Tested by State Mandate

The state required pilot testing of the Leopold Clari-DAF system in tandem with membrane filtration. Both the DAF and membrane filtration systems earned acceptance due to performance compared to competing technology in the pilot tests. A tractor trailer equipped with a scaled-down Leopold Clari-DAF system operated at the site for six months to demonstrate the efficacy and compile data used for sizing the pretreatment unit. The data compiled during the pilot testing led to sizing a membrane filtration system consisting of three, 1.33 MGD trains with two, 48 modules (expandable to 60) per cassette.

The project reflects the major reasons why the Leopold Clari-DAF system often earns acceptance for pretreatment. These included the smaller footprint required on the constrained site, higher quality effluent water than that which is produced by settling basins; higher potential loading rate on the membrane filters, and more concentrated sludge. Freedom WTP's twin DAF systems provide redundancy and optimize coagulation and flocculation in the source water, which helps maintain higher flow through the filters.

The pretreatment ahead of membrane filtration also extends intervals between both the backwash cycles and the frequency of chemically cleaning that takes the membrane units off-line. Collectively, these reduced intervals can ultimately increase the overall life of the costly membranes. Since startup, the daily maintenance of the membrane units has involved cleaning with 100 mg/L of sodium hypochlorite for five minutes. While in operation, the filters are programmed for backwash intervals every 30 minutes to achieve 95 percent recovery for the membranes. Every month the membrane filter trains normally undergo

a ten-hour chemical soak with 500 mg/L of sodium hypochlorite followed by a 12-hour flush with 1000 mg/L of citric acid. The goal is to get as close as possible to 2.1 pH.

Pretreatment solids and filter sludge are stored in a pre-existing 100,000-gallon settling basin. The waste is concentrated in a drum thickener with polymer added for dewatering before advancing to a plate and frame press that creates a cake. The processed cake is then hauled off to a land application site by a contract trucker.

Start-Up Operations

The District continues to operate the original plant's S/D filtration, but reduced to eight hours once a week and continues to comply with state regulations, Wantz said. The new 4.0-MGD plant has otherwise served the utility exclusively since the startup.

The high-tech plant has achieved its operational goals of particle and pathogen removal. High log removals, often in excess of 5-log were achieved through membrane integrity testing and membrane filter loadings exceeding 45 gfd/sf. Filtered turbidity reads continue to run below 0.03 NTU.

The former facility operated mostly in manual mode and was vulnerable without quick response to changing water conditions. The new plant is highly automated by a programmable logic controller and can be monitored even remotely via the District's SCADA system. The daily maintenance of the membrane units has involved cleaning with 100 mg/L of sodium hypochlorite for five minutes.

Wantz emphasizes that inadequate capacity was the driving issue behind the expansion. In fact, the former plant earned high quality marks—even awards in taste competitions—and therefore deserved to remain in operation on its merits. However, the new plant's superior clarification and membrane filtration reflect how far technology has come in the water treatment industry.

Six-Month Performance

Parameter	Water Quality Goal	Average (3/1/09 to 9/8/09)
Filtered pH	6.5 - 8.5	8.0
Filtered Turbidity	≤ 0.10 NTU	0.04 NTU
TOC Removal	35% - 45% (Dependent on raw TOC and alkalinity)	35% - 60%
Taste and Odor	Reduce to non-detectable levels	Non-detectable
Color	< 5 CU	< 5 CU
Manganese	< 0.050 mg/L	0.007 mg/L
Chlorine Residual (Free)	0.2 - 4.0 mg/L	1.96 mg/L
Fluoride	0.75 - 1.50 mg/L	1.05 mg/L
<i>Giardia</i> Removal / Inactivation	3-log minimum*	Achieved / Exceeded
Virus Removal / Inactivation	4-log minimum*	Achieved / Exceeded
<i>Cryptosporidium</i> Removal	2 log*	Achieved / Exceeded
* Calculated via Zenon process software and routine membrane integrity testing.		