Bioretention Applications

Inglewood Demonstration Project, Largo, Maryland
Florida Aquarium, Tampa, Florida

Key Concepts:

- Retrofits
- Structural Controls
- Source Controls

LOW-IMPACT DEVELOPMENT CENTER

Project Benefits:

- Retrofit Opportunity
- Pollutant Removal
- Volume Reduction
- Cost-Effectiveness

Introduction

Two case studies demonstrate the potential to use integrated management plans (IMPs) in the design of new parking facilities and as retrofits for existing parking facilities. The Inglewood study in Largo, Maryland, compared the pollutant removal efficiency of a bioretention cell in a laboratory setting to that of a comparable facility constructed in a parking lot. The Florida Aquarium study in Tampa, Florida, included monitoring of several storm events for volume and water quality control.

Inglewood Project Area

The project area is an existing 5-acre outdoor parking area located in a highly urbanized office park adjacent to Interstate 95. Runoff from adjacent areas does not flow across the lot. The slope of the parking area is approximately 3 percent. Parking stalls are aligned at 90-degree angles, and there are approximately 30 cars in each row of an aisle. At the end of each aisle are planting areas surrounded by curbs and gutters. Curb drainage inlets have been placed in some of the islands to intercept and collect runoff as sheet flow, which is piped to a downstream regional stormwater management facility.

Inglewood Project Description

The Inglewood project consisted of a laboratory segment and a field segment. The laboratory segment involved construction of a planter box filled with a typical bioretention facility soil mixture (50 percent construction sand, 20 to 30 percent topsoil, and 20 to 30 percent compost). This facility is approximately half the size in volume of the Inglewood facility. The box was planted with representative plants and mulched. A synthetic stormwater mixture was applied and the pollutant removal efficiency, temperature, and runoff volume rate were measured. The pollutant mix included metals (copper, lead, and zinc), phosphorus, organic nitrogen, and nitrate.

A landscaped island measuring approximately 38 feet by 12 feet was chosen as the retrofit area. The island contains a curb inlet that drains into the municipal storm drain system. Almost the entire drainage area is impervious. A 4-foot slot was cut into the curb immediately before the inlet. The landscaped island was then excavated to a depth of 4 feet. An underdrain was installed and tied into the bottom of the existing inlet to completely drain the planting soil to avoid oversaturation. The underdrain was covered with 8 inches of 1- to 2-inch gravel and backfilled with typical bioretention soil mix. The backfill extended to a depth of about 12 inches below the top of the curb, which allows for a ponding depth of approximately 6 inches of water in the island

Figure 1. Bioretention landscaping at the Inglewood demonstration project site.

Table 1. Summary of bioretention pollutant removal results for the Inglewood demonstration project.

Pollutant	Input mean ± standard deviation	Output mean ± standard deviation	Output range	Output percent removal mean ± standard deviation
Cu dissolved (μg/L)	120 ± 27	63 ± 6.5	55–75	48 ± 12
Cu total (μg/L)	120 ± 27	69 ± 9.4	55–85	43 ± 11
Pb dissolved (μg/L)	54 ± 9.4	11 ± 6	6.7–25	79 ± 26
Pb total (μg/L)	54 ± 9.4	16 ± 7	6.7–26	70 ± 23
Zn dissolved (mg/L)	1.1 ± 0.021	0.24 ± 0.44	0.11–0.56	78 ± 29
Zn total (mg/L)	1.1 ± 0.021	0.39 ± 0.44	0.12–1.4	64 ± 42
Ca (mg/L)	44 ± 6.4	32 ± 6.1	24–41	27 ± 14
Cl^- (mg/L)	5.1 ± 0.48	162 ± 80	74–228	3,000[a]
Na (mg/L)	3.1	359 ± 170	68–497	11,000[a]
P (mg/L)	0.83	0.11 ± 0.017	0.10–0.13	87 ± 2
TKN (mg/L as N)	6.9 ± 0.81	2.3 ± 0.64	1.7–3.0	67 ± 9
NO_3^- (mg/L as N)	1.3 ± 0.05	1.1 ± 0.15	0.94–1.2	15 ± 12

[a]Shows percent production.

before a backwater is created at the curb opening. Subsequently the area was planted and covered with 3 inches of shredded hardwood mulch. Figure 1 shows the bioretention area after vegetation was established.

The stormwater mixture was applied to a 50-square-foot area in the field facility at a rate of 1.6 inches per hour for 6 hours. The removal rates for several pollutants are shown in Table 1. In addition to pollutant removal, the runoff temperature was lowered approximately 12 °C as the runoff was processed and filtered through the soil mixture. Most of the pollutant removal process occurred in the mulch layer.

A similar field investigation was conducted on an 8-year-old facility, and the metals removal rate was much higher (Davis et al., 1998). This effect might be attributed to slower flow rates through the soil, which has higher clay content, as well as greater pollutant uptake by vegetation.

Inglewood Project Summary and Benefits

This study showed the feasibility of retrofitting an existing parking facility and demonstrated the consistency of laboratory and field pollutant removal performance. The retrofit cost approximately $4,500 to construct and treats approximately one-half acre of impervious surface. The bioretention retrofit was a more cost-effective way to filter pollutants than many proprietary devices designed to treat the same volume of runoff. These proprietary devices could cost $15,000 to $20,000, would be more expensive to maintain, and would not significantly decrease runoff volume or temperature. Also, bioretention areas offer the ancillary benefit of aesthetic enhancement. It is interesting to note that a drought occurred after the installation of the plants, and although many of the other plants in the parking lot died or experienced severe drought stress, the plants in the bioretention facility survived because of the retained water supply.

