World's Largest Compressible Media Filtration Plant Eliminates Combined Sewer Overflows, With Potential For Dry-Weather Use

by Jim McMahon

Ground level view of high-rate treatment facility

The City of Springfield, Ohio recently opened its 100 MGD enhanced high-rate treatment facility, designed to treat and disinfect combined high-volume stormwater and wastewater flows generated by wet-weather conditions. Utilizing EPA-documented Compressible Media Filtration technology – FlexFilter™ from WWETCO – the system can also provide tertiary filtration and disinfection during normal dry-weather conditions, demonstrating its functionality as a dual-use technology.

Eliminating untreated wet-weather combined sewer overflows (CSOs) is a significant issue facing many water utilities worldwide. CSOs contain stormwater-flushed contaminants from the watershed, plus untreated human and industrial wastes. These can include oxygen-consuming organics and nutrients, toxic materials, pathogens and debris. They are a major water pollution concern for the approximately 800 cities in the United States that have combined sewer systems, according to the U.S. Environmental Protection Agency (EPA).

Usually, combined sewer systems transport all of their wastewater to a treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall, however, the wastewater volume in a combined sewer system can far exceed the capacity of the downstream sewer system or treatment plant. For this reason, combined sewer systems have been designed to overflow when capacity is exceeded, and discharge excess stormwater and wastewater directly to nearby streams, rivers or other water bodies.

Driven by the Clean Water Act of 1972, communities that have CSOs are required to develop plans to mitigate their impacts on the environment. EPA's CSO Control Policy, published in 1994 and later made into law, is the national framework for control of CSOs. The Policy provides guidance on how communities with combined sewer systems can meet Clean Water Act goals in as flexible and cost-effective a manner as possible.

Similar in nature to CSOs are sanitary sewer overflows (SSOs), which also occur during heavy rainfall conditions. These problems are typically associated with leaky sewer pipes that were designed to only carry the wastewater component, and as a result, act as a French drain during heavy rain. The SSO problem typically results in diluted wastewater discharges with potential for pathogen contamination. With approximately 20,000 separate sanitary systems across the U.S., EPA has estimated the SSO issue to be at least as large as the CSO problem, but unlike CSOs, this problem resides in a changing regulatory position.

Treatment solutions to both of these issues seem to be moving towards non-biological technologies that can be brought on line quickly, treat high-flow rates in a small footprint, produce clean and disinfected effluent, and be utilized for other purposes the other 95 percent of the time when wet-weather conditions are not an issue.

City of Springfield, Ohio Wastewater Treatment Plant

One city that has proactively embraced a solution to mitigate its CSO impacts is the City of Springfield, Ohio. In addition to Springfield's population of 60,000, the city's Wastewater Treatment Plant (WWTP) provides treatment for four other utility districts within Clark County, serving an additional 20,000 residents.

Built in 1934, Springfield's combined sewer system collects water from storm events, as well as normal sewage within the same system. The combined sewer system transports all of the sewage to the city's WWTP, where it is treated and then discharged to the Mad River. During CSO events, the combined sewer system is designed to overflow and discharge excess wastewater directly into the Mad River, and at various points along Buck Creek and its tributaries. Flows above approximately 40 MGD would discharge, largely untreated, as combined sewer overflow.

According to the Ohio Environmental Protection Agency (OEPA), segments of the Mad River and Buck Creek are listed as impaired by the agency. Consequently, the City of Springfield worked with OEPA to develop their control plan, and install a high-rate treatment facility that would augment the 40 MGD capacity of the existing WWTP to provide auxiliary treatment and disinfection for up to 100 MGD of additional wet-weather flows.

Facility Planning Addresses Combined Sewer Overflows

To achieve this goal, the city retained CDM Smith, a civil and environmental engineering consulting firm, to do a comprehensive facility plan. The facility plan was to identify existing plant shortcomings, review wet-weather treatment alternatives, and develop an overall plant improvement plan. This plan was completed in April, 2009. The main recommendation of the plan was to build a high-rate treatment system that was capable of treating up to 100 MGD to accommodate peak wet-weather flows. The plan also recommended adding a new tertiary clarifier, primary digester, sludge press building, and a 150-day biosolids storage building.

"The size of the system needed was a result of studies conducted pertaining to our CSO long term control plan," said Tim Weaver, Operations Engineer, City of Springfield Wastewater Treatment Plant. "According to our data, we were going to need something in the magnitude of 100 MGD to collect and treat flows from our peak storms."

