AUBURN UNIVERSITY
Highway Research Center

Evaluation of Sediment Basin Performance using Large-Scale Testing Techniques

Tech Transfer Summary

This project evaluated the performance of standard and modified temporary sediment control basins through controlled, large-scale testing at the Auburn University - Stormwater Research Facility (AU-SRF). Modifications to the standard basin design included geotextile lining, upstream forebay, surface skimmer, porous flow baffles, and flocculant application. Performance was evaluated through measured sediment retention and turbidity reduction parameters.

Objectives

- Develop a large-scale testing procedure and apparatus that mimics the scale and hydrologic behavior of field-installed sediment basins in Iowa
- Understand the sediment capture and turbidity reduction of the Iowa DOT standard sediment basin design and the performance of potential improvements provided by structural and chemical basin treatments
- Develop practical and cost-effective design and construction recommendations for Iowa DOT sediment basin implementation

Most Feasible and Effective Installation (MFE-I) during sediment-laden flow introduction

Findings at a Glance

- The Most Feasible and Effective – Installation was determined to be the basin configuration including a geotextile liner, upstream forebay, and floating surface skimmer. This installation exhibited 96% sediment retention.
- Flocculant application further improved sediment retention to 98% and captured particles 51% finer than installations without flocculant. Minimal residual flocculant concentrations were detected downstream of basin.

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RESEARCH PROJECT TITLE
Evaluation of Sediment Basin Performance using Large-Scale Testing Techniques

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Background

The Iowa DOT is required to develop stormwater pollution prevention plans (SWPPPs) to minimize the risk of downstream pollution emanating from highway construction, as specified in the National Pollutant Discharge Elimination System General Permit No. 2. The Iowa DOT commonly employs temporary sediment control basins to detain sediment from stormwater runoff prior to offsite discharge. Sediment basins can be effective in capturing sediment if properly designed and implemented. The current Iowa DOT temporary sediment control basin standard specifies constructing an earthen dam across a conveyance channel to create an impoundment favorable for sedimentation. The basin is primarily dewatered through a perforated riser pipe and auxiliary spillway.

Problem Statement

Sediment-laden discharges have the potential for downstream consequences including negative impacts on aquatic habitats, reduced conveyance capacities, increased water treatment costs, and poor public perception. Sediment basins are often implemented to capture entrained sediment from stormwater; however, results from the 18-SPR1-001 erosion and sediment control field monitoring project indicated that installed and monitored temporary sediment control basins provided negligible turbidity and total suspended solids reduction when comparing inflow to discharge samples. Enhancements to the current design of sediment control basins could provide improved performance and reduce the sediment load discharged from Iowa DOT managed sites. In this project, large-scale testing techniques were employed at the AU-SRF to evaluate various sediment basin design components and configurations for enhanced sediment capture and water quality improvements.

About the AU-SRF

The AU-SRF is a 10-acre outdoor research laboratory aimed to improve and develop stormwater technologies and strategies. The facility is situated adjacent to the National Center for Asphalt Technology Pavement Test Track in Opelika, AL. Since its inception, the AU-SRF has aimed its mission to developing improved erosion and sediment control stormwater technologies and practices; advancing the body of knowledge through research and development, product evaluation, and training.

Materials and Methods

Flow and sediment introduction rates were modeled, calibrated, and introduced to the temporary sediment control basin at the AU-SRF to emulate field conditions experienced in Iowa.

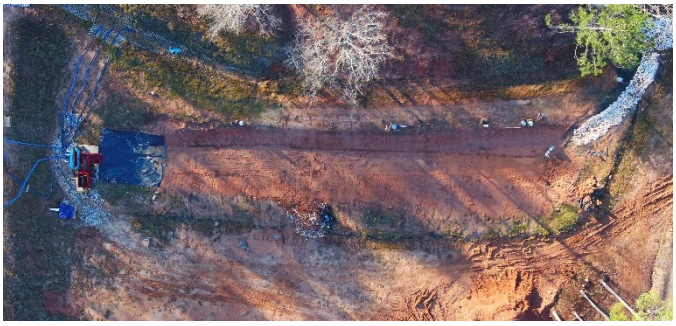
- A 200 ft long earthen channel and temporary sediment control basin was constructed at the AU-SRF following the Iowa DOT typical roadside channel (3.5H:1V and 3H:1V sides slopes, 10 ft. bottom) and sediment control basin standards (EC-601).
- The channel and basin resulted in a storage volume of 3,031 ft^3, large enough to treat a 0.84 acre drainage area, when following the USEPA minimum sizing criteria of 3,600 ft^3 per acre of contributing drainage area.
- A state-wide GIS study was conducted to determine average soil hydrologic conditions and design rainfall parameters.
- Iowa native soil was acquired from the U.S. 30 construction site in Tama County, IA was used throughout testing.
- Flow introduction consisted of a 30-min fill duration with a flow of 1.7 ft^3/s mixed with 62.7 lbs/minute of sediment introduction to mimic runoff and soil loss from a typical Iowa roadside construction site.
- Each sediment basin test sequence was subjected to a total of six fill cycles and dewatering periods to simulate a series of storm events.
- Water quality and quantity parameters were monitored throughout testing.
- The basin was dredged out after a series was completed for sediment quantification.
- Basin performance was evaluated for sediment retention, water quality, and quantity improvements.

