Plant Profile: Frankfort Wastewater Treatment Plant –1929 to Present

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The City of Frankfort, Indiana is centrally located in Clinton County and was founded in 1830. The wastewater treatment plant (WWTP) serves a population of approximately 17,000 including the unincorporated community of Jefferson and a heavy industrial base. The collection system comprises approximately 400,000 feet of sewers ranging in size from 6 to 48 inches, 10 lift stations, and one combined sewer overflow (CSO) located at the WWTP.

WWTP History

The original WWTP was placed online in 1929 and is the seventh known WWTP to be constructed in Indiana. The 2.6 MGD facility consisted of a grit chamber, Imhoff Tanks followed by trickling filters, sludge drying beds, an office/laboratory building, and a maintenance/sludge processing building. The original maintenance building is still in use today as a garage, and the original office building serves as a break room for plant personnel.

In 1956 the plant was expanded to 3.5 MGD, and an anaerobic digester and solids processing building were added. In 1968, a second anaerobic digester was constructed and became the primary digester, while the original digester was converted to a secondary digester. Methane generated in the digesters was compressed and stored in a spherical steel tank and utilized by a boiler/heat exchanger to heat the primary digester.

The City's first NPDES Permit became effective on January 18, 1980 and included requirements to monitor ammonia. The City had already secured Environmental Protection Agency (EPA) and state grants, and was under construction at the time to convert the facility to the current 4.68 MGD conventional activated sludge treatment plant. This major upgrade included much of the current facility, including a new headworks and raw sewage pump station, four equalization (EQ) basins, primary settling tanks, coarse bubble aeration tanks, secondary clarifiers, multi-media sand filters, aerobic digesters, sludge drying beds, and a new administration/lab building.

Pretreatment Program

With a large industrial base fueling Frankfort's economy and growth, the Frankfort WWTP started issuing industrial pretreatment permits in 1977. Today, Frankfort continues to run a delegated pretreatment program with 18 active pretreatment permits that include five federal categorical industries. These industries contribute approximately 12% of the average flow of 4 MGD.

CSO Reduction and Elimination

The City began an aggressive campaign to reduce CSOs in the 1980s. With portions of the collection system built in the 1920s, inflow and infiltration (I/I) remained a challenge even after the system was completely separated and three of five overflows had been eliminated.

The City prepared its CSO Operational Plan in 1992, in addition to conducting cleaning and televising of the entire sewer system. Smoke testing was also performed, and approximately 800 illicit direct connections to the sanitary system, both public and private, were eliminated within two years. In 1993, the Kyger Road Lift Station was replaced with a larger capacity lift station, and a fourth CSO was eliminated. As a result of these efforts, the City was able to convey all flows to the WWTP and was nominated for a 1998 US EPA National CSO Control Program Excellence Award.

In April 2002, the City submitted its CSO Long-Term Control Plan (LTCP). Frankfort has only one CSO located in the WWTP EQ basins. The main LTCP tasks included two new fine screens, electric actuators and automated control of air valves to two of the EQ basins, and construction of a new CSO Disinfection Structure. The LTCP was approved in 2005 and has been completed within the WWTP improvements project currently

Click here to return to the TABLE OF CONTENTS

under construction. With the new fine screens and CSO disinfection facilities, Frankfort has completed all projects in its LTCP and is now in the post-construction monitoring phase of its LTCP efforts.

Long-Time Superintendent

The efforts and achievements of the City and the WWTP are the result of many people. However, the leadership, vision, and determination of WWTP Superintendent Dennis Shirar has been instrumental in bringing the early visions to reality. Denny began working as a night operator in 1975. By 1977, he was tasked with pretreatment monitoring and installed the City's first industrial monitoring station in the collection system. He became superintendent in 1991 and led the City through much of its CSO reduction and elimination efforts. From running the daily operations of the WWTP, dealing directly with City administrators and industrial leaders, planning with engineers, and negotiating with IDEM, Denny maintains that the citizens of Frankfort are ultimately his boss, and he has spoken with many of them about their concerns and problems regardless of what other duties might be pressing at the moment.

Current Facility Description

The Frankfort WWTP is a Class IV facility with a design average flow (DAF) of 4.68 MGD. The facility does not have a rated design peak flow, as peak flows are stored and equalized by the EQ basins and pumped out at a constant rate. Influent flows of up to 48 MGD can be pumped to the EQ basins, and flows of up to 8 MGD during wet-weather can be treated through the complete treatment process by operating both constant rate pumps at the EQ basins. The City's NPDES Permit establishes limits on conventional pollutants, as well as numerous metals. The Permit has stringent summer limits on CBOD5, TSS, and Ammonia (10, 12, & 1.5 mg/L, respectively). The following facility description includes the improvements made in the current construction project.

