ADVANCED VORTEX TECHNOLOGIES

Like many cities in the U.S. with combined sewer systems, the city of Saco, Maine, had issues of wet-weather flows overwhelming its wastewater treatment plant. This was leading to the discharge of untreated sewage and storm water into the Saco River, threatening the area's water quality and sensitive shellfish beds. The city also was faced with the need to comply with the U.S. Environmental Protection Agency Combined Sewer Overflow (CSO) Control Policy, which mandated new stringent discharge requirements.

By Bob Andoh

Maine WWTP implements CSO control, treatment and disinfection solutions

The city embarked on a CSO abatement program that included a number of milestone projects involving the implementation of best management practices to help contain trash and other sewer-derived debris from being discharged directly to receiving waters. Having controlled trash and debris, the next major challenge was addressing the issue of excessive wet-weather flows conveyed from two of the main sewers from the downtown area. One option for compliance was to build separate storm water sewers in order to separate storm water runoff from combined and sanitary sewer flows. But apart from this solution being very expensive, it also would cause major disruptions to businesses, particularly in the downtown commercial district.

CSO Control Technology

After evaluating a number of options, the city opted to convey the wet-weather flows from the main sewers directly into the wastewater treatment plant (WWTP). A new 24-in. influent line would transport peak wet-weather flows to the local WWTP, and a CSO treatment system utilizing advanced vortex technologies would control and treat excess wet-weather flows.

Upstream of the WWTP, the flow in this new sewer line passes through new diversion structures that regulate wet-weather flows with self-activating, passive vortex flow control valves. By harnessing the energy in the flow, the valves operate with no external power source and have no moving parts. These units are 22.5- and 16-in. Type C Reg-U-Flo vortex valves, supplied by Hydro Intl. Inc. The valves allow a maximum of 5.2 million gal per day (mgd) of the combined flow to pass through to the headworks at the treatment plant, then divert any excess flow to a wet-weather treatment system comprised of a Storm King with Swirl-Cleanse screen advanced hydrodynamic vortex separator (HDVS) and a Grit King vortex separator, also supplied by Hydro Intl.

The systems installed at Saco provide improved handling, management and treatment of combined sewage and wet-weather flows to meet the Maine Department of Environmental Protection's primary treatment equivalency and disinfection standards for CSO and wet-weather discharges.

The 22-ft-diameter HDVS combines floatables capture, high-rate sedimentation, grit removal and effective mixing (and contact time) for disinfection in a single, compact vessel. The system achieves primary treatment and disinfection with a contact time at design flows of eight minutes, contributing to the compact size of the system. The underflow from the HDVS unit (comprised of grit, sediment, settleable fecal solids, debris and floatables captured by the integral self-cleaning Swirl-Cleanse screen) is returned to the treatment plant in a significantly smaller proportion of the treatment flow—typically less than 10%—for additional processing (e.g., preliminary treatment via the Grit King separator and conventional biological treatment through the rest of the plant). Meanwhile, the clarified, screened and disinfected excess wet-weather overflow is discharged into the Saco River following dechlorination.

Like the flow control valves, the HDVS has no moving parts, relying instead on the energy of the flow to achieve high-rate treatment. The device has a series of internal baffles that produce a stable rotary flow regime in the unit, conducive to high-rate sedimentation and disinfection. The HDVS has a peak design flow of 5.6 mgd, although it can effectively handle hydraulic flows higher than that.

Post-Implementation Performance

Since the system went online in November 2006, the CSO treatment facility at Saco has been subjected to compliance monitoring as part of its consent requirements. This monitoring included a period in the spring of 2007 when a series of storm events caused widespread flooding in a number of New England states. With overflows occurring for five successive days, the storms provided a real test of the robustness of the system. Solids removal, measured by total suspended solids (TSS) and biochemical oxygen demand (BOD), have been observed to be consistently high, even during the period in 2007 when the system was subjected to the sustained loading (see Table 1).

