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Improvements to the RV Waste-transfer Station Design to Reduce Contaminated Storm Runoff

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Abstract

Mammoth Cave in Central Kentucky is the world's longest cave system and has been designated an international biosphere. It has unique organisms that live in the cave system and they are dependant upon high quality water supplied through rain recharge. We have documented quaternary ammonia compounds (QAC) levels ranging from 0.2 to 22 mg/L in storm flow, as well as, other chemicals coming from the RV waste-transfer station. The objective of this project was to re-design the drain system around the dump station to prevent spillage from washing down into the cave. The first design feature is a v-trench to catch storm runoff and redirect it into the sanitary sewer. The second feature is a gently elevated barrier that will impede the flow of runoff from the impacted area. The designs presented in this paper incorporate both features.

Background

Mammoth Cave National Park in Central Kentucky has been designated as an international biosphere. Approximately 400 miles have been mapped and explored in Mammoth Cave. The National Park Service encourages campers and tourists to visit the park, while balancing that with protecting the ecosystem above and below ground. The cave system was formed by erosion and dissolution of limestone by the groundwater over hundreds of thousands of years. Water still plays an important role in today's cave, especially the high quality water needed to sustain the unique ecosystem in the cave.

Tennessee State University, Mammoth Cave International Center for Science and Learning, the U.S. Geological Survey and Mammoth Cave partnered to monitor water quality in areas of the Park with high visitor traffic. Those water-quality monitoring activities identified a new source of contaminants. Quaternary ammonia compounds (QACs) spilled at the recreational vehicle (RV) waste-transfer station were washing into the storm drain. The storm-water filter system receiving this runoff was not very effective at removing all the contaminants and QACs were making their way into the cave system during storm runoff. The objective of this project was to design a modification to the RV waste-transfer area to prevent the release of QAC since the filter system is inadequate. This issue must be resolved by re-designing the drainage area adjacent to the RV dump station.

Materials and Methodology

QACs

Storm monitoring was conducted to determine water quality of parking lot storm runoff and how effective the storm-filters were at reducing pollutants (McMillan, et al., 2013). These activities included catching first-flush storm runoff and analyzing for QACs at several parking lots. The runoff from the Post Office parking lot was surprisingly high in QACs during the summer, ranging from 0.2 to 22 mg/L QAC.

Storm runoff

Storm flow patterns in the Post Office parking lot were observed during several rainstorms. It was apparent that on the south side of the building, water flowed from the front of the building, down through the RV waste-transfer area, and into the storm drains to the filter (Figure 1). The filter released the storm water out the discharge pipe, and down the hillside to a sinkhole. The water would sink at the sandstone-limestone contact, and enter cave system at Annette's Dome. This process would take approximately 1 hour and 15 minutes (Painter, et al., 2013).

RV Waste-transfer station

The engineering design drawings, along with measurements taken at the RV waste-transfer station, were used to re-design the drain area. Some design constraints included minimizing disruption to the parking lot, holding down costs, limiting the flow of non-QAC storm runoff water into the sanitary sewer (i.e., storm runoff from areas away from the RV waste station should be directed to the storm filter), keeping the station user-friendly, and preventing the release of QAC and other RV wastes into the storm-filter. CAD was used to visualize the design.

Figure 1: Storm-water drains from the Post Office parking lot and mixes with spilled waste residue, rich in QAC, at the RV disposal station. It carries the QAC into the storm filter, down the ravine, and into Annette's Dome (Cave level B). This drain area needs to be re-designed to prevent chemicals from getting into the cave.

Results and Discussion

QACs

The average summer concentration of quaternary ammonia compounds, starting at the Post Office parking lot (RV dump station), decreases as it flows through the filter system and into the cave (Figure 2). However, the concentration in the cave is higher than desired. The regression shows the reduction in QAC along the flow path.

Storm runoff

The most efficient design option to prevent the transport of spilled QACs in storm runoff is to prevent stormwater from washing through the disposal area. That is, prevent the waters from the other parts of the parking lot from flowing through the RV waste-transfer area. Concurrent with that, waste-waters that do spill in the RV transfer area should be contained and directed to the sanitary sewer. These flow changes could be accomplished using low berms and trenches in the vicinity of the RV waste-transfer station.

RV Waste-transfer station

A berm, similar to a low speed bump, would be placed on the up-gradient side of the disposal station. Inside that berm would be a V-trench drain to catch any water and direct it to the sanitary sewer. Figure 3 shows a CAD drawing oriented from upgradient to down-gradient, the direction of storm runoff flow. Storm runoff from the upper part of the parking lot would be deflected by the berm so that it wouldn't run through the waste-transfer station or get caught by v-trench. The berm does not need to encircle the entire station, but only

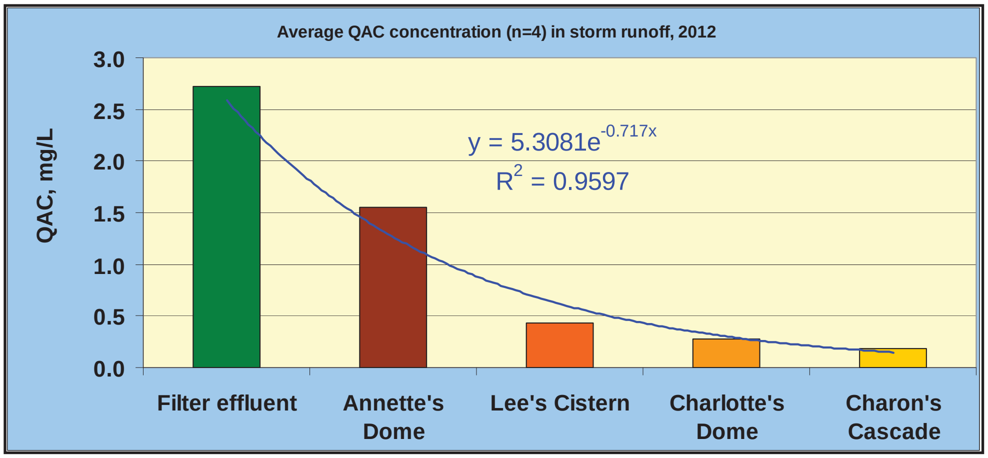

Figure 2: Average QAC concentration along the storm flow path from the Post Office parking lot into the cave system. [bars are average of four rain events in May - September of 2012]

