Concept Development

Conceptually, cities can be viewed as living systems that rely on sustenance much as other living organisms do. Plants require a healthy root system for water and nutrient uptake, stabilization, and growth just as cities require ecological, economical, and social connections to continue to function. The roots of plants are also capable of generating new plants. But plant roots will fail to grow where there are issues such as compaction, heavy pollutants, or physical barriers. In cities, existing programs may fail to generate new development if there are surrounding issues to halt the growth of their "roots." Through responsible design, these barriers can be reduced or removed, and allow old roots to grow new shoots within the city.

Tap Root: The first root formed from the seed. It breaks through even dense soil, allowing new roots to form.

Lateral Roots: Roots that extend from the tap root horizontally and stabilize the tree.

Root hairs: Only new roots are capable of forming root hairs, which are reasonable for gathering water from the soil.

Root Cap:
Protective cover of sensitive dividing zone of new cells
New programs and designs require similar protection as they develop

Cell Division:
Meristematic tissue that rapidly divides and is responsible for root growth
New designs grow rapidly once installed and can encourage more new growth

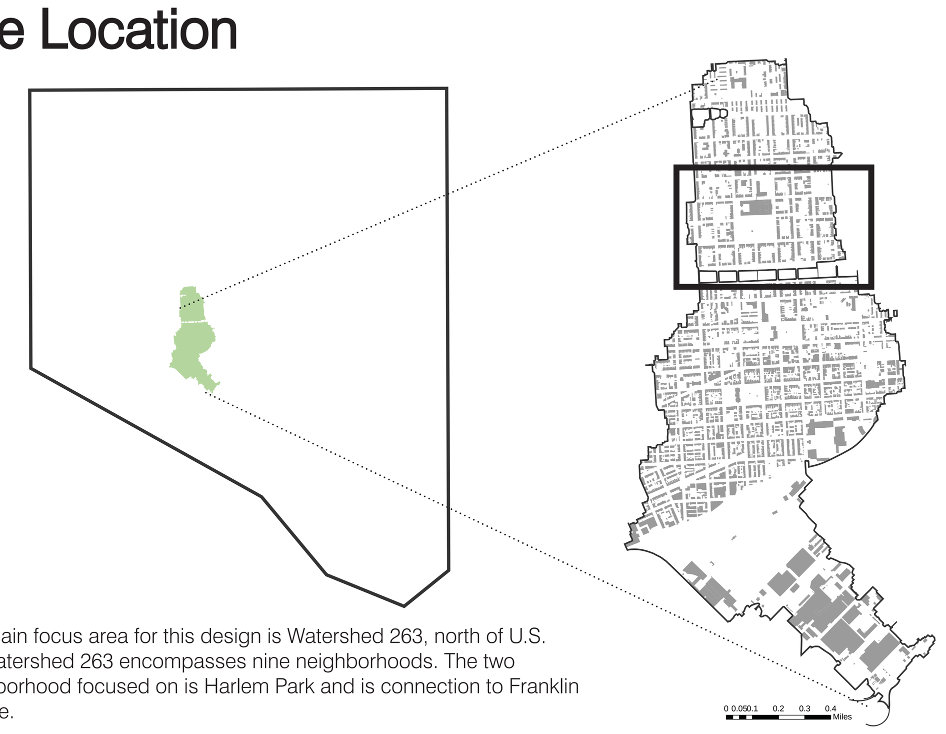
Cell Elongation:
No new cells are formed in this section of the root, rather root growth is generated through the elongation of existing cells
Once established, design influence begins to spread further throughout the city

Cell Differentiation:
Root hairs (which allow roots to absorb water and nutrients) are only formed in differentiation zones
Benefits of established designs may be capable of crossing disciplinary and socioeconomic barriers through diversification

This natural system of roots inspired and drove the phasing process of developing a stormwater management design. Immediate large scale implementation of a design is not only impractical and improbably, it is also likely to fail as it may be lacking the "nourishment" it needs. Like roots, new development thrives and grows best in areas with lower resistance levels. The first tap root of a seed can break through even tough obstacle, creating a beneficial environment for further supporting roots.

