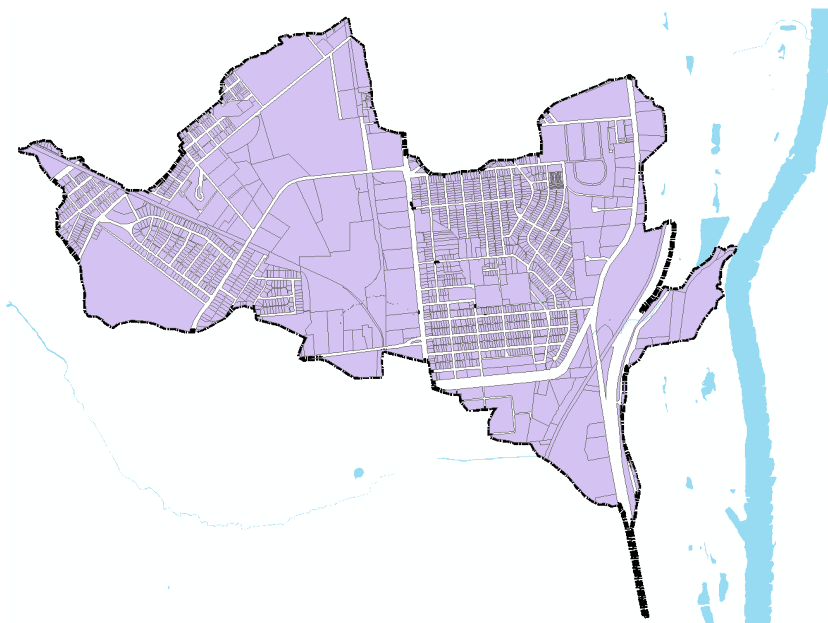
Strategic Water Action Team (S.W.A.T.)

Using GIS Analysis to Find Opportunities for Stormwater Retrofit Technologies in the Bellemeade Watershed of Richmond, Virginia



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Prepared for Michelle Virts, City of Richmond

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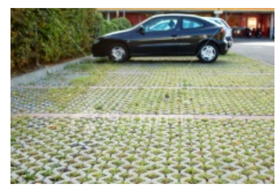
Introduction to Watershed

Bellemeade Watershed is in Richmond and has large amounts of older, industrial buildings and post-1940s residential buildings. Most stormwater pollution comes from soil erosion from the neighborhoods. The Green Infrastructure Center tapped Bellemeade as a pilot site for stormwater management practices. With anticipated redevelopment from the opening of the Port of Richmond, improving stormwater management techniques and greening the area will bring business and commerce to the area (Geiger, 2012).

The Strategic Water Action Team uses GIS analysis to identify and locate potential areas for stormwater retrofit. We then run calculations for water savings and cost of retrofitting. Our proposal, which combines permeable pavement, green roof, reforestation, cistern use, and Filterra® boxes can reduce runoff during a 2-year, 30-minute storm by 300,000 gallons. This runoff reduction is the same as turning off 700 water hoses or half of an Olympic-size swimming pool.

Technologies

Permeable Pavement



Permeable pavement is a great way to infiltrate more water in heavily urbanized areas where open space is limited. Parking lots and sidewalks are ideal locations to be converted because they generally have no or limited heavy vehicle traffic. Also, previous land use must be analyzed to determine if the area has been contaminated. If contamination has occurred, the lot or paved area should not be converted to a permeable surface.

The pavement works by allowing water to seep through pores in the concrete during rain events. About every six months, the pavement should be vacuumed in order to keep the pores clear.

Green Roofs

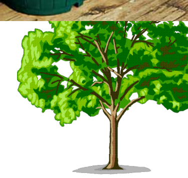
Green roofs are permeable roof systems designed mainly to limit runoff, but have other advantages effects as well. These include reduction in the urban heat island effect, more efficient energy use for heating and cooling, and are generally aesthetically pleasing. There are various types of green roofs, ranging from simple turf roofing to rooftop gardens and parks. For the purpose greening large areas atop warehouses, simple green roofing will be most efficient. Limitations on green roofs stem from the load buildings can withstand, as green roofs are relatively heavy, and also the pitch of the roof, as steeper slopes are not very effective at retaining water. Generally, buildings built pre 1950 have concrete roofs and can withstand the added weight.

Vegetation and engineered soils placed on top of roofs captures and holds water from rain events, and the plants soak up the water and reintroduce it to the hydrologic cycle. This method not only significantly reduces runoff, but also works well to filter out pollutants carried in rainwater.

Cisterns

Cisterns, also known as rain barrels, are easy-to-use storage devices for catching rain from roofs. The water can later be stored and used for landscaping, which is one of the largest usages of water in residential neighborhoods.

