

Pipes, Detention, and Sand Filtration

Solutions for impervious drainage areas

BY JANET AIRD

For stormwater detention and filtration in small, highly impervious drainage areas, sand filter systems with detention may be the perfect solution. In urban areas, they may sometimes be the only solution. They're appropriate for commercial, municipal, and industrial operations.

Ideally, the contributing drainage area will be as close to 100% impervious as possible to reduce the risk that eroded sediments will clog the filter, according to the Virginia Department of Environmental Quality.

These systems capture, temporarily store, and treat stormwater runoff, and then return it to the storm drainage system. They may be installed underground, on the surface, or just below grade along the edge of an impervious area such as a parking lot.

Such systems may be proprietary or non-proprietary; contained in pipes or vaults, or free form, or a combination; made of concrete, steel, or plastic. Each has advantages, disadvantages, and specific applications.

Underground, they generally consume no surface area at all, except for their manholes. Aboveground, they typically consume about 2–3% of the surface area. Perimeter systems typically consume less than 1%.

These detention and filtration systems provide moderate pollutant removal. They consist of three chambers, or cells. The first chamber, the detention chamber, decreases peak flows by capturing and temporarily storing potentially damaging floodwaters. It also removes trash and heavy sediment by gravitational settling.

The second chamber, the filtration chamber, consists of a bed of clean, washed concrete sand or organic matter such as a peat/sand mixture or

a leaf compost mixture over a layer of gravel. The runoff filters through the media, which often has a microbial film on its surface. The microbes enhance biological removal.

The third chamber polishes the filtered water and leads to an outlet pipe that releases the water back into the stormwater drainage system at predevelopment flow rates. Some



The outlet pipe was weighted down by concrete collars under the riverbed and filled with water.

systems are designed to release runoff into the surrounding soil to recharge the groundwater.

These systems should be sized so that the water-quality volume is filtered completely through the sand media within a maximum of 40 hours, to ensure that aerobic conditions are maintained in the filter between storm events.

The following projects show the usefulness of pipe in two stormwater detention and sand filtration system installations.

Gerald R. Ford International Airport

It took nearly 20,000 feet—more than three and a half miles—of concrete pipe running under a railroad, a local road, several access roads, an expressway, and a golf course, and over two streams to reach from the Gerald R. Ford International Airport (GFIA) to its new onsite stormwater detention and treatment system, and from there to an outfall on the Thornapple River.

“This is something that started with our de-icing program,” says Roy Hawkins, R.L.A., planning engineer for GFIA, the owner and operator of stormwater system. At the airport in Grand Rapids, MI, airlines use propylene glycol to deice aircraft in cold weather conditions. During storm events and snowmelt, runoff from the east side of the airport flowed directly into the Thornapple River. Runoff from the west side flowed into Trout Creek, a tributary of the river.

The bacteria covered the creek bed, forcing aquatic insects and fish to leave the area and lowering dissolved oxygen levels.

Glycol is a sugar that feeds organisms—including bacteria—that naturally occur in waterways. The bacteria grew to become a nuisance condition in the creek every deicing season. They covered the creek bed, forcing aquatic insects and fish to leave the area and lowering dissolved oxygen levels.

In August 2011, the Michigan Department of Environmental Quality (DEQ) issued GFIA a National

Pollutant Discharge Elimination System (NPDES) permit. The permit required the airport to eliminate its contribution to the nuisance biofilm condition and to conduct a study on how to remove it.

The airport worked with the city of Grand Rapids and determined that the municipal treatment plant couldn't accommodate the airport's stormwater. It then looked at the ways other airports around the world addressed the issue in their runoff.



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Concrete pipe ran under a railroad, a local road, several access roads, an expressway, and a golf course, and over two streams.

GFIA chose to install a new stormwater detention and treatment system on the east side of the airport and rerouted the stormwater from the west air carrier apron to the new system. From there, pipe takes the treated stormwater to a new outfall on the Thornapple River.

Prein & Newhof, an engineering consulting firm, led the design of the system and oversaw its construction.

GFIA specified reinforced concrete pipe (RCP) to carry stormwater from the airport to the detention basin and treatment system, and from there, to the new outfall. "At this airport, any pipe over 12 inches has to be concrete, this is our stand," says Hawkins. "I could sell concrete pipe, because I believe in it."

