Elevated BioSwales for Water Quality and Habitat Enhancement

Project Location: Shepherd, Montana

Contaminated surface runoff from stormwater events is a major potential cause of water pollution in urban, residential and agricultural settings around the world. Elevated treatment swales (Elevated BioSwales™) containing vegetation are one promising method for treating stormwater and agricultural runoff.

In August 2008, three Elevated BioSwales were installed in irrigation ditches at the Shepherd Research Center located northeast of Shepherd, Montana. The Center is the international headquarters of Floating Island International, Inc., a research and development business focused on developing technologies for water quality improvement and habitat enhancement. The bioswales were durable, successfully grew and maintained vegetation, reduced turbidity and performed well during high-water events. A typical bioswale is depicted in Figure 1.

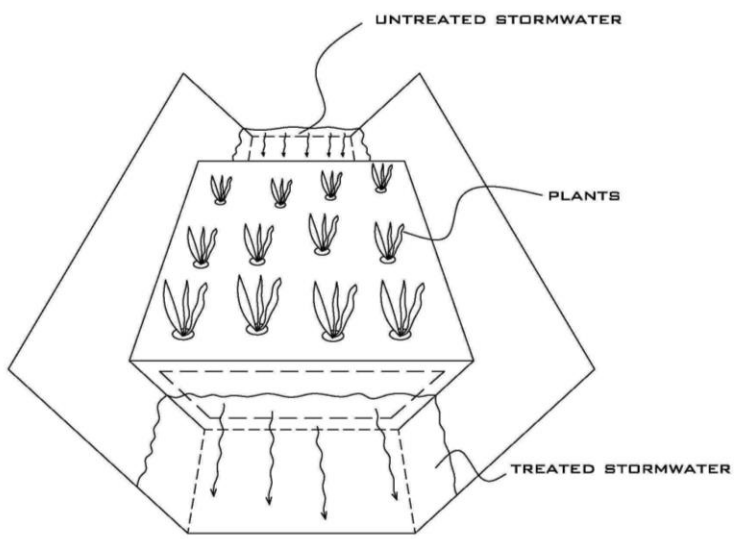

Figure 1. Elevated BioSwale installed in a channel for agricultural wastewater treatment

These Elevated BioSwales contain a recycled polymer-based nonwoven filter matrix that provides about 250 square feet of surface area per cubic foot of matrix. Numerous independent studies have confirmed that this matrix represents an effective substrate for biofilm development, and that in combination with circulation, it can be highly effective at transitioning agricultural-based nutrients and urban contaminants out of water and into local food webs. A Shepherd bioswale before and after installation is shown in Figures 2 and 3.

Figure 2. Inverted bioswale before installation

Figure 3. Installed bioswale

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Elevated BioSwales at Shepherd were designed to form-fit into irrigation ditches of irregular dimensions. They were monitored for several criteria:

- Plant success
- Durability and weathering
- Performance in flood or high-water events
- Turbidity and nutrient reduction
- Laboratory determination of hydraulic conductivity.

Plant Success

The Elevated BioSwales were overlaid with Kentucky bluegrass sod to provide immediate protection of the plastic matrix from potentially-degrading ultraviolet light, and were then sprinkled with a mix of native grass seed. Native plants (both from seeds and neighboring "volunteer" plants) quickly took over the bioswales. The bedding material in each bioswale's planting pockets included hydrophilic foam to hold and wick up water to the sod. Two elevated bioswales were installed in a shallow ditch (18" deep) with only periodic water flow, while the third bioswale was located in a deeper ditch (40" deep). Even the shallow ditch, with periodic flow and precipitation, provided enough water for native plants to survive and thrive in Montana's dry climate over two years. While hydrophilic-based bedding soil can lift water up to 16 inches, consistent water flow may be required in deeper ditches until plant roots are established.