Schools offer opportunities for stormwater education, and have been actively working with organizations within Baltimore City to improve the permeability and livability of their properties. This offers a key area of lesser resistance to a new design. From here, over time, the artful, educational, and sustainable stormwater design can expand along opportune corridors throughout the watershed.

Site Location



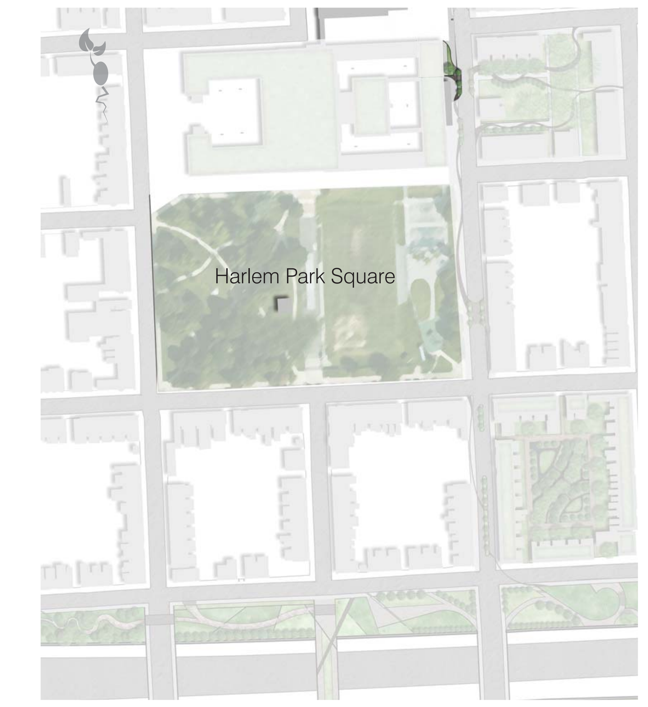
The main focus area for this design is Watershed 263, north of U.S. 40. Watershed 263 encompasses nine neighborhoods. The two neighborhood focused on is Harlem Park and is connection to Franklin Square.

Masterplan of Integrated Stormwater Development

Phasing Process: Development of New Shoots

Phase I

0 - 5 Years



- Initial stormwater garden implemented
- Artful piping pulls runoff from part of roof
- Collects water from roof and sidewalk
- Offers educational opportunities
- Reduced impermeable surface

Phase II

5 - 10 Years

- Expansion of first stormwater garden along street
- Curb extensions gather water from street
- Slows traffic at heavy pedestrian intersection
- Artful permeable paving draws attention to connection and movement of water
- Addition of partial green roof

Phase III

10 - 20 Years

- Further spread of street biorentention
- Each garden adapts to topography of its street
- Artful permeable paving visually connects
- Expansion of school's green roof

Phase IV

20 - 25 Years

- Development of stormwater gardens into neighboring inner block park
- Replacement of aging impermeable sidewalks with permeable paving
- Artful permeable paving continues to visually connect spaces
- Offers improved walking conditions for local students
- Privately maintained gardens encouraged
- Improved pedestrian bridge across I-40

Phase V

25 - 30 Years

- Beginning development of grassy strip near I-40 to reduce amount of stormwater entering the city's gray infrastructure systems
- Lowest elevation section of site primary focus
- Offers passive recreation for residents
- Potential to further connect separated neighborhoods
- Opportunities for varied phytoremediation research plots based on weirs for the BES

Phase VI

30 + Years

- Artful green infrastructure development spreads to other inner block parks
- Higher rates of redevelopment near artful green spaces
- Increase in local revenue provides opportunities for more advanced green infrastructure development
- Entire length of I-40 managing stormwater and providing unique spaces for residents
- Spread of design ultimately can spread across I-40 south to other parks in Franklin Neighborhood

For all Phase Maps: 100 200 400 N

Augusta Fells Savage Institute of Visual Arts Rain Garden

This rendering shows Phase II in its completion: the artful stormwater garden that gathers runoff from the roof through artful piping, multiple curb expansion stormwater gardens that capture runoff from North Calhoun St., and artful permeable pavement. Maintenance of the artful stormwater garden can be accomplished by school staff and if willing the students, too. The maintenance of the curb extension stormwater gardens will be the city's responsibility.

