AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

AquaPrime® Cloth Media Filter
PROJECT CASE STUDY

Project Name and Location
Rushville WWTP, Rushville, Indiana

Aqua-Aerobic Solution
AquaPrime® Cloth Media Filter – CSO / Tertiary Filtration

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Introduction

As part of its program to eliminate untreated combined sewer overflow (CSO) discharges into the Flatrock River, the City of Rushville, Indiana is undertaking the final phase of its Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) implementation program. This final phase was originally designed as an approximate one (1) million gallon storage tank to store wet weather flow in excess of the Rushville Wastewater Treatment Plant (WWTP) peak flow capacity of 4 million gallons per day (MGD). This tank size was selected to store the excess flow for a 1-year, 1-hour rain event for full treatment at the WWTP.

Early in 2015 representatives from Aqua-Aerobics Systems, Inc. made a proposal to the City of Rushville to pilot test its nominal five (5)-micron cloth filtration media utilizing the AquaPrime® `Cloth Media Filter (CMF) for treatment of CSO discharges at its WWTP. The City of Rushville was interested in exploring new technologies that showed the potential to reduce the cost to implement the final phase of its LTCP program to eliminate untreated CSO discharges and accepted the pilot testing proposal. An automated pilot test system was installed in the maintenance building of the Rushville WWTP in April of 2015 and a pilot test program was conducted for five (5) wet weather events during which CSO discharges occurred between May 16, 2015 and July 13, 2015. The results of this pilot testing were submitted to the Indiana Department of Environmental Management (IDEM) and acceptance was given by IDEM to the City of Rushville on March 17, 2016 to prepare a design utilizing the AquaPrime cloth media filters as part of a treatment system for CSO discharges.

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AquaPrime® Cloth Media Filter Process

The AquaPrime® filter features a disk configuration and an outside-in flow path which allows for three zones of solids removal that are shown in Figure 1. These zones are especially critical in wet weather applications due to the high solids typically associated with the first flush after wet weather events. The top zone is the "floatable zone" where surface materials such as fats, oils and grease are allowed to collect on the water surface. Solids are removed from this zone by allowing floating material to overflow a scum weir several times each day.

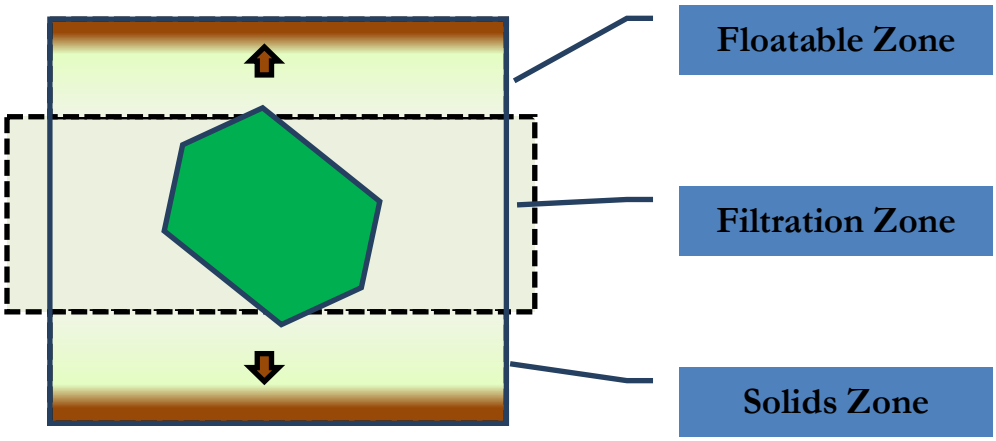

Figure 1: AquaPrime® Filter - Solids Removal Illustration

The middle zone is the "filtration zone" where solids are removed through filtration. Here, solids deposit on the outside of the cloth media forming a mat as filtrate flows through the media. This buildup of solids on the media creates hydraulic resistance to flow through the media and causes the water level in the tank to rise. Once a predetermined liquid level or time setting is attained, the disks begin to rotate and the backwash pump starts, which draws filtered water from the inside of the disk through the media and removes solids from the filter media's surface. This process fluidizes fibers to provide an efficient release of stored solids deep within the fiber. An illustration of the backwash mechanism is shown as Figure 2.

