Treating glycol runoff from airport deicing operations

Treatment systems must marry good stormwater management with appropriate treatment technology.

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Project
Buffalo Niagara International Airport engineered wetlands, Buffalo, N.Y.

Engineers/Suppliers
Jacques Whitford NAWE
Infiltrator Systems, Inc.

Product application
Aerated wetlands provide biological treatment of glycol-contaminated stormwater using below-grade gravel beds and Infiltrator chambers.

More than 200 gallons of propylene glycol can be used per plane for deicing.

Saying that a best available technology (BAT) exists for glycol treatment at airports is like saying that a best available spouse exists for marriage. What works in one case is not necessarily going to work in another. The U.S. Environmental Protection Agency (EPA) is, no doubt, struggling with this type of determination for the effluent guidelines program as it develops a rule for airport deicing. The EPA decision is due this year.

Although the glycols typically used for deicing are readily treatable, creating a steady state of predictable flow and concentration for treatment is the true engineering challenge. In this way, the means of treatment is secondary to managing the variability of flow and concentrations that are the basis for developing systems that marry good stormwater management with appropriate treatment technology.

EPA is evaluating BATs; however, in the end, the costs necessary to comply with the new regulations will be the sum of all components in the system — not only the treatment unit — and airport managers and their engineers should learn from those airports that already have systems in place.

Effluent guidelines

Under the Clean Water Act (CWA), EPA establishes technology-based national regulations — effluent guidelines — to reduce pollutant discharges from categories of industrial facilities that discharge to waters of the United States. The guidelines are designed to provide uniform guidance for NPDES permit writers.

The guidelines are based on an identified BAT that is economically achievable. In support of the development of the regulation, EPA has conducted sampling of treatment systems at airports to identify technologies currently in use for the treatment of glycol and other deicing chemicals. A wide range of practices are currently used by airports for management of spent deicing fluids. Technologies range from sophisticated recycling units to simple aerated lagoons. The systems reflect the deicing activity of the airport in which they are installed and are tailored for the climate and air traffic. The proposed EPA rule will effectively level the playing field by creating a national standard to which all airports must comply. The EPA plans to take final action by late 2009.

Stormwater and glycol treatment

The flows and loading associated with deicing and anti-icing activities are highly variable. They range from high concentration and low flows during "dry" days in the dead of winter to low concentrations with high flows during snow melts and freezing rain events. In the design of a management system for deicing fluid, the system must accommodate the extremes in flows and concentrations. An engineer must couple wastewater treatment with stormwater management; however, the two disciplines have competing interests. A wastewater engineer is interested in first-flush, high-concentration treatment and the stormwater engineer is interested in storing the peak, diluted flows. The competition leaves each fighting for storage volume that is typically hard to accommodate on an airfield.

Moreover, the highly erratic quality and quantity of glycol-contaminated runoff means that the wastewater engineer has little chance of achieving a steady state of flow and concentration in the influent. The benefits of equalization cannot be understated; it smoothes out the peaks, normalizes the flow, and provides flexibility to airport operations. Most importantly, it will reduce the cost of the treatment system.

The magnitude of the wastewater aspects should not be dismissed. Chemicals used by airports, such as glycols and formates, have an energy value, just like the calories in food. When those chemicals find their way into a stream or sewage plant, they exert an oxygen demand. If the oxygen supply runs out, the water turns anaerobic, resulting in fish kills and wastewater treatment plant upsets.

A gallon of propylene glycol (PG) has roughly 8 pounds of oxygen demand. To put that in some perspective, each person flushes about 0.2 pounds of oxygen demand down the toilet each day. In wastewater terms, 1 gallon of PG per day is equivalent to 40 people. New domestic sewage plants cost between $3,000 and $9,000 in capital costs per pound of oxygen demand per day. Using the same metric, each gallon of glycol used per day has a capital cost in the range of $24,000 to $72,000. Now consider that more than 200 gallons of PG can be used per plane for deicing.

Luckily, this math doesn't reflect the reality on the ground. Domestic wastewater treatment is a well-developed field in which solutions have evolved to meet needs: quick treatment of diluted wastewater with relatively steady flows. In contrast, airport deicing takes place only a couple of months per year with much of the liquid never making it to the treatment system, but instead being lost to evaporation and infiltration. Nevertheless, the math for treating domestic waste does reflect the scale of costs airport managers are seeing and the seriousness to which they must plan for EPA's guidelines.

Available technology

Airports are using a variety of approaches for managing deicing liquid. When the option is available, most airports

Five feet of technically specified aggregate cover the aeration and underdrain lines.

Infiltrator chambers were used at the Buffalo Niagara International Airport as an infiltration bed. The beds uniformly distribute stormwater through the gravel to a system of underdrains.

discharge to a sewage plant and pay a fee with respect to either the flow or loading. It is a convenient option, but not always the most cost effective. Handling the liquid on site is becoming a reality for many other airports. According to EPA's Preliminary Data Summary on Airport Deicing Operations, a narrow range of options is being used for these facilities.

Airports with centralized deicing pads are well suited for recycling of high-strength flows. Distillation, vapor recompression, and reverse osmosis units are being used to clean up and concentrate some of the stronger concentrations of deicing fluids. In these systems, dilution by stormwater is the enemy and great effort goes to collecting and storing the concentrate prior to processing. The systems perform best when concentrations are in the 8- to 12-percent range. Work with reverse osmosis and filtration units can be done on concentrations above 1 percent, however.