Reforestation



Increasing canopy cover through reforestation is a great way to reduce the nitrogen and phosphorous load that comes from residential and commercialized areas such as the Bellemeade watershed. Reforestation is done by simply planting more trees and the roots act to absorb water and reduce soil erosion.

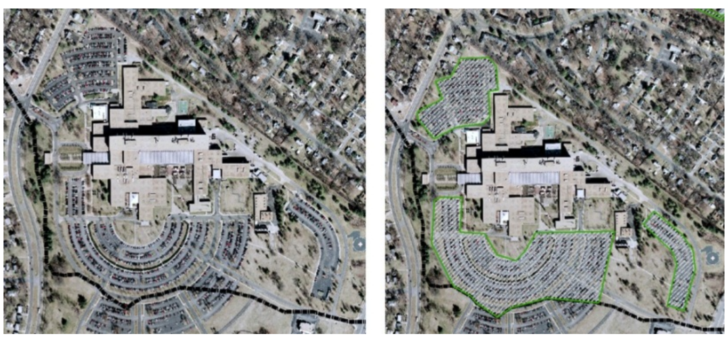
<u>Filterra® Boxes</u>

Filterra® boxes are specially designed to be placed in existing storm inlets. They are boxes placed inside a storm inlet with plant and soil material that filter the water before releasing it into the storm drain. The least expensive boxes run at $9,000, however they are effective and relatively easy to install.

Where to Apply

<u>Semipermeable Pavement</u>

Semipermeable pavement should be used to replace impervious lots around the Bellemeade watershed, some of which are highlighted in the map on the right. Below is an example of a large parking lot for light-vehicle use that can be retrofitted for permeable paving.



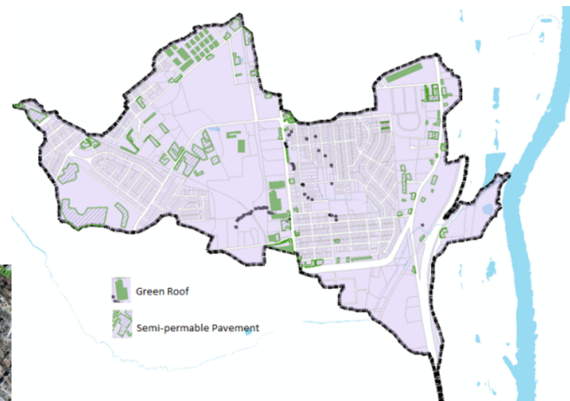


Figure 1: Potential Sites for Permeable Parking Lots and Green Roofs

Semipermeable paving is ideal because they will have a large impact on the overall infiltration rate of the watershed. Smaller lots and driveways should also be considered, but are out of the scope of this S.W.A.T. analysis. Seventy-six acres of impervious parking layer have been highlighted. To convert all of the area is not feasible, however, due to some areas receiving heavy vehicle traffic, and others being polluted.

Assuming half the area is convertible, and a 1.35-inch, 2-year, 30-minute storm, runoff can be reduced by 420,000 gallons, which is the equivalent of about 28 NHL ice hockey rinks (Hershfield, 1963 & Russel-Ausley, 2000). This runoff reduction was found using a change in the infiltration constant of impermeable pavement, 0.9, and semipermeable pavement, roughly 0.6, and multiplying by the area of parking lot changed and the depth of rainfall (Appendix A).

The cost of implementing semipermeable pavement is slightly higher than conventional methods. For this estimation, semipermeable pavement is assumed to cost roughly $4.00 per sqft. This comes to $6.21 million dollars. Maintenance should also be considered, which at $0.0063/sqft/yr would come to $10,450.

<u>Green Roofs</u>

The green roof projection was done in a very similar way as the semipermeable pavement. Shown below is a highlighted map of buildings larger than .5 acres and built prior to 1950.

Potential green roof sites were chosen based on size and potential impact, as well as ability to support the weight of green roofs structurally. These limitations place more emphasis on warehouses and office buildings as green roof candidates within the watershed. As the port of Richmond increases in size, more of the abandoned warehouses will become occupied and renovated. These renovations make them ideal sites for suggested green roofing.

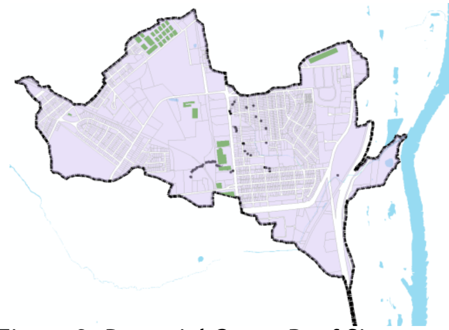


Figure 3: Potential Green Roof Sites

Of the 32.1 acres of potential roof area, if only half were converted, almost 175,000 gallons of runoff could be reduced in a 2 year, 30 minute storm. This calculation was made assuming a change in infiltration constant from 0.9 for impervious coverage to 0.6 for green roofs.