Rainfall + Stormwater in Baltimore City

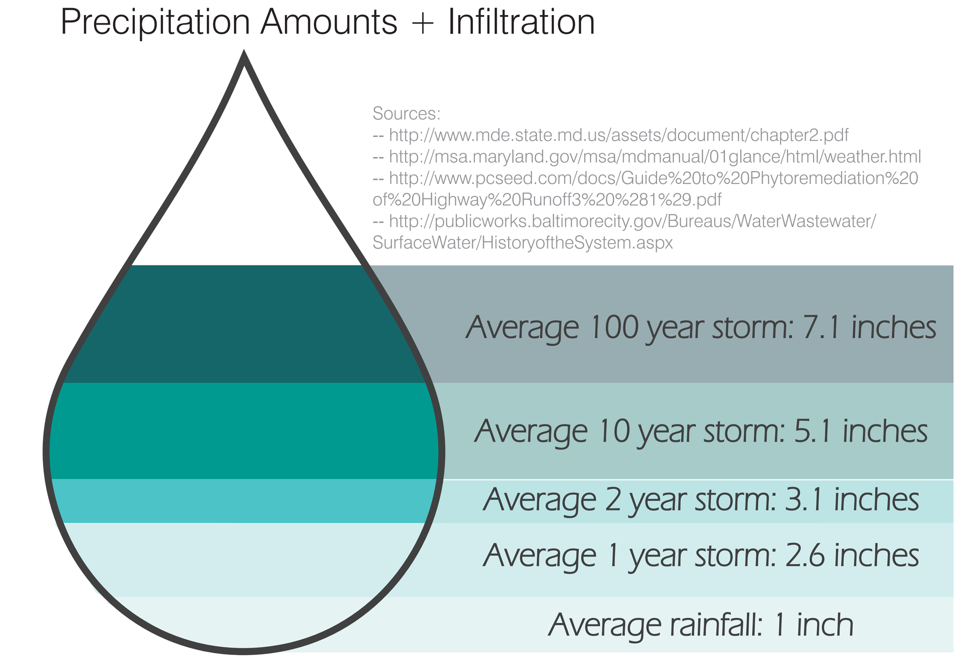
Movement of Runoff Over Site Topology

Baltimore City does not share the issue many other American cities are facing with combined sewer overflows (CSOs) because the sewer and stormwater systems were built separately from the very beginning. The present system now includes over 50,000 storm drain inlets and 1,100 miles of storm drains. Baltimore is still facing issues with mandatory stormwater treatment. The expense of building new treatment centers can be reduced, however, if the amount of stormwater entering gray infrastructure is reduced.