The average influent TSS and BOD observed during the April 2007 events are 111 mg/L and 81.8 mg/L, with corresponding average effluent TSS and BOD of 43.8 mg/L and 21.2 mg/L. These compare well with the results for the entire sample set for overflow events occurring in 2007, which gave overall average influent TSS and BOD of 130.3 mg/L and 86.3 mg/L, with corresponding average effluent TSS and BOD of 48.8 mg/L and 29.4 mg/L. Table 2 provides annual summaries up to the first week in April 2010.

These results show average removals in excess of those anticipated for primary treatment equivalency of combined sewage, particularly for the BOD. It is surmised that the higher BOD removal observed may be a function of the additional effects of the integral self-cleansing fine screen mesh within the HDVS, which has an aperture of 1/6 in. The fecal count numbers are also below the consent requirements for the site, confirming the effectiveness of the HDVS as a contact chamber for high-rate disinfection of CSO and other wet-weather flows.

Findings

The application of advanced vortex technology for optimal CSO control and treatment at Saco utilizes vortex flow controls in diversion chambers to regulate maximum flows to the existing WWTP. This prevents hydraulic overloading and facilitates the diversion of excess combined sewage and wet-weather flows to the new CSO treatment facility, where disinfection and solids removal to meet primary treatment equivalency standards are accomplished.

Project conclusions are as follows:

- The ability to perform several essential unit processes (e.g., grit removal, sedimentation, screening and disinfection) in one vessel resulted in significant savings in overall project costs. These savings were due to the more compact design of the advanced separation system coupled with the elimination of additional tanks and vessels that would have been required with the conventional approach.
- Results of compliance monitoring over several years have confirmed the efficacy of the advanced vortex technologies and their ability to consistently achieve disinfection and primary treatment equivalency standards, even under stress-loading conditions.
- The technologies deployed at Saco provide CSO communities with an option to achieve compliance with their CSO abatement commitments in a cost-efficient manner. WWD

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Figure 1. Saco's CSO Treatment Facility

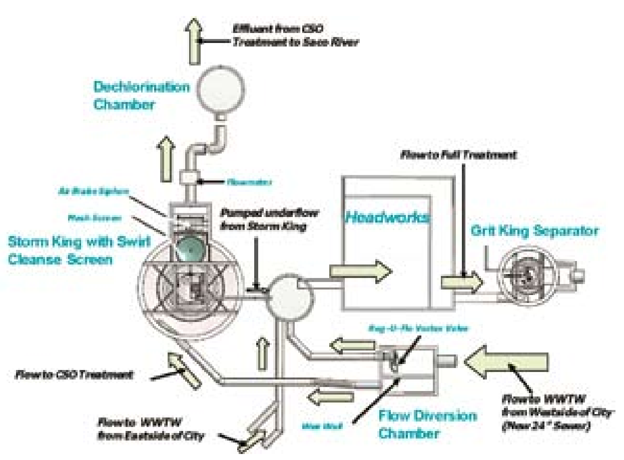

Table 1. Data for Sustained Period of Overflows in April 2007

Date	Influent BOD (mg/L)	Effluent BOD (mg/L)	BOD Removal (%)	Influent TSS (mg/L)	Effluent TSS (mg/L)	TSS Removal (%)	Daily Flow (mgd)	Duration (Hrs)
4/15/07	138	24	83	183	53	72	0.27	4
4/16/07	83	18	78	110	49	56	3.89	24
4/17/07	66	16	76	91	55	40	3.13	24
4/18/07	52	17	67	78	27	65	2.93	24
4/19/07	70	31	56	93	35	62	1.03	21

Table 2. Data Summaries from January 2007 to April 2010

Year	Number of CSO Events	Avg. Influent BOD (mg/L)	Avg. Effluent BOD (mg/L)	BOD Removal (%)	Avg. Influent TSS (mg/L)	Avg. Effluent TSS (mg/L)	TSS Removal (%)	Avg. Fecal Count	Total Precipitation (in.)
2007	19	86.3	29.4	66	130.3	48.8	63	110	22.2
2008	21	84.5	30.1	64	110.2	34.8	68	51	28.6
2009	21	51	34.2	33	93.2	47.5	49	129	29.5
2010*	15	43	28.3	34	67.3	27.3	59	74	17.5

*Note: 2010 is not a full year's worth of data.