Flow and sediment introduction apparatus

Basin Treatments and Results

Standard Configuration

The standard configuration evaluated the existing Iowa DOT Temporary Sediment Control Basin detail (EC-601), which consisted of an unlined basin with a perforated riser pipe for dewatering. Due to the design of the riser pipe, discharge only occurred during the first 12 hours of monitoring. On average, discharge turbidity was 44% higher than inflow turbidity, attributed to channel erosion contributing to the sediment load.



Standard basin configuration

Geotextile Liner

The first geotextile liner treatment was intended to stabilize the inflow channel, basin, and side slopes from eroding. Compared to the standard configuration, the geotextile liner treatment exhibited sediment retention of 76% and an average turbidity reduction of 64%.

Surface Skimmer

The surface skimmer treatment incorporated a floating dewatering device along with the geotextile lining. The skimmer decanted water from the top of the water column, presumably the least turbid water due to gravitational settling. This installation exhibited sediment retention of 88% and extended dewatering to a 48 hour period at a controlled flow rate.

Porous Coir Flow Baffles

The porous coir flow baffle treatment included the geotextile liner, perforated riser pipe, and coir baffles. The baffles were intended to reduce flow velocity and turbulence, and increase the effective flow width. This installation resulted in sediment retention of 84%.

Forebay

An upstream forebay was added to the geotextile lined channel with riser pipe. The forebay was created by a rock check dam wrapped in geotextile to enhance impoundment. The forebay was intended to capture rapidly settleable solids in an accessible location and increase available storage in the basin for polishing sediment-laden stormwater. This installation exhibited sediment retention of 89% and average turbidity reduction of 52%, capturing the majority of the sediment within the forebay.

MFE-I

The MFE-I consisted of a combination of treatments, including a geotextile liner, upstream forebay, and surface skimmer. Baffles were excluded from this installation due to the increased material, involved installation, and difficulty in navigating basin maintenance around the practice. The MFE-I installation exhibited sediment retention of 96%. Turbidity reduction was 25% within 1.5 hours of testing start, 50% within 8 hours, and 75% within 22 hours. Turbidity reduction remained between 75-80% for the remainder of dewatering.

MFE-I + Flocculant

The final configuration introduced flocculant in the inflow channel of the MFE-I. Flocculant is a chemical agent that binds fine particles to create coarser flocs, which settle out of suspension at a higher velocity, resulting in an increased sediment retention. Sediment-laden inflow was dosed with polyacrylamide flocculant blocks designed to dissolve in runoff. In total, 98% of introduced sediment was captured and the basin reached 80% turbidity reduction within 1 hr. Residual concentrations were monitored at discharge to understand chemical discharge from the basin. The average concentration at discharge was 6 mg/L, which poses little to no risk downstream due to low solubility of the flocculant.