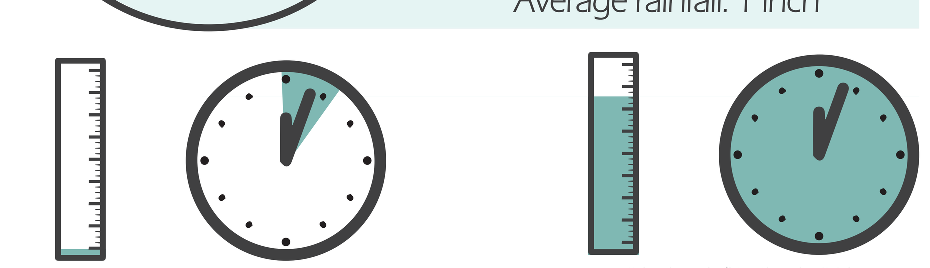
Peak Rainfall: July - August

On average: 1 rainstorm in every 5 days

Precipitation Amounts + Infiltration



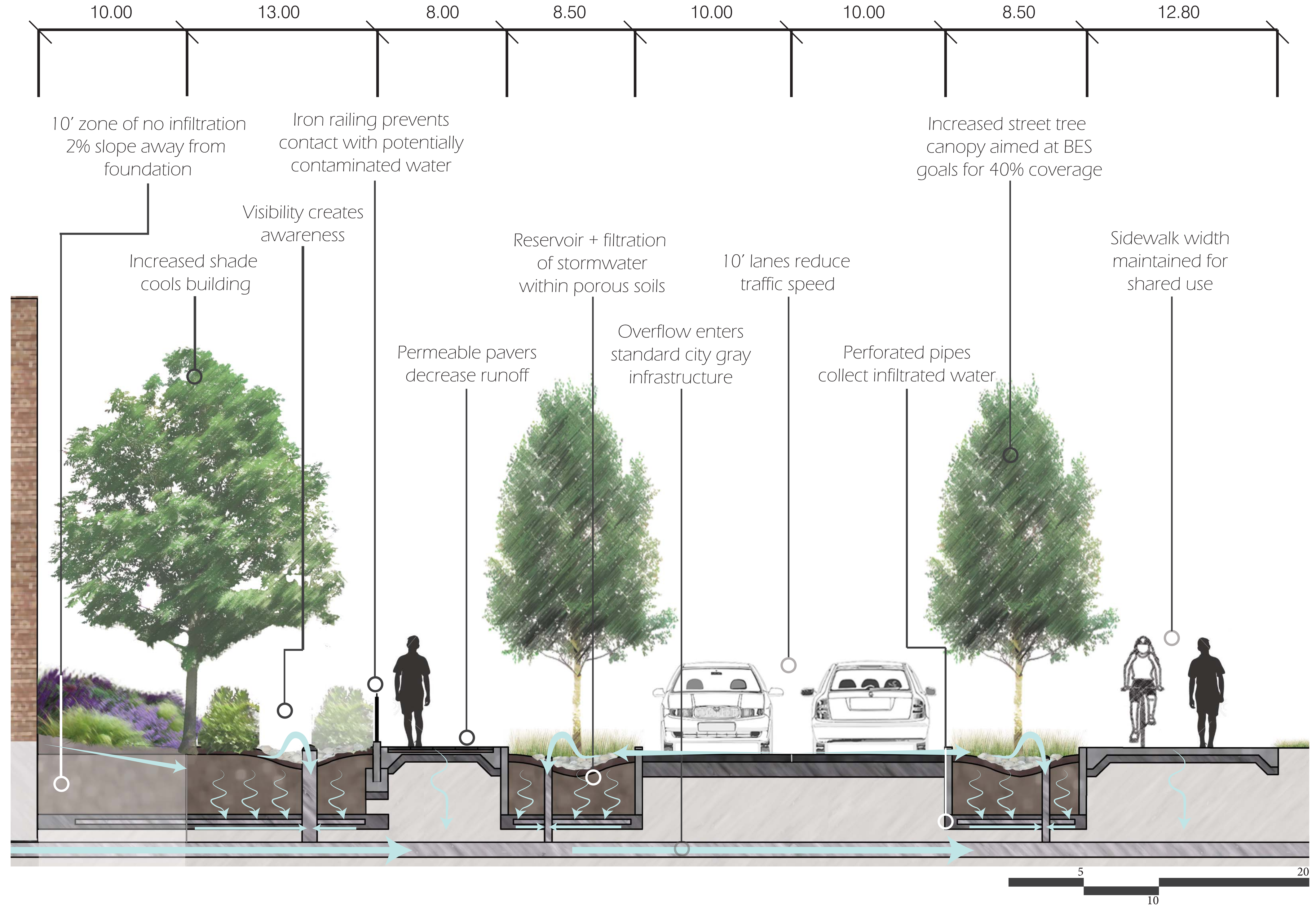
Sources:
-- http://www.mde.state.md.us/assets/document/chapter2.pdf
-- http://msa.maryland.gov/msa/mdmanual/01glance/html/weather.html
-- http://www.pcseed.com/docs/Guide%20to%20Phytoremediation%20of%20Highway%20Runoff3%20%281%29.pdf
-- http://publicworks.baltimorecity.gov/Bureaus/WaterWastewater/SurfaceWater/HistoryoftheSystem.aspx