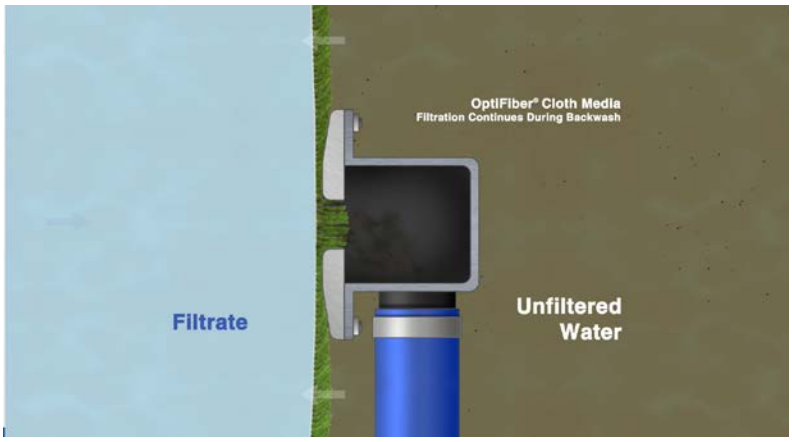

Figure 2: AquaPrime® Filter - Backwash Illustration

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The bottom or “solids zone” permits heavier solids to settle to the bottom of the tank for intermittent removal. The solids are evacuated from the hopper through collection laterals using the backwash pump.

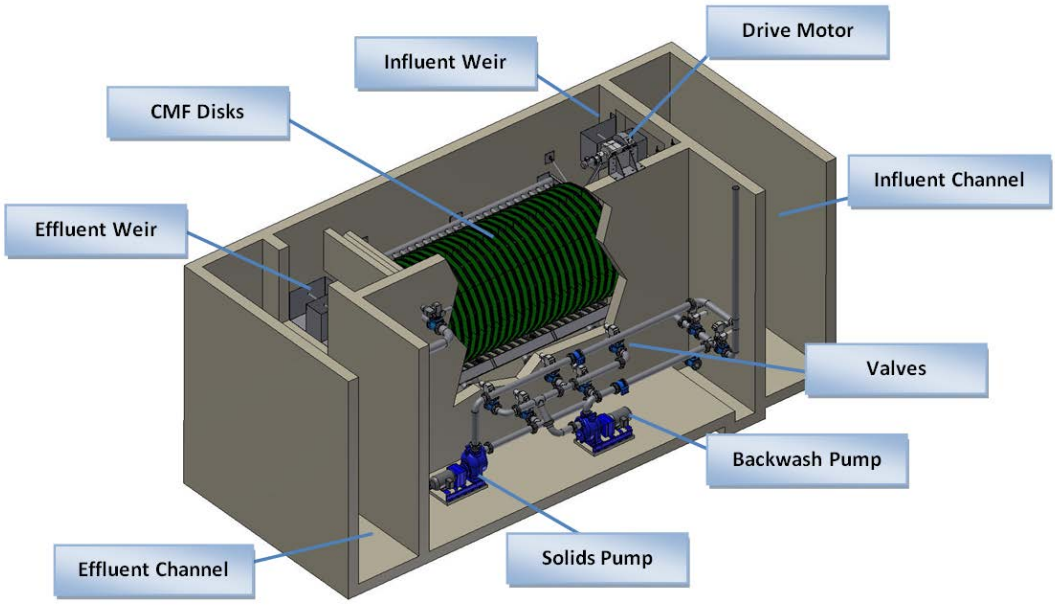

Figure 3: AquaPrime® Filter Arrangement

Methods

An Aqua MiniDisk® cloth media filter (CMF) system was installed for pilot testing at the Rushville WWTP in April of 2015. When a flow control gate at the WWTP headworks was opened to initiate a CSO discharge, a submerged transfer pump automatically started to pump a preselected wastewater flow to the CMF pilot test system.

The Aqua MiniDisk pilot unit and pilot setup shown in Figure 4 was used for the pilot study.

Figure 4: Pilot Unit and Setup.

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Results

The influent flow rate to the pilot filter system was set to 40 gallons per minute (gpm) or 3.7 gpm/ft^2 for the first CSO event and 70 gpm or 6.5 gpm/ft^2 for subsequent CSO events. Alum was fed to the influent wastewater as a coagulant at a dose of 4 mg/l of aluminum for the first two CSO events and no alum was fed for the remaining events to determine its impact on the performance of the cloth media filter. Influent and effluent discrete samples collected for the pilot testing were analyzed for BOD_5 concentration, TSS concentration, turbidity, ultraviolet (UV) light transmittance, NH_4-N concentration, and total phosphorus concentration. A summary of the collected average pilot test data for BOD_5 and TSS is as follows in Table 1:

Table 1: Pilot Summary Results.