Northern Concrete Pipe Inc., which has four manufacturing facilities, three in Michigan and one in Ohio, won the bid.

The airport is some 100 feet above the river. The entire drainage

area entering the river from the airport is nearly 900 acres. Stormwater comes from onsite and accumulates quickly because of the amount of impervious surface.

The entire drainage area drains into the new system, which has a 185-acre-foot storage volume and the capacity to accommodate a 100-year storm event.

The system captures and treats the vast majority of deicing runoff as well as pollutants from parking lot surfaces. In addition, the design allows for expansion of the system and eliminates the need for the existing detention basin to the north of the airport, which would have interfered with future runway development.

The funding source for the \$20 million project came from the Federal Airport Improvement Program. In accepting the funding, GFIA was required to complete an environmental assessment, which took approximately one year.

GFIA established an advisory committee composed of numerous stakeholders, including airport tenants, airline representatives, area residents, local officials, the Thornapple River Watershed Council, and the West Michigan Environmental Action Council. They held meetings throughout the study process. The airport also coordinated with railroad owner CSX Corp., the Michigan Department of Transportation, the Federal Aviation Administration (FAA), the Kent County Road Commission, Cascade Township, the Golf Club at Thornapple Pointe, and multiple consultants.

"We strive to have good relationships with everyone," says Hawkins.

As a result, in 2014, GFIA won an Environmental Achievement Award for Outreach, Education and Community Involvement from ACI-NA (Airports Council International-North America).

Northern Concrete Pipe supplied the standard and jacked pipe as well

as most of the other concrete products, including precast concrete box culverts, and manholes, which range from standard to tee-manholes to 15-degree and 45-degree bends. The storm system uses these products to move the stormwater from the airfield to the new detention and treatment system.

“We watched them make the 108-inch standard and bore pipe and do the pipe testing,” he says. “We learned a lot.”

The project used 108-inch, 72-inch, 60-inch, 48-inch, 24-inch, and 12-inch-diameter pipe. “We sized the pipe to be self-cleaning,” he says. “The bigger the pipe, the flatter you can lay it.”

The prime contractor, Kamminga & Roodvoets in Grand Rapids, began construction late in 2013. In compliance with the state Department of Environmental Quality regulations, the contractor waited until the area’s endangered Indiana bats flew south for the winter before it began moving dirt and trees. It completed the project in October 2015.

“They moved a lot of dirt,” says Hawkins. “They filled in some areas and cut out others, including the side of a hill to install the pipe.”

During the work on the airfield, GFIA and the FAA coordinated taxiway closures. There were three taxiways on the apron and all had to be closed, but they couldn’t all be closed at once. At any given time two of the taxiways remained open.

The contractor waited until the area’s endangered Indiana bats flew south for the winter before it began moving dirt and trees.

“It took the summer of 2015 to complete the airfield work,” says Hawkins.

GFIA also worked with the county road commission to allow access to bore and jack the pipe under the railroad and primary road.

Kamminga & Roodvoets used more than a mile of 72-inch, 60-inch, and 48-inch pipe to connect the storm system on the west side of the airport to the 108-inch pipe that leads to the new detention basin and treatment

system. The company used 4,000 feet of standard 108-inch-diameter RCP for the sections of pipe between the airport and the railroad, and between the county road and the new system.

The subcontractor, Lowe Construction Co. of Horton, MI, did the work in the river and all the boring and jacking under the county road and the expressway, as well as boring and jacking the specially made 108-inch pipe under the railroad.

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“They did almost 1,100 feet of bore,” says Hawkins. “They did a great job.”

The railroad had requirements about the track and the pipe, which determined the elevation of the detention basin and treatment system.

Kamminga & Roodvoets placed rings of plywood to cushion each joint between each pipe section. The pipe was pushed under the railroad and grouted as required by the owner of the railroad, CSX.

“There were no problems,” he says. “That all went very well.”

Lowe removed old sections of corrugated metal pipe at two streams and replaced them with precast concrete box culverts. Crews also enclosed two other streams between the railroad and the expressway.

GFIA had to write an easement for the pipes to go under the golf course in spite of the fact that the golf club is on airport property. “It’s considered parkland,” says Hawkins.