Headworks and Raw Sewage Pumping

Raw sewage enters the WWTP through 36-inch and 48-inch interceptor sewers and is screened by two new fine screens with a screenings washer/compactor. A manually cleaned bypass bar screen is available during maintenance or emergency situations. The influent fine screens are an essential component of not only the WWTP process, but the CSO treatment process as well.

All flows from the collection system are delivered to the WWTP even during the most extreme wet weather flows. The raw sewage pumps are rated for a much higher flow than the rest of the treatment plant. Four vertical extended-shaft raw sewage pumps rated at 12 MGD each are located in the lower level of the pump house, with the motors located on the intermediate level. All four pumps have separate 20-inch diameter force mains, and operating simultaneously, they have an approximate total capacity of 48 MGD.

Equalization Basins

The raw sewage force mains discharge to a concrete channel located between EQ Basins 1 and 2 where a Parshall flume with an ultrasonic level sensor measures the influent flow. The four EQ basins have a total storage volume of 10 million gallons and are concrete lined and aerated.

The EQ basins have two main purposes in acting as a flow buffer to the downstream treatment processes. Flows to the WWTP fluctuate throughout the day because of typical diurnal patterns of water usage. As the higher flows enter the plant, the flow pumped to the downstream treatment process is kept fairly constant, resulting in increased volume stored in the lagoons. When influent flows subside, the same constant rate is pumped out of the lagoons, lowering the volume stored.

The EQ basins also store excess wet-weather flows from rain or snowmelt. The sewer system is classified as combined, and the aging system also experiences high levels of infiltration. Since the flow rate though the treatment processes is kept fairly constant, the volume stored in the basins continues to increase as the influent flow is greater. Once the maximum storage capacity of 10 MG is reached, overflows occur from the CSO. New automated controls can shut off the airflow to basins 3 and 4 shortly before an overflow event occurs, allowing solids to settle prior to overflow. Overflow pipes from basins 3 and 4 are also baffled to prevent the discharge of floatable material that was not removed by the influent fine screens. Overflows from the basins pass through the recently completed CSO disinfection facility.

Primary Clarifiers

Two primary clarifiers, each 65 feet square with a 9-foot side water depth (SWD), are arranged with similar equipment as a circular clarifier. The sludge rakes were originally equipped with corner sweeps that would extend into the corners of the square tanks. These sweeps required frequent repair and modifications over the years—because of wear and tear on the moving parts—and have been removed. The sludge rakes push settled solids to center hoppers where they are drawn off and pumped to the anaerobic digesters. Scum is removed and flows by gravity to the head of the plant.

Aeration Tanks

Two aeration tanks are located on the northern side of the aeration complex, and two on the southern side, with two aerobic digesters in between. Each aeration tank is 120 feet long by 25 feet wide with a 15-foot depth and a total volume of approximately 328,300 gallons. The aeration system in each tank consists of new fine-bubble ceramic diffusers with a tapered aeration arrangement. Two existing blowers have a capacity of 3,500 cfm each, while two new blowers each have capacities of 1,400–2,700 cfm. The blowers also supply air for the aerobic digesters.

Return activated sludge (RAS) is introduced near the point where the raw sewage enters. The RAS is pumped by the RAS/WAS pumps through piping running the length of each aeration tank. Typically, the sludge is discharged at a single point at the influent end of the tank to maximize mixing, but valving allows RAS discharge at two other locations along the length of the tanks.

Secondary Clarifiers and RAS/WAS Pumps

Mixed liquor flows to two secondary clarifiers, which are similar to the primary clarifiers in both size and function. The two tanks are 65-foot square with circular clarifier equipment and a side water depth of 9 feet. Sludge from the secondary clarifiers is pumped as RAS to the aeration tanks or as WAS to the aerobic digesters. WAS can also be pumped to the anaerobic digesters, to the primary clarifier influent to co-settle, or straight to the sludge drying beds. Three 3,000-GPM pumps controlled by manually adjusted VFDs serve the dual purpose of conveying RAS and WAS, depending on how the discharge valves are configured. Flow meters measure the RAS and WAS for monitoring and record keeping.

Tertiary Filters

Effluent from the secondary clarifiers flows by gravity to eight gravity sand filters, each 15-feet by 15-feet. New improvements include mono-media with air scour and a PLC control system. The filters operate in a variable head mode. As the headloss through each filter tank increases due to blinding (caused by the solids in the water being captured in the media), the water level in each filter will slowly rise until it reaches a level requiring backwashing. Backwashing is typically an automated process.