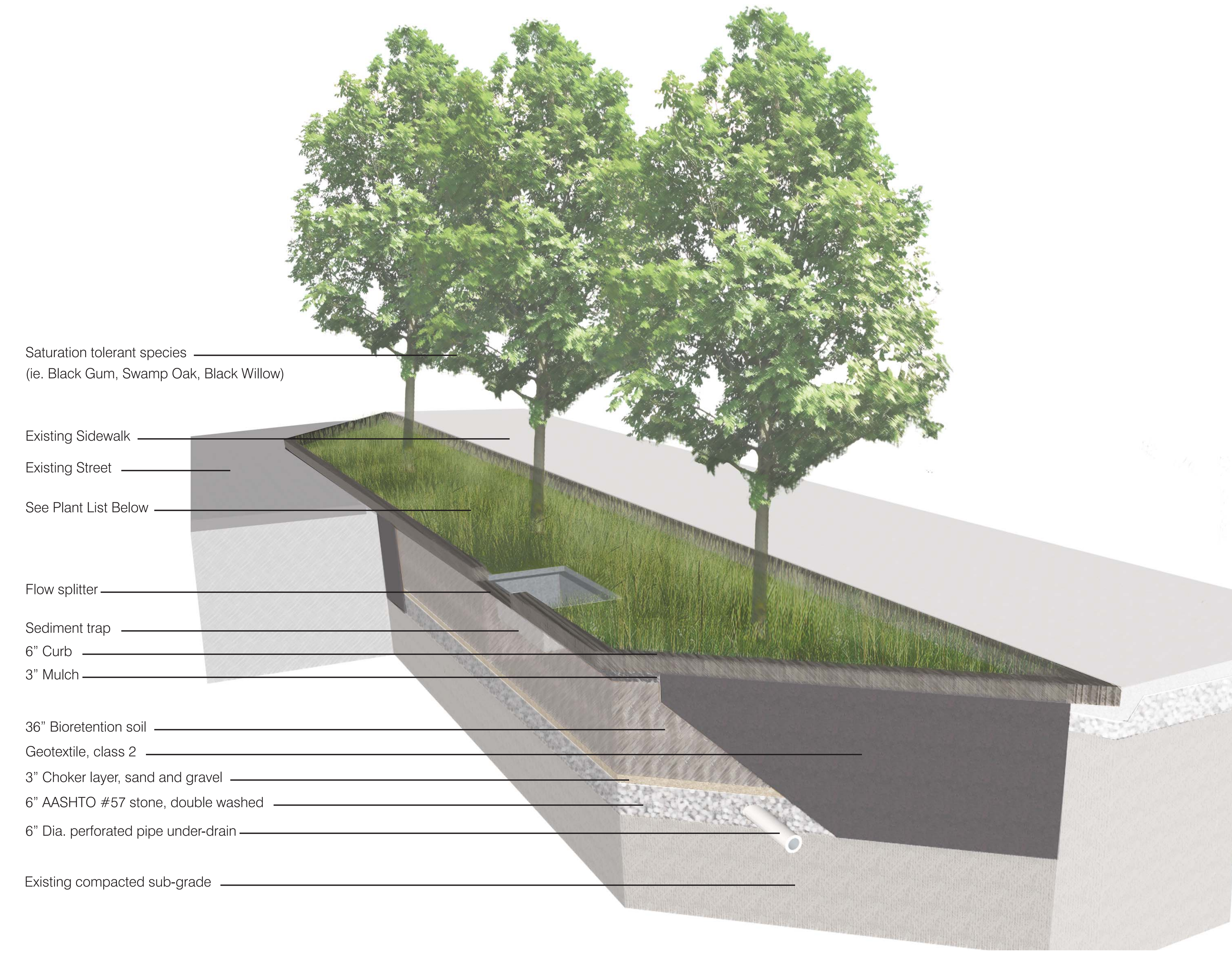
The majority of the soil found north of U.S. 40 in Watershed 263 is Type B soil. This means these soils are of moderate to moderately deep depth, fine to coarsely textured, and have a moderate infiltration rate of 0.15 - 0.31 inches of water per hour when thoroughly wet. This allows for rain gardens to infiltrate if desired, as the minimum for infiltration is 0.25 inches per hour or greater.