GFIA was not permitted to install the pipe when the course was in use,



The Sandy Springs detention and treatment system used some 1,800 feet of 144-inch 10-gauge aluminized steel. It holds approximately 220,300 cubic feet of runoff.

Southeast Culvert Inc.

so the work had to be completed during the winter, and construction was not allowed to touch the tee boxes or the greens. The contractor

was able to avoid restoration issues by hiring the golf club as the subcontractor to complete all the landscape and restoration work.

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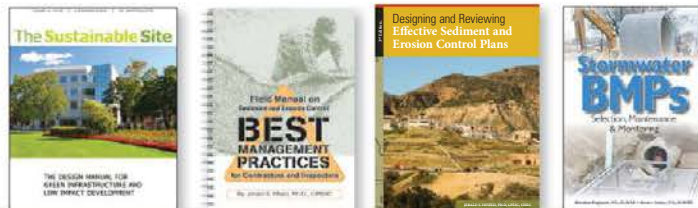
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Several hundred feet of 24-inch-diameter pipe leads from the detention basin to the treatment system. Because the elevation is considerably lower than the airfield, the water flows by gravity.

A trash grate at the inlet to the detention basin keeps larger solids out of the basin. Check dams remove the first flush of sediment. A log boom at the outlet collects floating debris. A trash rack structure at the outlet filters out smaller debris and pollutants.

After the water travels through the trash rack, it enters a splitter box structure directing flow to six chambers. Each chamber has two siphons. When the stormwater reaches a predetermined elevation, the siphons activate and pulse the water into the stage 1 treatment cells.

"It's like flipping a switch to a motor pump on and off, but the siphon system does it by itself," explains Hawkins.

Kamminga & Roodvoets placed pinhole tubes throughout the bottom layers of stone in the stage 1 treatment cells. In the future, pumps may be installed to pump in oxygen, which is an even more efficient method of treating the glycol.

Stormwater then travels through a pipe distribution system to the stage 2 treatment cells, which are composed of a layer of geofabric covered by multiple layers of various-sized stone, which is covered by a layer of mulch and grass. Here, naturally occurring bacteria and fungi break down the remaining glycol and other pollutants into carbon dioxide and water.

As the water levels rise in the stage 2 cells, the water fills another chamber where siphons activate and release the treated stormwater to the stage 3 treatment area, a swale lined with bacteria-covered stone that further treats the stormwater.

At the outlet of the swale, a 60-inch-diameter pipe carries the filtered water over a culvert-enclosed stream at the bottom of a ravine to the M-6 Expressway.

Lowe bored and jacked 48-inch concrete pipe under the expressway

and then trenched the pipe until it connected to a 48-inch high-density polyethylene pipe (HDPE) outfall pipeline and diffuser at the river. Several drop structures allow for additional aeration of the stormwater before it enters the river.

HDPE pipe was used because the pipe had to bend to allow its placement under the bottom of the river, says Hawkins. Its walls are approximately 3 inches thick to allow it to

bend as necessary. The pipe was pressurized to prevent material from the river from entering the pipe.

The pipe was weighted down by concrete collars under the riverbed and filled with water. A scuba diver assisted in the alignment of the diffuser pipes, a series of openings along the end of the pipe that discharge the treated water to reach the required pressure, and ensured they were tight.

"The weather was cold," says

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Hawkins. "The scuba diver was the only one who was warm that day. He had heated water pumped into his suit."

As part of its permit, GFIA tests the system and reports the results to DEQ every month. GFIA installed two solar panels to power the two remote testing locations, both of which are located before the treated stormwater flows into the river.

The system has allowed GFIA to

meet its permit limits, and the airport is still tweaking the system to treat even more glycol.

"This is the most exciting project I've ever worked on," he says. "It's good for the environment, good for everybody. I think this is the future for other airports as well. We're looking to connect more of the airport's storm system and possibly add more treatment cells if necessary in the future. This is definitely the right thing to do."

Sandy Springs Gateway Project

In 2014, the planned stormwater detention and filtration system for the new Sandy Springs Gateway mixed-use development in Georgia was in crisis: It was rejected during the stormwater permitting process.