Disinfection Facilities

The chlorine contact tank provides disinfection prior to discharge to the Prairie Creek. Liquid sodium hypochlorite is injected at the head of the tank, with dechlorination using liquid sodium bisulfite at the end of the tank. New chemical feed systems and storage tanks for the plant effluent were included in the new disinfection building, which also serves the CSO disinfection tank.

Sludge Handling

The handling of sludge is one of the most complex, costly, and time-consuming processes at a WWTP. The Frankfort WWTP produces both primary (raw) sludge and secondary WAS, which are typically handled separately.

Two aerobic digesters are located in the center of the aeration complex. The tanks are similar in dimension and layout to the aeration tanks, with the exception of a supernate/thickening chamber located at the east end of each tank. Sludge from the thickening chamber can be pumped to the anaerobic digesters for further stabilization, but it is normally sent directly to the sludge drying beds for dewatering.

Two anaerobic digesters are utilized for treatment of primary sludge. The two digesters operate in series, and each plays a different role in the sludge processing. The east tank serves as the primary digester. The sludge is pumped directly into this tank for acid fermentation, the first stage of treatment when the organic material is converted to organic acids, alcohols, and new bacteria cells. A new internal draft tube mixing system was recently installed in the primary digester. Recirculation pumps convey the sludge through a new combination boiler/heat exchanger in the sludge process building to maintain a desired 95°F to optimize the digestion process. The primary digester produces most of the methane gas (which is removed for use in operating the boiler) and is 55 feet in diameter and 22 feet deep.

The west tank serves as the secondary digester and is 50 feet in diameter and also 22 feet deep. Sludge from the primary digester is transferred to this tank where methane fermentation continues and supernatant is withdrawn. The secondary digester will receive a new floating gas-holder cover to store gas from both digesters, replacing the gas storage sphere and high-pressure gas system previously used. The methane produced in the digesters is used to fuel the boiler for heating the sludge. Digested sludge is pumped directly to the sludge drying beds for dewatering.

Dewatering is provided by 36 drying beds: 12 outdoor and 24 enclosed in a 240-foot square building covering more than 1.3 acres, one of the largest covered drying bed buildings in the state. Each bed is 20 feet wide by 100 feet long with 2-foot 6-inch high walls. After a bed is poured, the biosolids are allowed to dewater to a cake and are then removed using a front-end loader. After removing biosolids, the sand is tilled to prevent blinding and leveled off, adding sand as required. And the bed is then ready for another cycle. Biosolids are stored on site and wind-rowed until they are ready for disposal by land application, typically at 45%–55% solids. The current renovation includes painting the steel structure, new fiberglass siding and roofing, and ventilation improvements.

CSO Disinfection Facility

The new CSO disinfection facility consists of a 260,000-gallon serpentine tank and a new disinfection building. The building includes the liquid chemical storage tanks and feed systems that serve both the CSO disinfection tank and the plant effluent disinfection tank.

Overflow from EQ Basins 3 and 4 enter the CSO disinfection tank and is mixed with liquid sodium hypochlorite through a mechanical induction/mixer. Influent flow then passes over a weir and is measured with an ultrasonic meter. Effluent flows from the tank are dechlorinated with liquid sodium bisulfite and again measured with a weir and ultrasonic meter prior to passing over cascade aeration steps and discharging to Prairie Creek. After an overflow event, the 260,000 gallons stored in the tank is drained back to the plant headworks by gravity along with settled solids.

Benefits of Current WWTP Improvements Project

Replacement of much of the 30-year old equipment in the plant provided a good opportunity for improving energy efficiency. Improvements to reduce energy consumption and lower power costs include the following:

- New 200 Hp premium-efficiency motors and VFDs for the existing raw sewage pumps to replace older, less efficient 75/200 Hp 2-speed motors;
- New 150 Hp blowers and VFDs for the EQ basins to replace larger 100/250 Hp 2-speed blowers;
- New fine bubble aeration system and smaller blowers to significantly reduce power requirements for aeration.

The previous multi-media tertiary filters and media scour backwash systems were in poor condition and limited the hydraulic capacity through the plant, leading to short filter runs, excessive backwashing, and significant recycle streams back to the plant influent. The current filter improvements will increase filter capacity, improve filter performance, and decrease backwashing cycle times and volumes—all of which will reduce energy consumption, costs, and labor and allow for complete treatment of higher flows through the plant.

A complete renovation of the two anaerobic digesters will increase digester gas production for fueling the boiler and reduce natural gas consumption.

The improvements will allow the City to meet its LTCP and also provide energy-efficient solutions to reduce operational costs. Construction is anticipated to be complete in May 2012, with an estimated construction cost of $8,500,000.

Click here to return to the TABLE OF CONTENTS