CSO Event	DATE	Average BOD_5 Data			Average TSS Data		
		Influent	Effluent	Removal %	Influent	Effluent	Removal %
1	05-16-2015	87 mg/l	3.5 mg/l	96 %	141 mg/l	5.2 mg/l	96%
2	06-30-2015	37 mg/l	4.3 mg/l	88%	114 mg/l	4.8 mg/l	96%
3	07-7-2015	55 mg/l	18.2 mg/l	67%	136 mg/l	4.9 mg/l	96%
4	07-12-2015	60 mg/l	14.5 mg/l	76%	74 mg/l	3.8 mg/l	95%
5	07-13-2015	73 mg/l	18.1 mg/l	75%	24 mg/l	2.0 mg/l	92%

State Approval

Rushville, IN initial long term control plan was for a 1 MGD storage tank along with the sewer separation where viable. In August of 2015, the alternative of cloth media filtration was presented to the state as an alternative during a CSO Audit. In February 2016, Rushville, IN decided to seek approval of cloth media filtration as an alternative to building the storage. Indiana Department of Environmental Management's (IDEM) construction permit section initially was cautious about deviating from storage basin policy, but referred the city to NPDES Permits Section. Also, the Construction Permits Section Chief advised to propose the following to IDEM NPDES Section:

- City will add a storage basin if CMF does not meet pilot test performance during CSO monitoring period

  Or
- City should propose to use CMF for dry weather treatment to improve water quality

In March 2016, the city and engineer meet with IDEM Permits Section and proposed the following:

- Filtering all secondary effluent
- To feed alum to meet in advance future total P effluent limits
- Filtering all the wet weather flows

As part of the meeting, the engineer presented the information shown in Table 2 that compared the following information among various treatment options:

- 2015 CBOD5, TSS, total P and ammonia discharge loads
- Estimated discharge loads with a CSO storage basin

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- Estimated discharge loads with CMDF treatment of CSO flow only
- Estimated discharge loads with CMDF treatment of secondary effluent and CSO flow
- Estimated pollutant load reduction % for CSO storage basin versus CMDF treatment of secondary effluent and CSO flow

Table 2: Estimated Discharge Table to River Under Various Treatment Scenarios.

Treatment Scenario	Eff Flow (MG)	$CBOD_5$ Load (lbs)	TSS Load (lbs)	P Load (lbs)	NH_3-N Load (lbs)	Comments
2015 Annual Avg Daily WWTP Discharge	1.54	32.3	70.4	47.52	1.39	
2015 Total Annual WWTP Discharge	562	11,790	25,696	17,345	507	No P removal in existing permit
Avg. Annual CSO in LTCP	38.2	19,721	30,584	414.2	733	LTCP est annual CSO vol
2015 Annual WWTP & Average Annual CSO Discharge	600	31,510	56,280	17,759	1,240	Avg NH_3-N discharge ≈ 3.4 lbs/day
CSO Storage Basin Discharge + 15.8 MG drained back to WWTP	22.4	3,685	7,717	58.8	139	15.8 MG gets full treatment at WWTP
2015 Annual WWTP + Storage Basin Facility Discharge	600	15,474	33,413	3,809	646	With future WWTP P eff ≈ 0.8 mg/l
Annual Disc Filter Trt of CSO Flow	38.2	956	1,752	38.2	605	UV disinfection & 1.9 mg/l NH_3-N CSO effluent
2015 Annual WWTP + Disc Filter Treatment of CSO Flow Only	600	12,746	27,448	3,789	1,112	With future WWTP P eff ≈ 0.8 mg/l
CSO Disc Filter Reduction over CSO Storage Basin Facility		18%	18%	1%	-72%	Avg NH_3-N discharge ≈ 3 lbs/day
2015 Total Annual WWTP Eff with Tertiary Filter Treatment	562	8,842	7,709	1,406	507	Assumes alum added for P removal & eff =0.3 mg/l
2015 Annual WWTP Filtered Eff + Disc Filter Treatment of CSO Flow	600	9,798	9,461	1,445	1,112	Avg NH_3-N discharge ≈ 3 lbs/day
Disc Filtering of all Flow Reduction over Storage Basin Facility		37%	72%	62%	-72%	

In April 2016, IDEM accepted use of CMF technology for use in the Rushville, IN facility based the following:

- Filters to be continuously used for both dry and wet weather flows
- Alum to be fed for removal of both fine CSO particles and phosphorus treatment

Additional Bench Testing

During IDEM's review of the construction permit application they inquired if the influent *E. coli* concentration would always be below the specified maximum concentration. Because the *E. coli* concentration of the CMF effluent was not checked during pilot testing and it is typically also not monitored for secondary treatment effluent, bench scale testing of the cloth media filter was performed in November of 2016.