Jessica Fegley_Prof.(s) Gorenflo & Kew
Date:4.24.15
PENNSTATE
Department of Landscape Architecture
LArch 414_BES Studio_Spring 2015

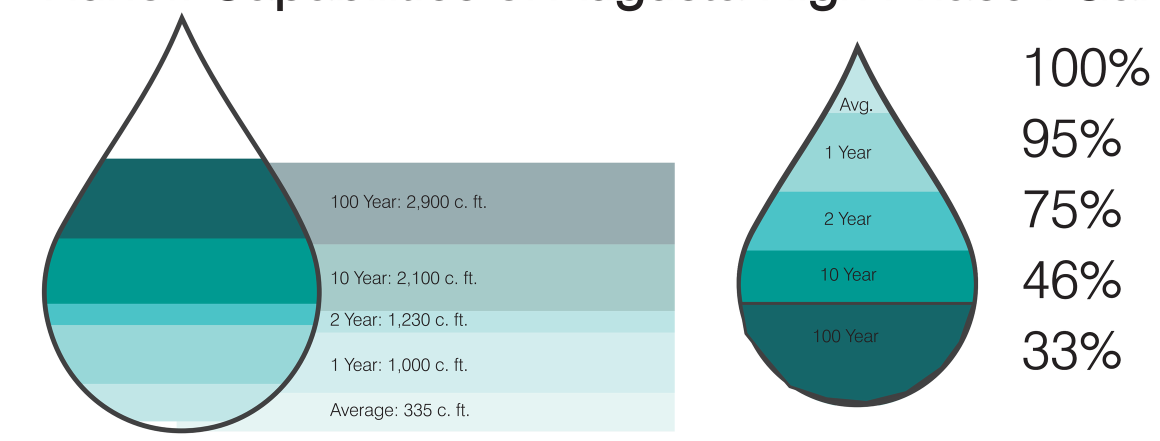
Augusta Fells Savage Institute of Visual Arts Rain Garden Section: 1/8th Scale



Standard Curb Extension Rain Garden



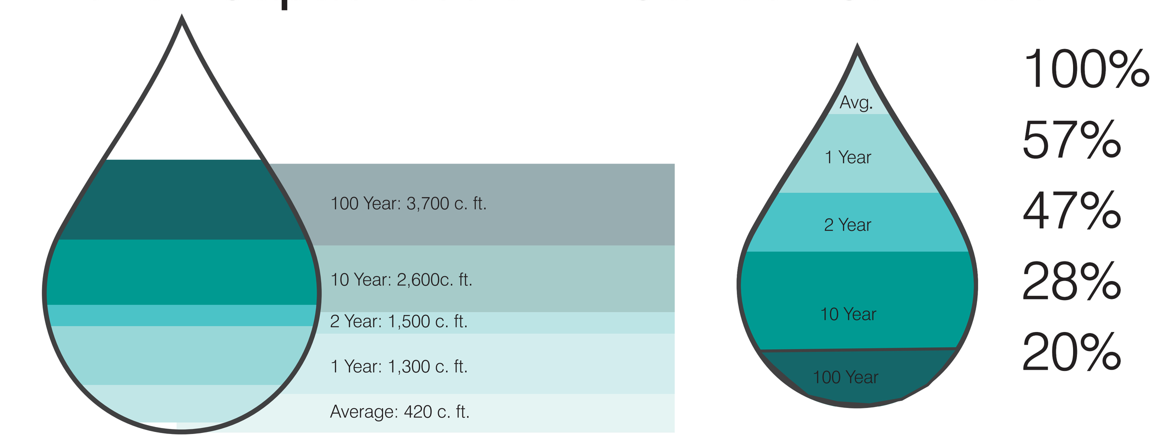
Runoff Capabilities of Augusta High Phase I Gar-



The initial rain garden that is installed directly next to the school is capable of containing 950 c. ft. of runoff from the school roof and the adjourning sidewalk. Overflow of this garden during rain events that generate more than 950 c. ft. of runoff enters a raised drain after ponding at a depth of 9 inches.

Total Amount of Runoff Diverted from Drains: 950 c. ft.

