Redesigning a "Big Box" Store Parking Lot
With a Bioretention Stormwater Control System

The parking lot that was installed is shown in the picture below. The runoff from both the parking lot and the building roof flows into a large pond system that lies just to the right of this view, occupying the entire length of the parking lot, and extending from the parking lot to the street right-of-way, a width of about 165 feet. The distance from the curb along the building front to the curb along the right side of this photo is about 350 feet.

This document reviews how a stormwater management system based on distributed bioretention beds could have been implemented within these limits, providing benefits beyond simply addressing the water quality impacts of the development.

Current parking lot has 11 "bays" of parking with 23 spaces in each row

➔ Total number of parking spaces = 11 x 2 x 23 = 506 spaces

Must retain this amount of parking

Width of a dual parking bay – parking line (18')/alley (24')/parking line (18') = 60'

➔ Pavement breadth = 11 x 60 = 660'

There are 3 existing landscaped medians at 13' wide each ~40'

➔ Total dimension from one edge of existing parking lot pavement to the other is ~700'

Newly reconfigured parking area must fit within this dimension

Reconfigure parking lot with 10' wide swale—doing double duty as a landscaped strip—between each parking bay, flowing into bioretention bed in each parking line

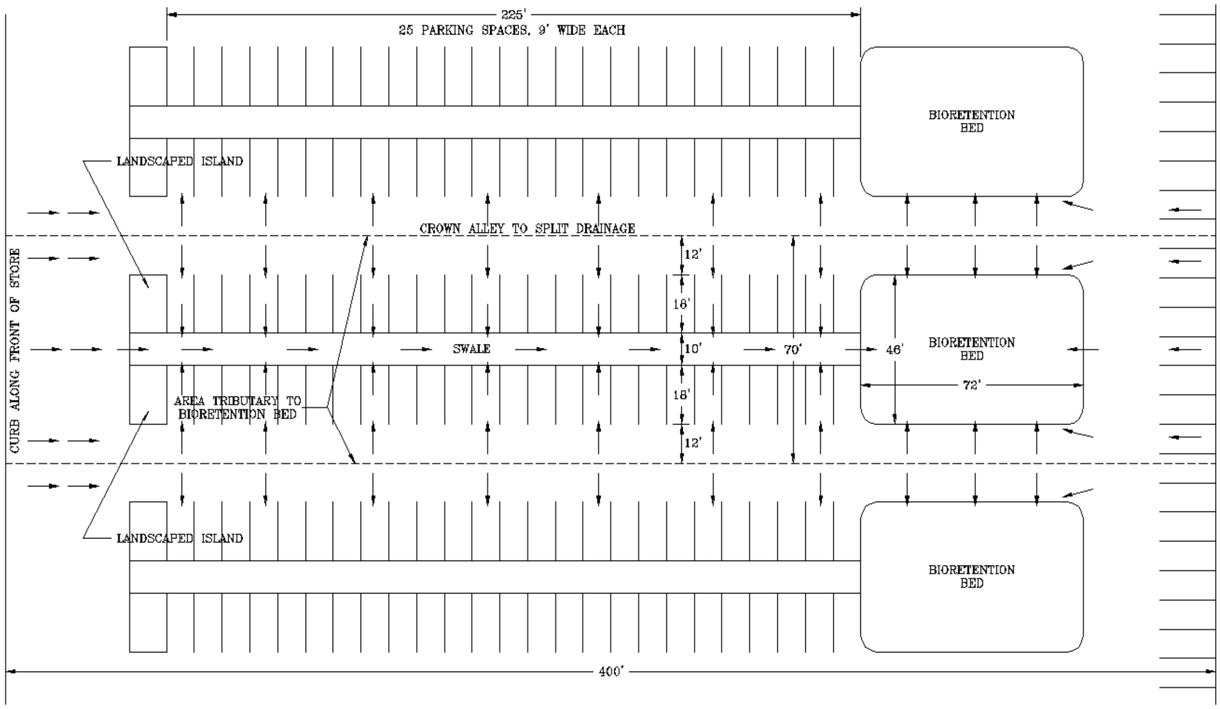
With a 10' wide swale added, each dual parking bay is 60 + 10 = 70' wide – see figure below

With this configuration, there can be 700/70 = 10 bays

➔ Lose 1 bay with 23 parking spaces on each side

➔ 46 spaces lost, to be made up by more spaces in each bay

As shown in the figure below, each of the 10 bays would have 25 spaces on each side ➔ 50 parking spaces/bay x 10 bays = 500 parking spaces – call it OK



The reconfigured parking lot, a part of which is illustrated above, measures 400’ from the building curb to the outer edge of the parking lot.

The available distance from the parking lot to the street is reduced to 165 – (400 – 350) = 115’
This provides sufficient area for any additional detention, beyond that provided in the bioretention bed itself – see analysis below.

