wetlands, remediation & the long haul

By Mark O. Liner

Wetland treatment systems certainly have matured in the past decade, though one thing about them stays the same: They have low operation and maintenance costs. Over time, the engineering of the systems also has been refined—from biological empiricism to chemical reactor design—from hippie to geek.

The evolution of wetland treatment system engineering

ARTICLE SUMMARY

Challenge: Pollutants, including petroleum hydrocarbons, sometimes linger in groundwater on former drilling and processing operation sites.

Solution: Microbial communities in wetlands are capable of breaking down these and other volatile organic compounds.

Conclusion: Wetland treatment systems provide the treatment needed to improve water quality, and engineering advancements mean these systems can perform for more than 30 years.

Engineered wetland under construction in Casper, Wyo.

This trend is apparent for pump-and-treat remediation systems in which engineered wetlands are proving successful and durable. Projects in New York, Wyoming and Michigan are good examples of how these systems are being used for the long haul. When contrasted with mechanical systems that become increasingly obsolete over 30 years, natural systems are now engineered for a full life—from teenager to senior citizen.

Wetlands Today

Improvements in the engineering of wetlands for wastewater treatment over the past decade have helped increase the predictability of performance of these natural systems. Engineers have borrowed the biology, chemistry and hydraulics of the wastewater industry and are employing them successfully to create remediation systems that perform like sewage plants but look like plant life.

Inclusion of aeration in subsurface wetlands has advanced the ability of the systems to aerobically degrade hydrocarbons and ammonia. This is critical for the design of wetland systems in applications such as produced water treatment or nitrifying ammonia found in tailings ponds for gold mines. By using understood hydraulic and thermodynamic principles, designers are creating wetland "reactors" that are stable and efficient. These reactors increase the reliability and performance over those of past systems by ensuring proper reactor kinetics and complete use of the wetland with minimal short-circuiting.

Wetland systems are larger than mechanical systems, but there is a trade-off between the mechanical complexity and land. Lagoons and wetlands do not need as much attention or maintenance as their mechanical counterparts: They are big, simple and low maintenance. But that is just one of their assets as compared to mechanical systems. With minimal moving parts, natural systems can be operated for decades without the need for overhaul or equipment replacement. That gets to the asset they offer to the bottom line: low life-cycle costs. The more we exploit bacteria degradation and other natural mechanisms, the less mechanical effort needed to get the job done—and ultimately, the lower the cost.

Engineered wetland for benzene removal in Casper, Wyo.

Built to Last

Site managers are regularly faced with the liability of contamination plumes affecting the groundwater of their neighbors. The liability is long term—decades, not days. When pump-and-treat systems are used, the "treat" part must do the job for the long term as well. Noncompliance is not an option. In this scenario of high-profile remediation projects, treatment wetland systems are an effective choice. They work and they have low, or in some cases no, operation costs aside from routine yard maintenance.

Petroleum Hydrocarbon Remediation

Through a unique combination of natural processes, wetland systems are being used to remediate petroleum hydrocarbons found in groundwater that are left over from previous drilling and processing operations. Treatment of a wide range of compounds, including benzene, ethylbenzene, toluene and xylene (BETX), occurs through volatilization and aerobic biodegradation.

Microbial communities in wetlands are known to break down many of these and other volatile organic compounds. The challenge is to engineer a system that provides a consistent environment to allow such microbial communities to flourish over the extended life of the system.

Application: Wellsville, N.Y.

Such a system is in operation at a former refinery in Wellsville, N.Y. The site, an oil refinery from 1901 to 1958, is located next to the Genesee River. The long-term closure plan for the site includes a barrier wall to prevent migration of contaminated groundwater to the river. Groundwater extraction pumps deliver contaminated water to a treatment wetland constructed on the site. The system consists of a cascade aerator, sedimentation pond, surface flow wetland and vertical flow wetland; it provides treatment for 650 cu meters per day of groundwater. The influent has elevated levels of iron, manganese and petroleum hydrocarbons, including aniline and nitrobenzene.

The cascade aerator provides passive aeration of the influent flow, permitting the iron and manganese to be oxidized. The oxidized metals generate precipitates that are allowed to fall out in the downstream sedimentation pond. After the sedimentation pond, the flow enters a surface flow wetland that is lined and operates at water depths between 0.3 and 0.6 meters.

There are four beds in parallel, each 0.6 acres, designed to expedite the biodegradation of petroleum hydrocarbons in the water. Flow is then introduced into a vertical-flow wetland comprised of limestone aggregate. The limestone beds are used to adjust for the pH depression related to the upstream iron precipitation.

Application: Casper, Wyo.

Another petroleum hydrocarbon remediation system was constructed by BP in Casper, Wyo. The site includes an office park, riverfront trails and a whitewater kayak course. The Casper system provides treatment of up to 11,400 cu meters per day of gasoline-contaminated groundwater. It blends into the middle of a premier golf course and is anticipated to operate effectively for more than 100 years.

This award-winning wetland project was innovative in a number of ways. It is one of the largest petroleum remediation wetlands in North America, and one of the first wetland treatment systems designed specifically for cold-weather hydrocarbon removal. The design of the wetland was integrated into the golf course, and many of the water features have dual uses for treatment and golf course play.

This project design includes a cascade aeration system for iron oxidation and air stripping; a soil-matrix biofilter for gas-phase benzene removal; surface flow wetland cells for removal of ferric hydroxide precipitates; storm water retention wetlands; and radial subsurface flow insulated wetland cells for BTEX removal. Support of the design required conducting a pilot to determine site-specific rate constants.

Surface flow wetland for aniline and nitrobenzene removal in Wellsville, N.Y.

Application: Wurtsmith AFB, Oscoda, Mich.

A wetland treatment system is planned for construction in 2010 at Wurtsmith Air Force Base in Oscoda, Mich. The pump-and-treat system is designed for a flow of 0.63 mgd and treatment of TCE and other chlorinated hydrocarbons. The need for hydrocarbon remediation here results from a landfill on the site that was used during World War II and the Cold War.

The system employs a cascade aerator for oxidation of metals. From the cascade aerator, the flow travels through a sedimentation pond, where precipitates are allowed to settle. Following the sedimentation pond, flow continues through a free-water surface wetland and a subsurface wetland before final disposal by soil infiltration.

There are no motors or other mechanical components following the pumps that deliver the groundwater to the cascade aerators, so operation and maintenance is limited to routine visual monitoring and groundskeeping. The subsurface wetland is constructed with aeration lines in place as a contingency measure, but the manifold for the lines is not expected to be connected to a blower unless needed. Ongoing operations costs will be limited primarily to the cost of operating the groundwater extraction pumps.

Treatment for Tomorrow

If Jerry Rubin was an engineer, he might say, "Don't trust any treatment system over 30." How things have changed. Treatment wetlands have grown up. The hippie days of design are long past. Middle age is here, and systems are designed on proven science and common engineering practices. Most importantly, they are proving financially viable over the long haul. The systems in the ground now will be around for many years to come and are expected to be working and trusted long past 30 years of age. WWD

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