In November, 2009, the city selected Black & Veatch to provide further study, design and construction management services for wet-weather and capacity improvements at the WWTP. In

FlexFilter media

conjunction with key stakeholders from the City of Springfield, OEPA, the electric utility, and other technical experts, the Black & Veatch team orchestrated a collaborative approach, which allowed the project team to capture valuable input in the early stages of the project.

The resultant planning encompassed improvements to multiple plant processes, designed to enhance capacity, operability and reliability. Central to the plan was the installation of an enhanced high-rate treatment (EHRT) process with the capacity to treat up to 100 MGD, with subsequent disinfection and effluent pumping.

"We looked at all of the alternatives that were available for handling our CSOs," continued Weaver. "We assessed various physical filters and chemically-enhanced clarification processes that would produce the results we needed within EPA standards. Both economic and non-economic factors were considered. The evaluation revealed life-cycle costs for each of the EHRT technologies."

"Our review committee's review of the EHRT processes was influenced heavily by several factors," added Weaver. "Key was the flexibility of the system to handle a wide latitude of storm sizes, and the ability to handle tertiary filtration during dry weather. Also critical was minimization of operating and maintenance costs, specifically in terms of chemical usage and personnel. Simplicity of the EHRT system operation was also an important consideration."

EHRT facilities are specifically designed to treat and disinfect highly-variable flow and pollutant loadings generated by wet weather. They include physical and/or chemical processes operated at high-flow rates to treat these variable wastewater conditions. To perform efficiently, biological processes used in conventional wastewater treatment plants require relatively steady-state conditions to maintain a relatively constant amount of biomass, and relatively uniform sewage flow (food) to feed that biomass. The sporadic and highly variable nature of wet-weather conditions plays havoc with biological systems, and can impair its health long after an event has passed. EHRT allows high-volume flows to be treated in parallel to similar levels much more quickly, at lower costs, and protecting the integrity of the biological process.

Compressible Media Filtration Selected for Enhanced High-Rate Treatment

"Our recommendation to the city for the enhanced high-rate treatment process was to go with FlexFilter™ Compressible Media Filtration (CMF) technology, as designed by WWETCO, LLC," said Jim Fitzpatrick, Senior Process Engineer with Black & Veatch. "We piloted this technology in two other WWTPs, so we were quite familiar with its process."

"As an enhanced high-rate treatment technology, FlexFilter provides an alternative solution for CSO treatment that can operate at higher flow rates and provide cleaner effluent compared to conventional clarification technologies," continued Fitzpatrick. "It is uniquely capable of treating stormwater and wet-weather overflows, as well as providing effluent polishing during normal, dry-weather conditions."

CMF technology was originally developed in the mid-1980s as a tertiary treatment process. In the mid-1990s the technology was

Aerial view of high-rate treatment facility under construction

Aerial view of high-rate treatment facility under construction 2 first implemented as a treatment method to mitigate CSOs. Most other EHRT technologies used in wet-weather treatment were adapted from drinking water applications. This is one of the few technologies that grew out of wastewater treatment applications.

To validate the FlexFilter technology, the city operated a 400 GPM demonstration unit for 15 months from September, 2010 to November, 2011. The plant monitored its operation, while connected to its SCADA system, and measured its performance. Over 150 test events were measured for various operating conditions.

Testing confirmed design criteria for sizing of the operating cells, and loading conditions. Test results were incorporated into a model, using design influent criteria of solids and flow, together with measured filter durations for solids loadings to confirm the filter matrix size and operating conditions.

"We tested using a much higher strength wastewater than what the system would ordinarily see," said Weaver. "We were taking raw plant influent into the FlexFilter system and testing it to see how well it treated the wastewater. If it performed well with high-strength wastewater, it should perform even better with diluted combined stormwater and sewer flows."

"Influent moving through the EHRT system was filtered out of suspended solids, directly impacting sediment loads and BOD levels," Weaver added. "The EPA mandate was to get treatment down below 30 milligrams per liter of suspended solids. "We were getting test results that met, or exceeded that regularly. This seriously swayed us to select the FlexFilter EHRT system."

FlexFilter: How It Works, and How It is Applied

FlexFilter utilizes a simple, gravity filtration process, utilizing small-diameter synthetic fiber balls as a media bed. The influent liquid passively applies a lateral hydrostatic force through compression bladder sidewalls, causing the media bed to compress in a tapered fashion along the vertical axis. This creates densely compressed media at the bottom that graduates to an expanded bed toward the surface. This method of compression eliminates the need for mechanically actuated internal components.