Green roofs are more expensive than traditional roofing, and are just an added cost when renovating a building. However, there are paybacks for installing green roofs, from added energy savings to government tax breaks. For green roofing, a higher end estimate of $30/sqft was used. This comes to $21 million for implementation, and $161,000/sqft/yr maintenance at $0.23/sqft/yr (Live Green Lancaster, 2012).

<u>Cisterns</u>

Cisterns can be used at nearly every house in the neighborhoods. Assuming that only 250 of 5,000 residents utilize cisterns, Bellemeade can reduce runoff by over 12,000 gallons at any given time.

Classes and materials for cisterns are already available for the cost of $65 per cistern. At this cost with 250 residents, the cost for the retrofit will be $16,250. (Clean Virginia Waterways, 2012)

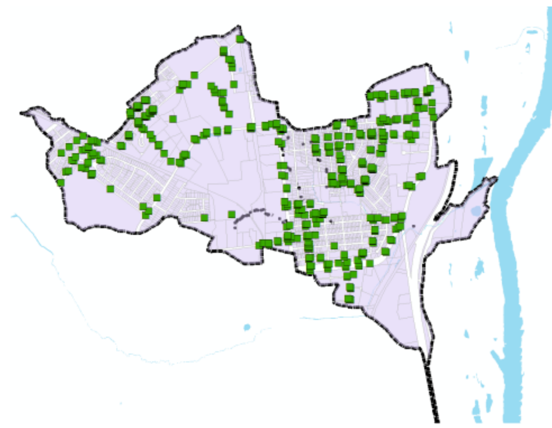
<u>Reforestation</u>

Large areas of land or existing green space are ideal for reforestation. For example, Maury Cemetery is a large parcel of land that is mostly grass cover. Planting trees would beautify the cemetery as well as provide additional canopy and reduce stormwater runoff.

According to Inforest data and i-Tree calculations (Appendix A), the watershed has 11.7% canopy cover. Increasing canopy cover by 20% can reduce nitrogen and phosphorous by 100 and 15 lbs/year, respectively. The cost per tree is usually around $50 and is small compared to the lifespan of an urban tree. Volunteers can be used for planting and it can be a community or learning activity.

Filterra® Boxes

Filterra® boxes can be placed in any existing storm inlet. The storm inlets in the Bellemeade watershed are mostly built in the early 1900s and are in dilapidated condition. This provides ample reason to retrofit the storm inlets and during the retrofit, it is convenient to turn them into Filterra® box storm drains. The image to the right shows the existing 427 storm inlets. Assuming that only 30% of inlets are retrofitted, the boxes can filter the runoff from over 25 acres of land.



The cost for the smallest 4x4 foot box is $9,000 for materials and installation. Installing 128 boxes would cost $1.1 million at a rate of $45,000 per acre treated. This is a large investment but is effective, has a long lifetime, and requires minimal maintenance ($100 a year) by the city.

Conclusion

There are many significant opportunities for reducing run-off and improving stormwater management in the Bellemeade watershed. These improvements come at a time when the watershed is undergoing redevelopment with the anticipated opening of the Port of Richmond. The retrofits will help revitalize the area and make Bellemeade a model, demonstration area for stormwater management techniques.

Sources

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Appendix A: Sample Calculations

Resourfacing												
	ft^2	acres	Volume On surface	volume reduction (ft^3)	Vreduction (gal)	half implementation	42 gal/barrel	Hockey Rinks	cost (ft^2)	maint	total cost	total maint
Roofs	1400000	32.1396	157500	47250	353430	176,715.00	3681.563	11.781	30	0.23	$ 21,000,000.00	$ 161,000.00
Parking lots	3310560	76	372438	111731.4	835750.872	417,875.44	8705.738	27.85836	4	0.00631	$ 6,621,120.00	$ 10,450.00
Change in C	0.3											
I 2 year 30 minute storm	1.35	0.1125										
Totals					1189180.87	594,590.44	12387.3	39.63936				

Peak Flow Calcs						1 gal	163.799	gal
Total Drainage Area	65993400		Ft^2/acre	43560	Garden hoses	4.333333333	709.7957	
acres	1515							
Change C	0.021414							
Q=KCiA	21.89826	ft^3	163.799	gal				

Cisterns					
Residents	usage	gal storage	area for 1 inch storm	cost	total cost
5000	250	12500	22057.3	$ 65.00	$ 16,250.00

Inforest and i-Tree Canopy Analysis