Durability and Weathering

The bioswales were inspected weekly and required no maintenance. Although some matrix was exposed on the upstream side, it did not degrade significantly during the three-year study. The bioswales continue to be used as bridges by people and wildlife.

Performance in High-Water Events

Elevated BioSwales essentially serve as a "leaky dam" by reducing water velocity and mediating storm events. During high water flow, up to a six-inch difference in water level was noted between the upstream and downstream sides. Water was high enough at times to create soggy conditions at the top of the swale, with no detrimental effects. The system's ability to reduce water flow rate suggests that it can function as an erosion mediation tool.

Turbidity

Turbidity in the ditches preceding the Elevated BioSwales is variable. When turbidity is high, the bioswales substantially reduce it visually, although the effect has not yet been quantified. It is also anticipated that the efficacy for water quality improvement will be proportional to bioswale length, although data have not yet been collected to demonstrate this. The stormwater treatment process is illustrated in Figure 4.

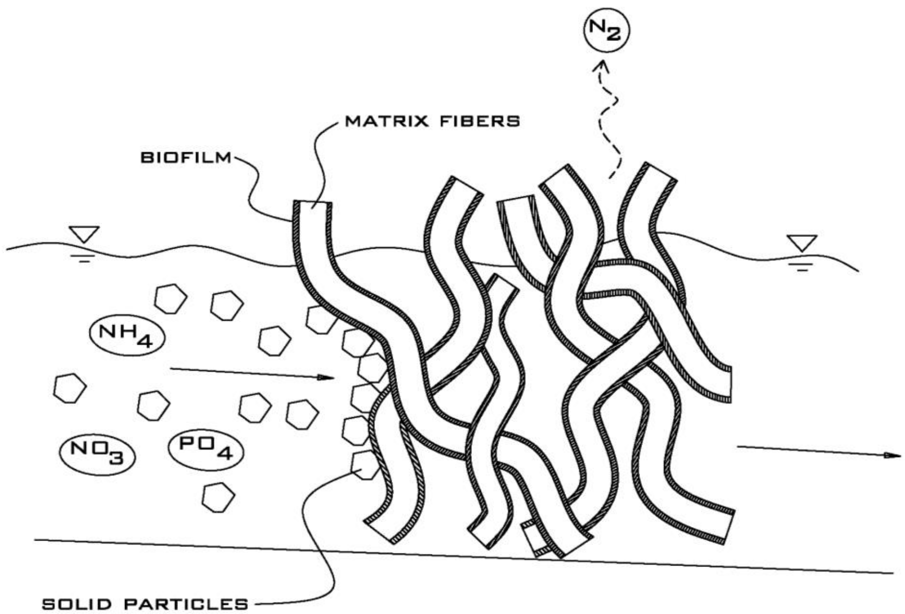

Figure 4. Magnified cross-sectional view of the Elevated BioSwale matrix, showing mechanical and biological stormwater treatment

Parameters such as nitrogen and phosphorus were not monitored but it is expected that they will be reduced in similar proportions. Nutrients are present primarily as dissolved constituents, so elevated bioswales will mitigate them in the same manner as floating islands—conversion into bacterial and plant biomass, along with biotransformation of ammonia and nitrate to nitrogen gas (Figure 4).

Hydraulic Conductivity

Controlled bench-scale tests were conducted in the Shepherd Research Laboratory using constant-head permeameters in order to determine hydraulic conductivity values for the Elevated BioSwale matrix. In a first series of tests, new matrix (without biofilm growth) was tested with clean water under constant flowrate conditions. In a second series of tests, matrix was subjected to a constant recirculation flow for a two-week period using water high in dissolved nutrients and native bacteria, which resulted in a rich growth of biofilm on the matrix fibers. Results of these tests indicated an average hydraulic conductivity of the new matrix of 0.042 ft/sec and an average conductivity of the biofilm-coated matrix of 0.007 ft/sec. These values can be used to estimate water backup and required channel cross-sectional area for different flow scenarios using Elevated BioSwales.

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