"The city review engineer left and was replaced with one who had a completely different idea about what were good water-quality practices," says Mark McCord, a civil engineer at pipe manufacturer Southeast Culvert Inc. (SEC) in Winder, GA.

The change required a larger system in a very limited space. McCord, who was working at the time with the engineer of record, Charlie Beadles of Summit Engineering Consultants in Alpharetta, GA, came up with an alternative.

Together, they redesigned the system to use the underground DC (for Washington DC) sand filter system. "That was the biggest challenge in the project," he says. "It required us to drop back and do a bit of rethinking."

SEC manufactured Aluminized Steel Type 2 corrugated metal pipe (CMP) for the pipe leading from the storm drains to the sand filter system and the same Aluminized Steel Type 2 CMP for the 144-inch-diameter pipe for the system. Pipes of such a large diameter are more affordable than any other kind of pipe, he says.

SEC sourced the metal from AK Steel. "AK Steel was probably the salvation of this industry," says McCord. "By making aluminized steel, they somewhat revolutionized the durability of CMP and allowed us to maintain our viability within the stormwater drainage industry."

Although sand filter systems can be relatively expensive to construct and install, the final costs for this one were within a few thousand dollars of the original system.

In 2015, SEC won the National Corrugated Steel Pipe Association's Project of the Year award in the detention retention category. In addition to its salvaging the project, it's a fairly large detention system and different from the typical project.

He says sand filter systems are in the *Georgia Stormwater Management*

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Manual, but are rarely used. They're especially well suited to high-density areas with extreme space limitations and highly impervious areas where the sediment load is relatively low.

The Sandy Springs drainage area is 21.33 acres. Structures and a parking lot cover the site almost completely. Stormwater comes primarily from onsite, although some comes from the northern part of the city. The main pollutants are hydrocarbons and sediment.

The system holds approximately 220,300 cubic feet of runoff. It's designed for a 100-year storm event. It removes pollutants through a combination of gravitational settling, filtration, and adsorption.

Removal rates are 80% for total suspended solids, 50% for total phosphorus, 25% for total nitrogen, and 50% for the heavy metals cadmium, copper, lead, and zinc. It also removes fecal coliform and streptococci bacteria.

An inlet pipe under the parking lot leads from a storm drain to the underground detention, or sedimentation, chamber under roads just 10 feet from some of the buildings. Trash, debris, and heavy sediment are removed here.

"It's a long detention," says McCord. "The water sits until there's enough volume for the first 1.2 inches to spill over a weir plate onto a sand media." The rest of the water drains over time.

The sand media is in the filter bed chamber, which contains a base layer of 1 foot of gravel with a 2-foot layer of sand above it. As water seeps through the media, hydrocarbons and other pollutants are removed. A small horizontal perforated PVC pipe in the sand collects the filtered water and sends it back to the detention chamber.

There are access risers above each chamber. At the lowest part

of the system, an outlet control structure releases runoff back into the stormwater sewer system at the same rate as it left the site predevelopment.

Contractor Brent Scarborough and Co. of Fayetteville, GA, installed the system in approximately three weeks in 2014. Crews used some 1,800 feet of 144-inch 10-gauge aluminized steel.

"There's quite a bit of volume underground," says McCord.

Because of the site characteristics, Brent crews excavated between 14 and 25 feet deep. The pipe was laid at a 0% slope.

Crews placed 4 to 6 inches of aggregate under the pipe and around the sides, and 3 to 6 inches above the pipe, compacting all thoroughly. The depth of the stone was at least 13 feet along the length of the pipe.

As they added the aggregate around the sides, they used a geofabric to separate it from the surrounding soil. They also placed a geofabric

on top of the aggregate above the pipe. The geofabric helps keep the compaction as well as prevent fines from infiltrating into the aggregate.

"When you're dealing with a system this large, you have to be very careful," he says. "The pipe can get flexible because of the diameter. You have to be sure there's proper compaction."

Brent crews placed approximately 4 inches of soil above the aggregate on the low side of the site and approximately 12 inches on the high side.

"It all went off without a hitch," says McCord. "Brent is a very good installer."

Maintenance includes raking the first inch of sand to inspect the sand filter for clogging and replacing the sand as needed. This should be done every six to seven years, he says. Sediment should be flushed from the detention chamber somewhat less often. ♠

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