Area tributary to each bioretention bed with this configuration
= 70 x 400 = 28,000 sq. ft. = 0.643 ac.
Pervious (non-pavement) areas:
Swale – 10’ x 237’ = 2,370 sq. ft.
Landscaped islands – 2 x 12’ x 18’ = 432 sq. ft.
Bioretention bed – 46’ x 72’ = 3,312 sq. ft.
➔ Total pervious area tributary to biorention bed = 2370+432+3312 = 6,114 sq. ft.
➔ Impervious area (pavement) tributary to each bioretention bed
= 28,000 – 6,114 = 21,886 sq. ft.
➔ Impervious cover portion = 21,886/28,000 = 78%

Water Quality Volume (per City of Austin rules) to be captured by bioretention bed
Total tributary area = 28,000 sq. ft.
Impervious tributary area = 21,886 sq. ft.
Water quality capture depth = 0.5 + (21886/28000 – 0.2) = 1.08 inches
WQV = 28,000 x 1.08/12 = 2,524 cu. ft.

Size bioretention beds using Prince George County sizing chart

CN of drainage area
21,886 sq. ft. at CN = 98 (concrete pavement)

6,114 sq. ft. at CN = 74 (grassed Group C soil)
Composite CN = (21,886 x 98 + 6,114 x 74)/28,000 = 93

From sizing chart, with CN = 93, required bed size is ~9% of drainage area
➔ 28,000 x 0.09 = 2,520 sq. ft.

Available width for bioretention bed = swale width + parking stall depths
= 10' (stall width) + 18' (stall depth) + 18' (stall depth) = 46 feet

Presuming a width of 40' is available for "active" bed area (within this 46-foot parking bay width)
➔ Length along parking line required = 2520/40 = 63'
Size overall "island" containing bed at 72' long
Active bioretention bed area = 40' x 65' = 2,600 sq. ft.

Water retention potential

Assume bioretention bed soil matrix is 2.5' deep
➔ Soil matrix volume = 2600 x 2.5 = 6,500 cu. ft.

Presume soil moisture capacity is 0.1 feet/foot of soil depth (sandy soil – so is probably a low estimate for the soil medium specified for bioretention beds, making this a conservative analysis)
➔ 0.1 cu. ft. of water can be held in each cu. ft. of soil matrix
Presume that soil moisture is midway between field capacity and wilting point at time of storm – this is typical of AMC II ("average") conditions
➔ Available soil moisture capacity = 0.05 cu. ft./cu. ft. of soil matrix
➔ Water "adsorbed" before water starts draining from bed = 0.05 x 6500 = 325 cu. ft.

Spread this over the drainage area to determine volume of runoff that can be fully stored within bed
➔ 325 cu. ft./28,000 sq. ft. = 0.0116 ft = 0.139 inches

From rainfall-runoff calculator, with CN = 93 at AMC II (which would roughly correspond to the presumed soil moisture level), this much runoff accrues from a rainfall depth of ~0.55 inches.

This is an approximation of the maximum depth storm event that can be fully retained within the bioretention bed when the storm occurs with soil moisture at AMC II. From an analysis of the frequency of daily rainfall depths in the 8-year period 1987-94 in Austin, over 3/4 of the rainfall events were less than 0.55 inches.

From rainfall-runoff calculator, it is seen that the CN of a site that does not start producing runoff until an "initial abstraction" of 0.55 inches of rain has fallen is 78. This implies that the "effective CN" of the site has been "restored" to 78 – not too dissimilar from the CN of the "native" site.

This shows that the bioretention bed replaces much of the initial abstraction that was lost in the process of transforming the site from the predeveloped state to the parking lot. This strategy RETAINS a majority of the storms, rather than draining, treating and releasing the increased volume of runoff, thus maintaining the hydrologic integrity of the site better than the large-scale end-of-pipe strategy.

The way the overall system is arranged, the vast expanse of pavement is effectively transformed into small segments of "disconnected" imperviousness, since each segment drains to an independent bioretention bed. This enhances the overall function of the system and minimizes the vulnerability of the system by routing small flows through many bioretention beds rather than all the flow through one large pond.

Total water capacity of the bioretention bed:

According to COA rules, it can be presumed that the “effective porosity” of the bed media is 30%. This is presumed to be the porosity between field capacity and full saturation.
➔ Storage volume in filter bed matrix = 6500 x 0.3 = 1950 cu. ft.
Storage over surface (6” ponding depth) = 2600 x 0.5 = 1300 cu. ft.
Total storage capacity = 1950 + 1300 = 3,250 cu. ft.
The “surplus” storage in excess of the Water Quality Volume = 3250 – 2524 = 726 cu. ft.

Runoff depth over drainage area accommodated by available storage:

3250/28000 = 0.116’ = 1.39”
This is (1.39/1.08) 129% of required capture volume

From an analysis of the frequency of daily rainfall depths in the 8-year period 1987-94, 93% of the rainfall events were less than 1.4 inches

➔ Only the largest 7% of storms would not have all the runoff treated before release

Summary

This bioretention design, illustrated in the figure below, still fits very well into the existing site design, and it will minimize the need for additional detention to control the peak runoff rate, as it fully detains the vast majority of all daily rainfalls. As noted, there remains a 115’ wide strip between the parking lot and the street in which any required detention pond could be placed.

By planting trees along the edges of the swales, much of the pavement would eventually be shaded, creating a “nicer” environment for shoppers and reducing the heat island effect. The trees would intercept some rainfall, effectively increasing the initial abstraction even more.

It remains to account for the runoff from the building roof. This could be addressed by rainwater catchment and sequestration – either to be used as a supplemental water supply or just as a detention strategy – or with a green roof, or with foundation planters – a variant of the bioretention bed explicitly designed to capture roof runoff.