Runoff Capabilities of N. Calhoun St. Phase II - III



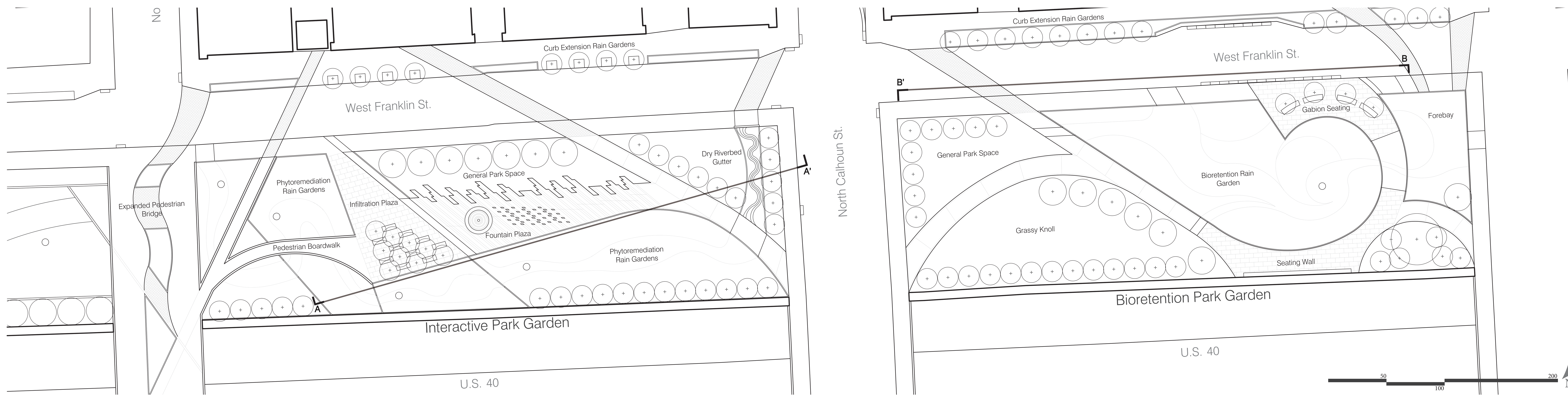
*Drainage area changes based on location. Above is a sample set.

The curb extension rain gardens constructed in Phases II and III can be implemented in a range of locations. The basic design holds 730 c. ft. of runoff. Overflow of these gardens during rain events that generate more than 730 c. ft. of runoff exits through the curb flow splitter after ponding at a depth of 9 inches and enters the existing storm system.

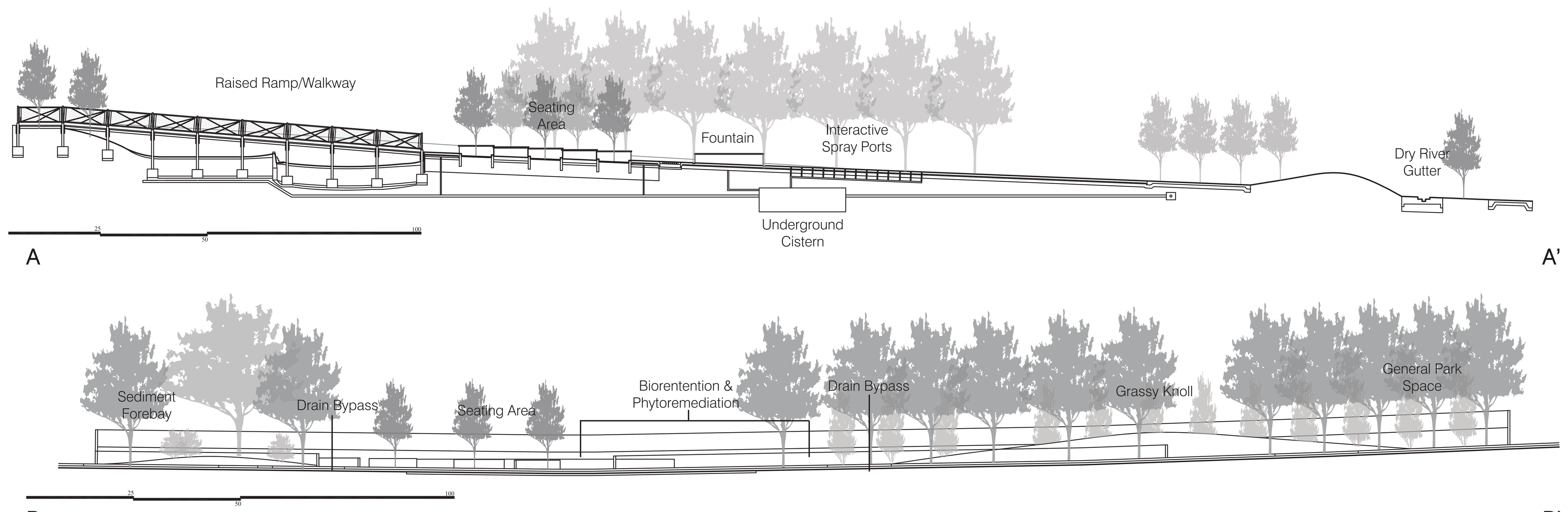
Total Amount of Runoff Diverted from Drains: 5,100 c. ft.