As the liquid flows onto the top of the media, larger particles are trapped in the upper portions of the filter. As the liquid works its way down, smaller particles are captured. This porosity gradient within the filter bed allows for a more effective use of the entire media bed, and allows for a higher mass load to the filter prior to backwashing. As the filter bed becomes plugged, the influent level increases, signaling the need for a backwash.

For the backwash, the feed to the filter is stopped, and the compression bladder chambers are drained, allowing the media to decompress. The backwashing of cells is accomplished by fluidizing and air scouring the media, followed by complete draining of each cycle. The air scour and strategically located backwash troughs maximize the media scrubbing while minimizing the volume of backwash water needed. The backwash water and solids then are sent to the plant activated sludge process that effectively attenuates the feeding of the biomass. Once cleaned, the filter is put back into service. Simultaneously, additional filtration cells are opening or closing to accommodate influent volumes.

Aerial view of high-rate treatment facility

Aerial view of full plantSpringfield 3 - FlexFilter 3D image

The FlexFilter process operates unmanned in a sequence of filling, filtering and backwashing. The filters do not need seasoning nor chemicals to operate, and captured solids are returned as food to the biological process.

Black & Veatch prepared final design drawings and specifications for the new EHRT facility, centered on the FlexFilter technology. The construction contract was awarded to Kokosing Construction Company, Inc., headquartered in Fredericktown, Ohio. Construction of the 310-foot long x 100-foot wide, largely below-surface system, was started in August, 2012 and completed for operation in January, 2015.

WWETCO, and its parent company WesTech Engineering, designed and supplied the FlexFilter EHRT components. The 100 MGD system is comprised of 11 filter cells, each rated at approximately 10 MGD per cell.

"The addition of the 100 MGD facility is 10 times bigger than the next largest of its kind," said Fitzpatrick. "The biggest challenge was that this technology had never been constructed at this scale. We wanted to ensure that our design was robust, but not overly conservative."

Storm Event Operation: Automatic or Manual Control

The flow entering Springfield's dry-weather facilities from the combined sewers is throttled to a peak rate of 40 MGD by controlling sluice gates at the downstream side of the overflow screening structure. Screenings and grit are directed to the dry-weather headworks. Excess flows receive screening (1/2" openings) before being directed to the EHRT.

"In wet-weather storm events, the plant's FlexFilter matrix goes into standby mode due to elevated plant flow," said Mark Boner, Vice President of WWETCO. "It starts out with two or three cells ready for incoming CSO, then it brings up additional filters as the flow increases. The controls automatically add filter cells with increasing flows, and take cells off line with decreasing flows. An operator can override the automatic controls to add cells or initiate a backwash at any time. The cell matrix can also be operated manually by monitoring levels in the cells and in the influent channel. The operator can add cells, send up to two cells in backwash at one time, or remove cells after a backwash."

After filtration, the FlexFilter effluent goes through a disinfection process with sodium hypochlorite, followed by sodium bisulfite for neutralization of residual chlorine, before being pumped to the Mad River watercourse.

Following a storm event, the filter matrix goes into a post-event cleanup mode where the cells are automatically backwashed, and the channels are automatically flushed clean using secondary clarifier effluent water. All cells used during the storm event are cleaned during this operating mode. Similar to a storm event, the backwash water is sent back into the biological treatment process. After cleanup, the structure is left cleaned and drained.