Lined basin with skimmer

Lined basin with baffles

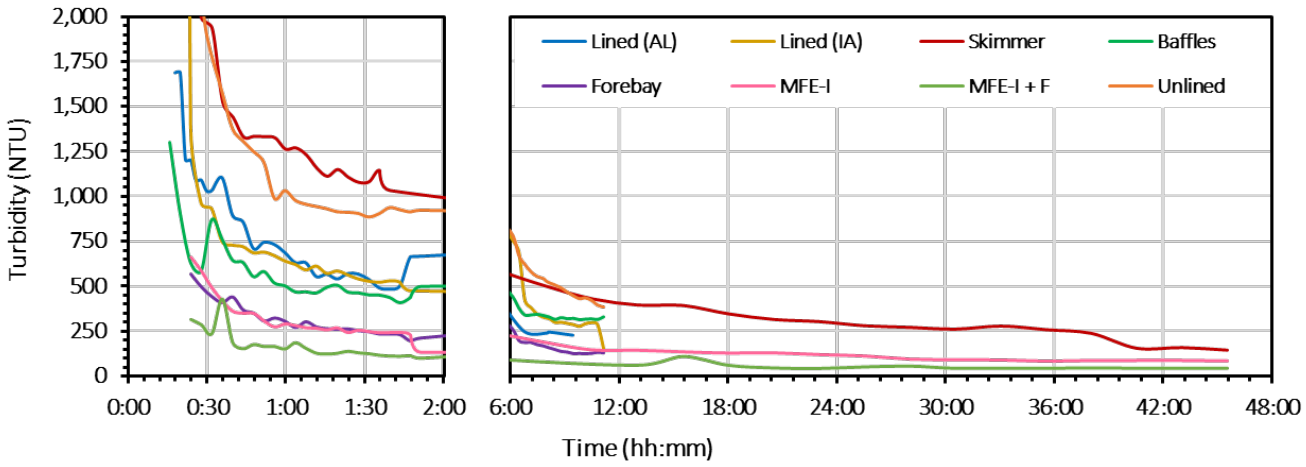
Lined basin with forebay

MFE-I

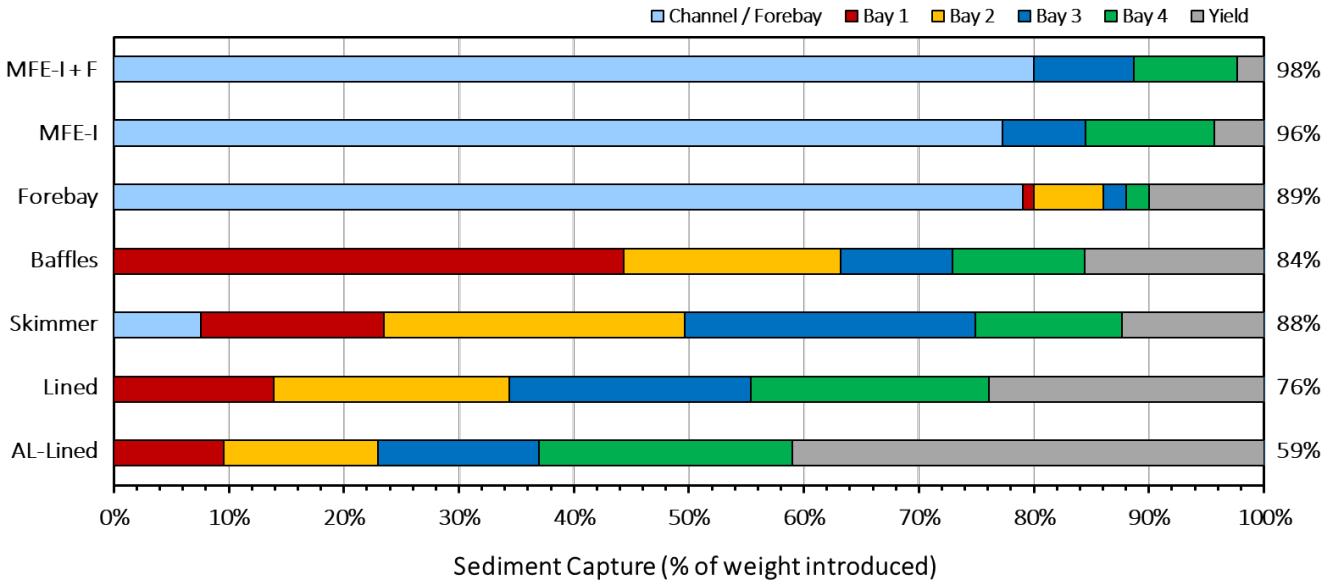
Flocculant blocks in inflow channel

Results

Discharge turbidity, a measure of relative water clarity leaving the basin, was plotted against time in the figure below. Turbidity samples were recorded for the two hours following the first fill period to examine the performance of the basin immediately following a storm event. Samples were also recorded for the 48 hours following the second fill to evaluate the basin during extended dewatering. Sediment retention was quantified in the channel / forebay area when applicable, and bays 1-4. The sediment yield, or sediment discharged from the basin, is shown in gray in the figure below.



Discharge turbidity for basin configurations



Sediment capture in basin

Recommendations & Implementation

The following recommendations should be considered based on research findings:

- Limit site disturbance and stabilize areas surrounding sediment basins;
- Direct inflow to a defined and stabilized conveyance channel;
- Adopt treatments included in the MFE-I as standard practice, with geotextile lining extending up to the ditch check practice upstream of the forebay;
- Construct auxiliary spillways on undisturbed ground where feasible to minimize embankment erosion potential;
- Apply flocculant on sites with fine-grained soils, or where less than 80% of suspended sediment is expected to settle;
- Provide designers, contractors, and inspectors with training for adopted basin techniques.

In addition to recommended design guidance, a spreadsheet-based tool was developed to aid in in-channel sediment basin implementation. The user can choose to input channel geometry, desired dewatering system and time, inflow hydrograph, site soil gradation, and expected water temperature in the basin environment. The tool outputs numerical tabulations and graphs related to basin stage, storage, discharge, particle settling, and suggested application of flocculant, and can be accessed at https://aub.ie/stormwatertools.