Florida Aquarium Project Area

The Florida Aquarium site is an 11.5-acre, asphalt and concrete parking area that serves approximately 700,000 visitors per year. Runoff was controlled using the following IMPs:

- End-of-island bioretention cells
- Bioretention swales located around the parking perimeter
- Permeable paving
- Bioretention strips between parking stalls
- A small pond to supplement storage and pollutant removal

Figure 2 is an illustration of the site that details the type and location of runoff controls.

Florida Aquarium Project Description

A total of 30 storm events were monitored for one year at the Florida Aquarium site during 1998-1999. The Southwest Florida Water Management

District measured rainfall and flow from eight of the subcatchments in the parking area and collected water quality samples on a flow-weighted basis. Comparisons between pavement areas controlled by IMPs and uncontrolled asphalt areas were made for peak runoff rate, runoff volume, runoff coefficients, and water quality. Sediment cores from swales also were collected and analyzed.

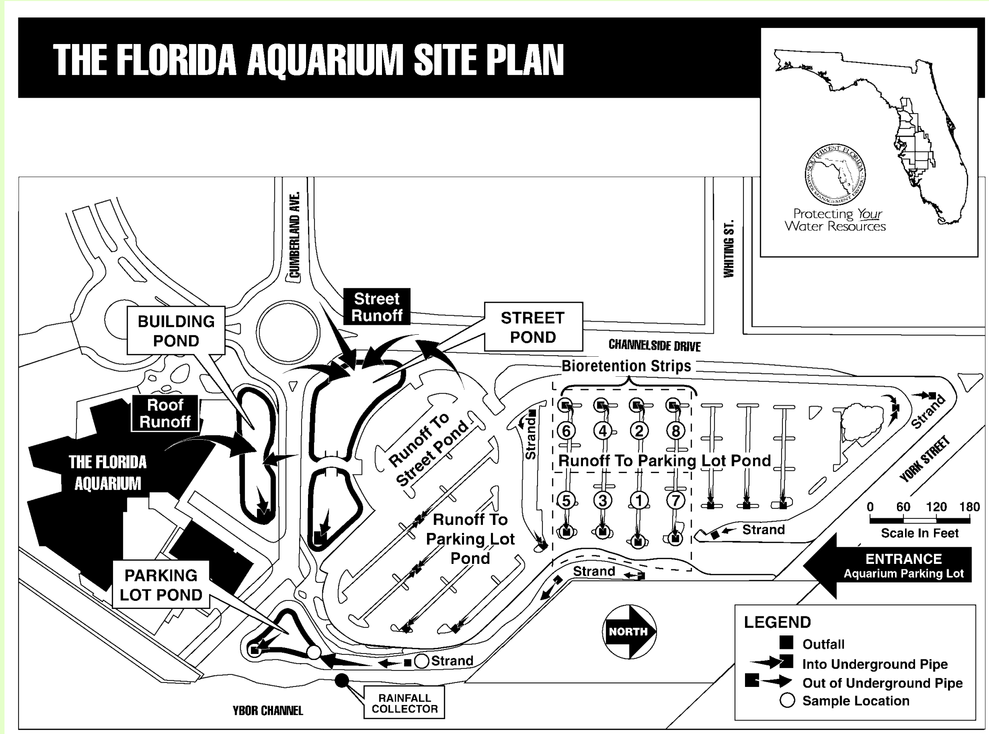

Figure 2. Layout of the Florida Aquarium site with IMPs. The eight basins outlined with dotted lines were evaluated in this part of the study.

Florida Aquarium Project Summary and Benefits

The parking areas controlled by IMPs showed a significant reduction in runoff volume and peak runoff rate. Table 2 shows pollutant load reductions for three pavement types; reduction is compared to pollutant loads in runoff from a basin without a swale. Much of the pollutant reduction is attributed to the reduced runoff in basins with swales. Because the swales are only the first element in the treatment train, even better removal efficiencies should be seen when data are analyzed for the entire system.

Table 2. Load efficiency of pollutants expressed as percent reduction for three types of pavement at the Florida Aquarium site.

Constituents	Percent pollutant reduction[a]		
	Asphalt w/swale	Cement w/swale	Porous w/swale
Ammonia	45	73	85
Nitrate	44	41	66
Total Nitrogen	9	16	42
Orthophosphorus	-180	-180	-74
Total Phosphorus	-94	-62	3
Suspended Solids	46	78	91
Copper	23	72	81
Iron	52	84	92
Lead	59	78	85
Manganese	40	68	92
Zinc	46	62	75

[a]The basins with swales were compared to a basin without a swale to determine the amount of reduction in pollutant loads possible using these small alterations. Notice that the efficiencies for phosphorus are negative, indicating an increase in phosphorus load in the basins with a swale.

References

Davis, A., M. Shokouhian, H. Sharma, and C. Minami, 1998. *Optimization of Bioretention Design for Water Quality and Hydrologic Characteristics*. Report 01-04-31032. Final report to Prince George's County, Maryland.

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