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DEPARTMENT OF TRANSPORTATION
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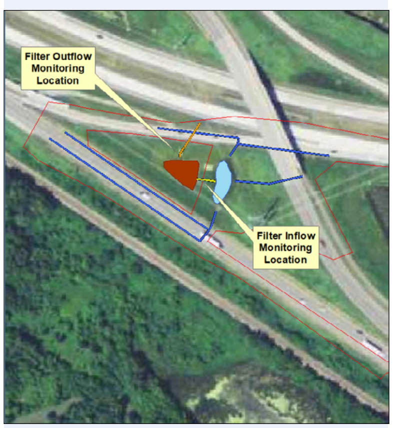
TECHNICAL SUMMARY

Questions?
Contact research.dot@state.mn.us.

Technical Liaison:
Beth Neuendorf, MnDOT
Beth.Neuendorf@state.mn.us

Principal Investigator:
Omid Mohseni, Barr Engineering Company

PROJECT COST:
$65,001



An overhead view shows the location of the TH 610 IESF wet pretreatment cell (blue) and filtration basin.

Monitoring Performance of an Iron-Enhanced Stormwater Filtration System

Researchers determined the effectiveness of a two-cell iron-enhanced stormwater filtration basin to remove phosphorus from highway stormwater runoff collected from 2012 to 2018. They recommended design changes that would allow for more accurate monitoring of these filter basins.

What Was the Need?

To treat stormwater runoff from Minnesota's highways, MnDOT employs many strategies, including stormwater infiltration and filtration basins. In addition to treating stormwater, these basins may use sand mixed with iron oxide—iron-enhanced sand filters (IESFs)—to remove phosphorus before directing stormwater to stormwater outfalls. A few IESFs have been installed around the state.

To determine how effectively an IESF removes total phosphorus (TP) and dissolved phosphorus (DP) from stormwater runoff, in 2011 MnDOT installed a two-cell system with a wet pretreatment cell connected through a berm to an IESF basin at Trunk Highway 610 (TH 610) and County Road 81. A testing unit monitored the system from 2012 to 2018 followed by an annual analysis of the data.

What Was Our Goal?

The objectives of this project were to determine if installing IESFs could enhance filtration basin performance and to present data showing the IESF's effectiveness in removing total phosphorus (TP) and dissolved phosphorus (DP).

What Did We Do?

First, researchers analyzed data collected from 2012 to 2015. MnDOT had constructed an outflow monitoring location using a Thel-mar weir to measure flow. Filter inflow was not measured beyond recording water levels, resulting in approximate inflow data. A manhole had been constructed in the berm between the two cells; water from the wet pretreatment cell flowed to the IESF via a pipe through the berm and the manhole. A pressure sensor measured water levels in the manhole. Water samples were collected at two inflow and outflow locations during rain events with automatic samplers. A rain gauge measured precipitation at the inflow location.

Researchers added another weir to monitor inflow in June 2016 at the manhole IESF inflow location to more accurately measure both inflow and outflow. Because the weir in the manhole could be easily submerged, researchers placed a pressure sensor downstream to determine when water levels would affect it.

In 2017, researchers installed two piezometers in the berm and one inside the filter near the berm. A third piezometer was installed in 2018 close to the IESF outlet. These sensors measured groundwater and water level pressure, allowing researchers to better understand the water level inside the IESF, learn how quickly it drained and possibly estimate seepage through the berm from the pond to the IESF.

Data from 2016 to 2018 showed that the volume of filter outflow exceeded the monitored inflow by about 30%. Researchers developed a hydrologic computer model to

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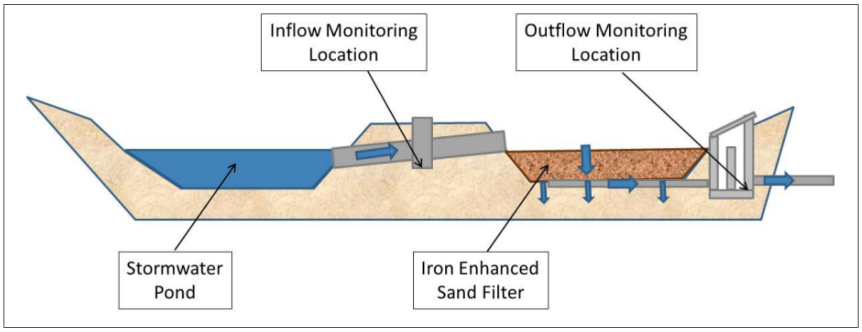

The TH 610 two-cell IESF system consists of a stormwater pretreatment cell (left) that drains through the berm via a connecting pipe to the IESF basin (right).

"Iron-enhanced sand filters are only effective in removing dissolved phosphorous when they are not subject to prolonged saturation. Monitoring IESFs is difficult because the actual treatment is influenced by many factors."

—Beth Neuendorf,
Water Resources Engineer, MnDOT Metro District

"This study clearly revealed the importance of initial filter basin design incorporating effective means of monitoring all inflow and outflow, and the need for strategies to avoid prolonged filter saturation."

—Omid Mohseni,
Senior Water Resources Engineer, Barr Engineering Company

help them determine sources of additional filter inflow and outflow within the entire 5.4-acre watershed area encompassing the IESF basin.

Researchers calculated the system's phosphorus removal from the 2012–2015 data. From 2016 through 2018, they analyzed samples automatically collected from every rain event, creating pollutographs of phosphorus levels for each and determining filter effectiveness each year. Finally, they developed recommendations for future IESF designs.

What Was the Result?

Researchers determined that the system removed phosphorus between 2012 and 2018, though there were substantial periods when monitoring devices failed. A comparison of TP and DP influent and effluent concentrations showed that the filter was removing TP but not DP. In six years of the seven-year monitoring period, the mean annual effluent concentrations of DP were higher than the mean average influent concentrations.

The hydrologic model examining greater outflow than inflow estimated that the additional inflow was coming from seepage through the berm and flow from pervious areas. The model estimated the filter's influent and effluent loads: IESF removed a significant amount of DP in 2016, removed nearly no DP in 2017 and released more DP than present in the influent in 2018. This DP was likely due to long periods of standing water in 2017 and 2018, which produced anoxic conditions. Oxygen-depleted water caused the iron oxide to release previously captured phosphorus.

The TH 610 IESF showed that when all inflows and outflows cannot be monitored, determining how well the system removes TP and DP becomes problematic. They offered recommendations for new installations, addressing reduction of uncontrollable factors and specific monitoring needs as part of the initial designs.

What's Next?

The final report, available on MnDOT's website, includes design considerations for new IESFs, as well as protocols for monitoring that will identify problems early, mitigating the collection of erroneous data.

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Minnesota Department of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research

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