The bench scale testing was run for secondary treatment effluent, dry weather influent wastewater, and several different simulated wet weather influent wastewater flow rates. Samples were collected for both the filter influent and effluent and analyzed for *E. coli* along with TSS, Turbidity and UV transmittance to confirm that the measured *E. coli* colony counts were valid. Based on the filter bench testing for various simulated dry and weather flow rates it was determined that the

maximum *E. coli* concentration in the CMF effluent would be less than 77,000 colonies per 100 ml. Therefore, the specified UV light disinfection system was determined by IDEM to have an adequate capacity to meet effluent permit limits. Table 3 shows the bench scale testing results achieved.

Table 3: Bench scale testing result for E. Coli Analysis

Rushville WWTP Weighted E. Coli Analysis									
Simulation Test Number	WWTP Inf. Flow (mgd)	Flow Through WWTP (mgd)	% of Flow Through WWTP	CSO Flow (mgd)	CSO % of Flow	Filtered SE E. Coli Colonies per 100 mL	Filtered CSO E. Coli Colonies per 100 mL	Maximum Filtered E. Coli Colonies per 100 mL	Average Filtered E. coli Colonies per 100 ml
1	0.80	0.80	100%	0.00	0%	15,700	0	22,800	17,000
	0.80	0.80	100%	0.00	0%	22,800	0		
	0.80	0.80	100%	0.00	0%	12,500	0		
2	4.00	4.00	100%	0.00	0%	15,700	130,000	22,800	17,000
	4.00	4.00	100%	0.00	0%	22,800	105,000		
	4.00	4.00	100%	0.00	0%	12,500	120,000		
3	6.00	4.00	66.67%	2.00	33.33%	15,700	57,900	42,400	34,044
	6.00	4.00	66.67%	2.00	33.33%	22,800	64,900		
	6.00	4.00	66.67%	2.00	33.33%	12,500	81,600		
4	8.00	4.00	50%	4.00	50%	15,700	15,200	23,200	18,033
	8.00	4.00	50%	4.00	50%	22,800	23,600		
	8.00	4.00	50%	4.00	50%	12,500	18,400		
5	10.00	4.00	40%	6.00	60%	15,700	14,400	20,760	16,500
	10.00	4.00	40%	6.00	60%	22,800	14,700		
	10.00	4.00	40%	6.00	60%	12,500	19,400		
6	11.50	4.00	34.78%	7.50	65.22%	15,700	105,000	**76,409**	**51,891**
	11.50	4.00	34.78%	7.50	65.22%	22,800	51,700		
	11.50	4.00	34.78%	7.50	65.22%	12,500	54,800		

Design Summary

Design of the CMF system was initiated in June of 2016 for a maximum flow rate of 12 MGD and a peak filtration rate of 5.53 gpm/ft^2. The design includes two 14-disk units with each disk being 6.6 feet in diameter. Each disk has an effective area of 53.8 ft^2 with a total filter area of 1,506.4 ft^2. In order to remove 85% or more of BOD_5 in CSO discharges and to remove phosphorus to comply with a future discharge permit requirement, it was decided that the CMF system would be designed for coagulant addition upstream of the filters. The coagulant storage system consisted of a 6,000-gallon tank for bulk deliveries and two feed pump systems to feed coagulant to both the WWTP secondary clarifier effluent for year round phosphorus removal and to the wet well of the wet weather pumps that pump influent wastewater flow in excess of the WWTP capacity to CMDF system. The design also included replacement of an existing 4.0 MGD chlorine gas disinfection system with a 12 MGD UV light disinfection system. The larger disinfection capacity was needed to treat the maximum 4.0 MGD secondary treatment effluent from the WWTP plus up to 8.0 MGD of CSO flow pumped by the wet weather pumps.

The new treatment systems were designed to be installed in existing under-utilized 42-year old structures at the WWTP. The coagulant storage and feed pump system was installed in the building that presently houses the chlorine gas and sulfur dioxide gas storage and feed systems, which are to be replaced by the UV light disinfection system. The new CMF system has been installed in the

abandoned sand filtration structure. The UV light disinfection system has been installed in the chlorine contact tank that will be taken out of service.