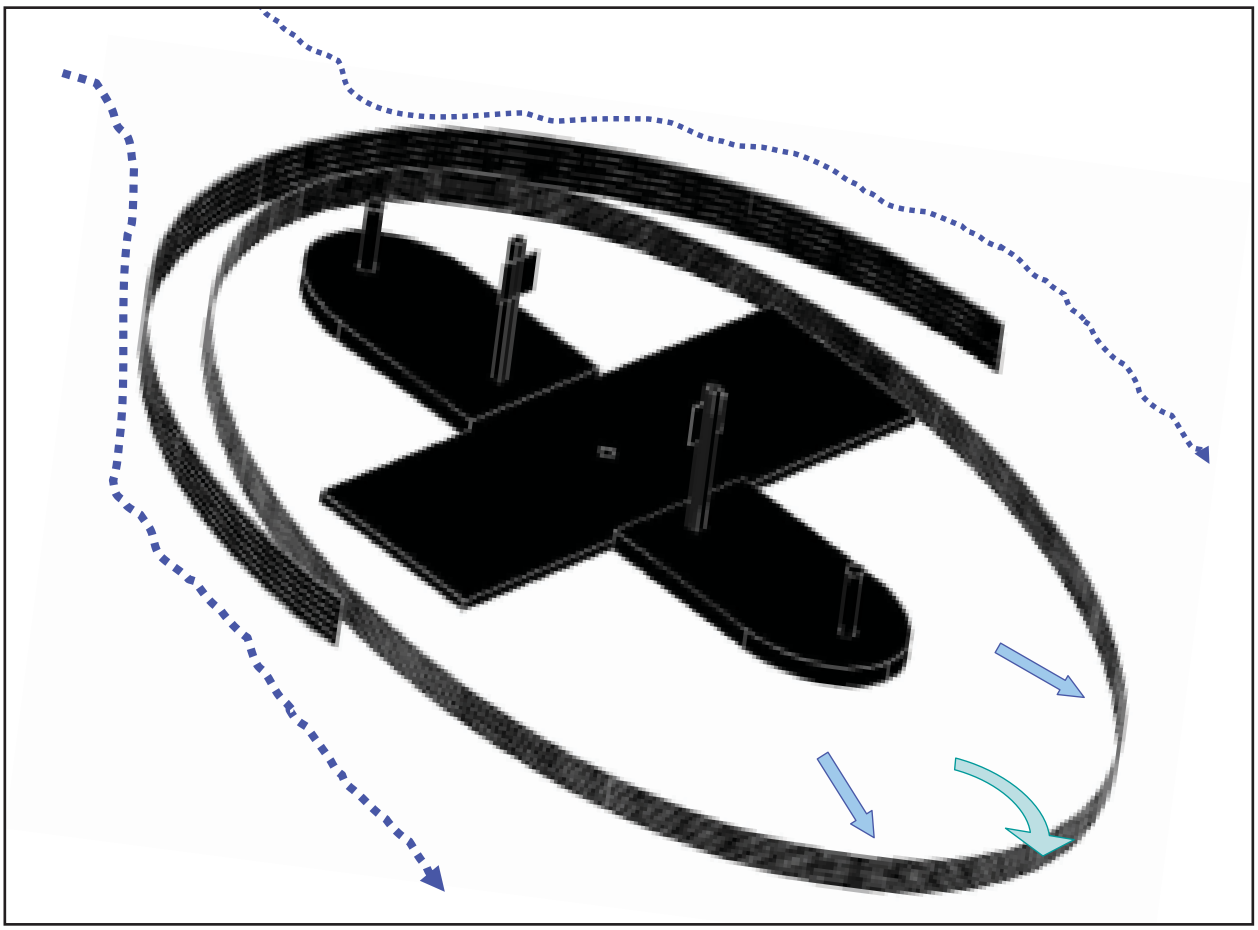

Figure 3: Drawing of the berm and trench system around the RV waste-transfer station to deflect and contain storm runoff. Dimensions of the waste-transfer station, berm and v-trench. Drain slope – moderate, <3%, Trench dimensions average is between 6 inches wide & at most 4 inches deep; Water diversion berm – Height- 2 inches with gentle slopes to avoid jarring bumps for RVs.

the up-gradient section. The small amount of storm water that falls inside the berm will be caught by the v-trench and sent to the sanitary sewer. The berm will minimize the amount of storm runoff that goes into the sanitary sewer. That water will be treated at the wastewater treatment plant since it would contain traces amounts of QAC and gray water from the RV water.

The v-trench would drain to the sanitary sewer. The drain pipe in the center of the waste-transfer station provides the closest connection. This union could be made through a shallow, subsurface pipe connection.

Summary

QACs residue at the RV disposal station are washing into the cave at alarming concentrations. The disposal station drain can be modified at low cost to prevent runoff. It would require a berm to divert runoff from the Post Office parking lot, and, a v-trench to capture any spillage near the dump station. That water captured inside the v-trench will be sent to the sanitary sewer for proper treatment.

Additional acknowledgements

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