Facilitates Wet-Weather and Dry-Weather Processing of Wastewaters

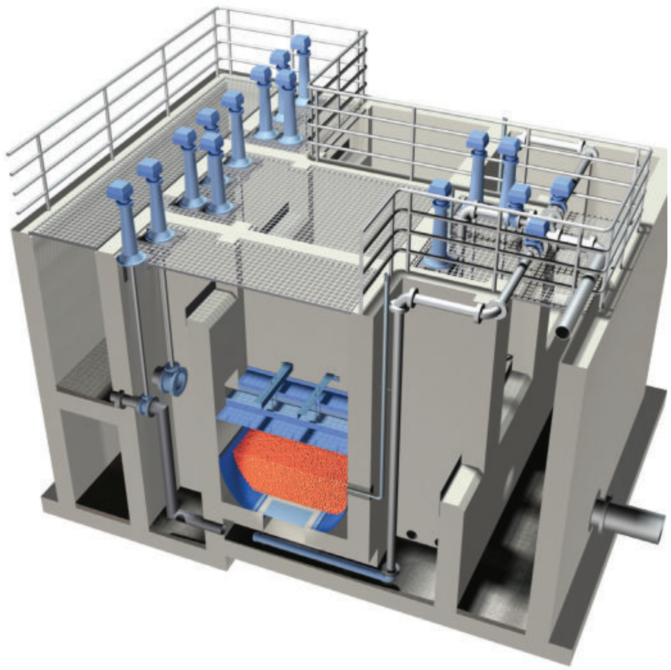
The City of Springfield's EHRT design enables versatility in treating a wide range of wastewaters. In addition to treating high-rate wet-weather flows, it can be used in a dual role as a tertiary filter during dry weather. This could significantly reduce the total pollutant load to the Mad River including control of phosphorous, anticipated as a future discharge limitation.

"Although not required for Springfield to operate in a dual-use function, the FlexFilter could be used to produce a reuse-quality effluent as a tertiary filter," continued Boner. "In addition to solids removal, the filter cells can be utilized to effectively remove or trim phosphate created by the addition of metal salts. Metal salts can be added in the upstream clarifiers or directly to the filter influent if and when needed to meet permit."

"Another dual-use function is where the EHRT filter is utilized to increase the organic removal capacity of the facility, reducing its power consumption as an enhanced primary treatment process, and thereby reducing loadings to the secondary portion of the plant," added Bonner. "There are sufficient nutrients and oxygen cycling from the operation of the filters to support a healthy biofilm population in the media bed," said Boner. "Pilot testing in Springfield demonstrated that the bio-filtration could consistently reduce soluble organics, as well as particulates. The bio-filtration process could then be used to treat wet-weather flows."

Performance Testing

Performance testing of the EHRT was conducted during startup in December, 2014 and continued for the first six months of



FlexFilter 3D image

operation in 2015. During this period test results from CSO treatment were used to tweak operating settings and demonstrate compliance with regulatory requirements.

Initial testing utilized secondary clarifier water, and it was applied to demonstrate and adjust control programs for the different operating modes, as well as assess facility cleanup. Tertiary filtration testing has demonstrated that the system produces a reuse quality of water having less than 2 NTU turbidity units.

Initial testing with raw sewage was used to demonstrate temporal head buildup in each filter cell for the measured loading conditions and to measure effluent TSS concentrations. Testing with raw sewage confirmed and excelled previous demonstration results. Filter durations under various solids loading confirmed pilot results and design criteria – TSS average filter effluent at 13 mg/l., and CBOD5 average filter effluent at 25 mg/l.

Operational testing has demonstrated that the EHRT system is operating better than expected with relatively long filter runs, and effluent quality better than secondary treatment criteria. In addition, the majority of the smaller CSO events that used to discharge to the Mad River are now captured in the structures with no discharge. The larger events have reduced discharge volume and significantly lowered pollutant concentrations. Automatic cleanup confirmed design expectations, leaving the entire structure empty and free from sewage residuals and odor.

The first six months of operation have revealed that the EHRT is removing significant portions of its influent TSS and BOD loads, with effluent concentrations averaging 19 mg/l and 24 mg/l, respectively. Peak flow rates of approximately 70 MGD have been treated. These results are without the use of any chemicals for solids separation, and with an insignificant impact on the solids handling facilities at the WWTP.

"The City of Springfield Wastewater Treatment Plant is one of the first adopters of this emerging enhanced high-rate treatment technology," said Weaver. "It has certainly handled our issues with combined sewer overflows. That it can be dual-purposed to efficiently handle dry-weather tertiary process, as well, makes it a strong benefit to our overall plant operations."

City of Springfield Wastewater Treatment Plant

Built in 1934, the City of Springfield Wastewater Treatment Plant is responsible for treating all the wastewater generated by the citizens, businesses and industries of the City, as well as several surrounding areas. The plant encompasses the operation and maintenance of an advanced secondary treatment system, as well as several sewerage pumping stations located throughout the collection system, monitoring of stream pollutants, and residual bio-solids management.

About The Author

Jim McMahon writes extensively on industrial and technology issues, including water and wastewater, energy from waste, power, and oil & gas. His features have appeared in more than 2,500 magazines worldwide, with over two million professionals reading his published content monthly. Jim can be reached at jim.mcmahon@zebracom.net.