The flow scheme for the Rushville CSO / Tertiary filtration system is as shown below:

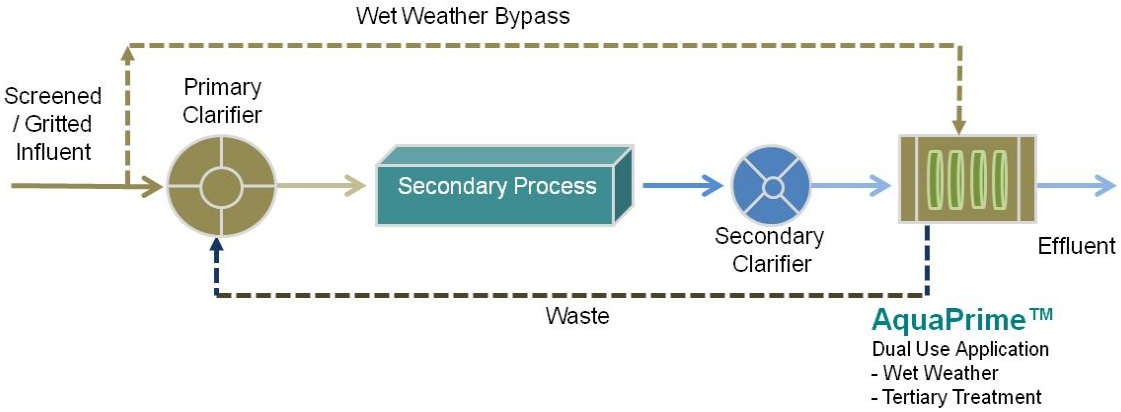

Figure 5: Plant flow scheme.

Status and Performance

Design for the project was completed in October of 2016, the construction permit application to IDEM was approved on December 12, 2016 and a contract for construction was awarded on December 19, 2016.

The filter portion of the installation was substantially complete in July 2017. Since startup of the filter portion of the installation, the filters has been operating in tertiary filtration mode until the first wet weather events which occurred in October and November of 2017. Below in Table 4 is a summary of the performance of the treatment plant operating in wet weather mode which includes full treatment of the flow up to 4 MGD and remaining excess flow being treated as shown in Figure 5 above.

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Table 4: Summary of Wet Weather Event Performance

Parameter	10/5/17 Event	11/5-6/17 Event	11/19-20/17 Event
Rainfall	2.18 in	2.86 in	1.57 in
Event Peak Flow	6.2 mgd	13.53 mgd	8.25 mgd
Avg. Daily Flow	2.5 mgd	2.74 / 6.45 mgd	4.1 / 3.3 mgd
Inf / Eff $CBOD_5$	-- / 4 mg/L	25 / 3 mg/L	42 / 1 mg/L
Inf / Eff TSS	-- / 5 mg/L	52 / 14 mg/L	58 / 3 mg/L
Inf / Eff Ammonia	-- / 0.51 mg/L	3.2 / 0.33 mg/L	2.0 / 0.08 mg/L
Inf / Eff Total P	-- / 1.4 mg/L	-- / 0.43 mg/L	1.02 / 0.18 mg/L
Inf / Eff E. Coli	-- / 3 colonies	-- / -- colonies	-- / -- colonies
Notes:	- Dosage of alum was not adjusted with flow during event.	- Rain in 2 hours & > 20 yr. event - Inf >200K colonies / Eff 2 colonies on Nov. 7th	- Rain in 6 hrs. - Disinfection season end Oct. 31st

It is important to note that the CMF has provided treatment in excess of the design capacity within the first few months after startup. Also, the CMF has provided the ability to treat for the duration of an event which can last for multiple days. Due to the continuous treatment capacity, no overflows have occurred. If the storage had been used, overflows would have occurred during the November 5-6 event due to the long duration.

AquaPrime Cloth Media Filter Advantages for Wet Weather Treatment

- Utilizes engineered OptiFiber® cloth filtration media
- Produces extremely consistent, high quality effluent
- Designed to handle extreme variation in TSS loadings
- Instant startup and instant high quality effluent
- Eliminates the need for chemical addition, in many applications
- Low waste volumes
- Simple to operate and maintain
- Unmanned operation at remote sites
- Vertical oriented disks reduce the footprint; resulting in small overall site requirement

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