Some of the airports that have worked on recovery systems include Pittsburg, Denver, Salt Lake City, Detroit, and Minneapolis. Experiences are varied. The units can and do work well when they are well operated and maintained. Advances and increased competition in filtration units have been considerable in the last decade. This has allowed many airports to consider recovery as a cost-effective option to treatment.

Anaerobic treatment units are also well suited for high-strength flows. The Albany Airport in New York uses fluidized bed reactors to produce high-quality effluent while converting captured glycol to methane. The methane from the process is used as a fuel source for heating the incoming water and a number of buildings on site. Two 35-foot-high reactors are at the heart of the duplex system and are valved to allow operation in parallel or in series. The influent to the system is maintained at a 1- to 2-percent concentration level, with a design loading rate of roughly 7,000 pounds per day. Built in 1998 for $7.5 million, according to *The Business Review*, the system processes roughly 150,000 gallons of glycol per season. The system also includes 11 million gallons of retention ponds and tanks, along with polishing filters for the reactor effluent. Effluent from the system is directed to a nearby stream or to an airfield spray irrigation system.

In other situations, simply storing the spent deicing liquid until the weather warms up is common. Warmer temperatures acceletrate biological treatment and discharge can be paced during the off season. The storage basins should be located away from the airfield to prevent bird air strikes and should be lined to prevent contamination of groundwater. At Greater Rockford Airport in Illinois and others, aeration equipment installed in the basins facilitate treatment and reduce odors. Other airports, including Green Bay, Wis., and Lansing, Mich., use insulated floating covers on their basins to control odors and algae. Keeping the solution simple usually keeps the costs low, and for these systems the cost is mainly associated with basin construction. The downside of this approach is that the quality of treatment may be erratic and require close monitoring to ensure discharge limits are met. Odors are another liability, and the use of aeration or floating covers should be considered.

Engineered wetlands

An innovative approach using aerated wetlands was constructed in 2008 at Buffalo Niagara International Airport (BNIA) and is expected to go online in 2009. Below-grade gravel beds are designed to treat spent glycol found in stormwater during the deicing season. Aeration of the gravel is critical. The system is designed to supply oxygen to bacteria attached to the gravel and can be controlled relative to the level of glycol being treated. Currently, the system is designed


Urban Engineering

The subsurface infiltration beds were topped with mulch and a no-mow grass seed mix to minimize maintenance and bird activity.

for 10,000 pounds of oxygen demand per day and is roughly the size of four football fields.

Compliance with a New York stormwater permit is driving the BNIA project. The discharge permit limits the concentration of biochemical oxygen demand (BOD) in stormwater to 30 milligrams per liter. Another regulatory restriction on the project is the volume of stormwater discharged to Scajaquada Creek to the south of the airport. The discharge from the southern half of the airfield is limited to a maximum flow rate of 181 cubic feet per second (cfs), which effectively translates to 154 cfs for the project area. To meet this restriction, the airport previously constructed a stormwater system with a 3 million-gallon vault. Pumps from the vault discharged to a culvert feeding Scajaquada Creek.

The airport selected engineered wetlands because they provide treatment of cold and variable-strength wastewater; integrate into the existing stormwater management system; handle large seasonal variations; can be sited on or close to the airport property; do not present a bird strike or airside hazard; produce negligible odor; and require low operation and maintenance costs

The ability to accommodate large fluctuations in flow and strength is of primary interest. The fundamental design constraint is areal loading (10,000 pounds of BOD per day), not volumetric flow, which means the system can handle large dilute flows as well as smaller concentrated flows.

The system, designed by Jacques Whitford NAWE, comprises four discrete wetland cells excavated from an open area near the airport's main runway. Only a field of grasses growing from a "dry" mulch surface is observable at ground level. The size of the gravel and the porosity of the bed is important. The relatively large size of gravel — 1/2 to 3/4 inch in diameter — allows for accumulation of bacterial biofilm (slime), which grows during the deicing season and degrades during the summer. Analysis of biomass growth, storage, and decay ensured that the gravel beds would not clog.

Based on that analysis, a vertical flow configuration with infiltration chambers was selected to distribute stormwater uniformly over the beds and flow downward to an underdrain system. The large application area provided by using Quick4 Standard Infiltrator chambers coupled with the large gravel voids minimizes the probability of clogging.

Flow and concentration of the stormwater will be monitored closely using electromagnetic flow meters and online analyzers and, as necessary, will be controlled to optimize performance of the wetland. Air and nutrients will be supplied to the system to match the pounds of glycol measured. The patented Forced Bed Aeration system used to distribute air uniformly over the floor of each bed is fed by four, 250-horsepower positive-displacement blowers. The operation of blowers can be modified to match the level of glycol being treated. Supplemental nutrients — nitrogen and phosphorus — can also be paced into the influent relative to organic loading to match nutrient requirements for bacterial growth.

The system is engineered to maintain an active biomass within the wetland throughout the winter. It is built below ground with an insulating mulch layer on top to maximize water temperature. During the warmer summer months, the accumulated biomass will degrade and be consumed by larger "bugs" that graze on the slime-covered gravel. This natural digestion of biosolids is a seasonal way to manage sludge generated in the treatment of the glycol.

Come spring and the end of deicing season, the wetland treatment system will be used as a tool in the management of stormwater volume. The water level in the gravel beds is fully adjustable, allowing the operator to use the beds to buffer the flow from summer storm events. Since the system is already piped for managing peak flows, no additional infrastructure modifications are necessary. The beds provide treatment in the winter and storage in the summer.

Pairing airfield stormwater management with glycol treatment can be a difficult match. A good place for each operation to start is to differentiate the treatment requirements from the stormwater management realities and then develop a system that equally addresses the needs of each. ■

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