Sources:
http://www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

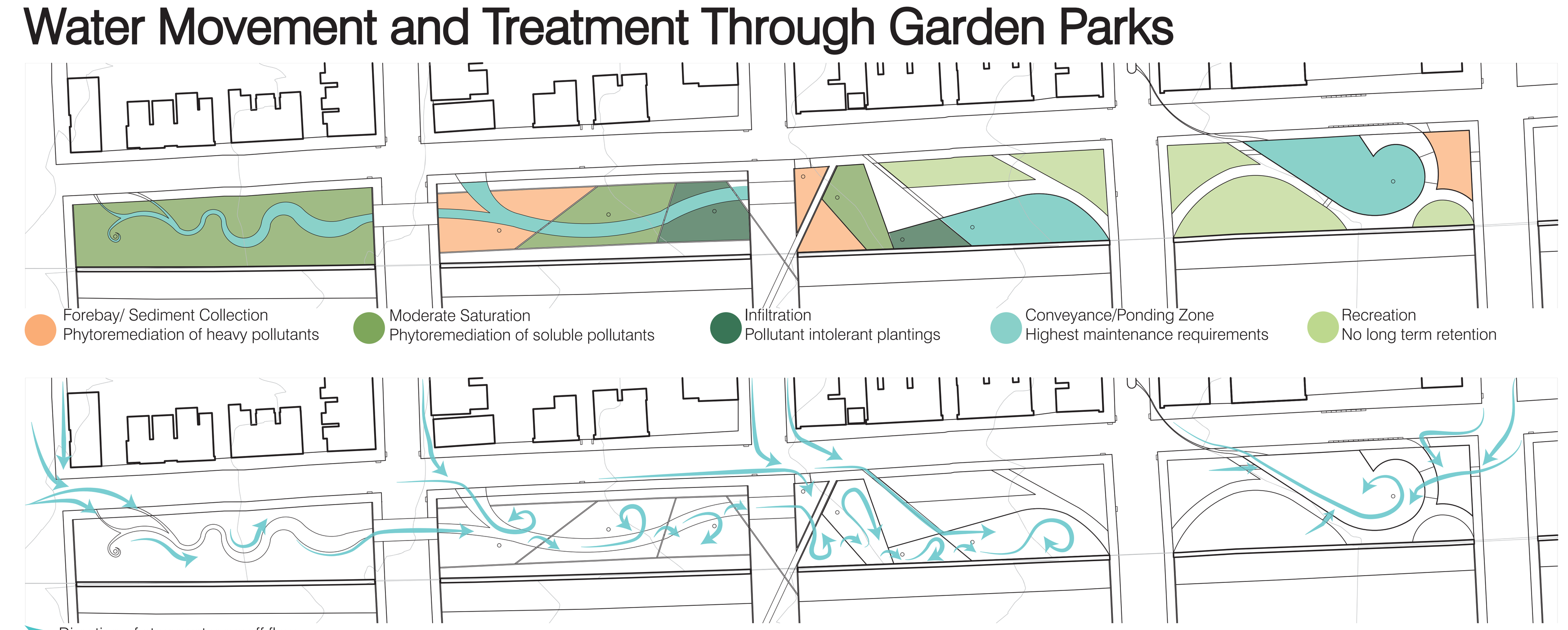
Phase V West Franklin Street Highway Park Plan: 30 Scale



Sections of Highway Garden Parks



Water Movement and Treatment Through Garden Parks



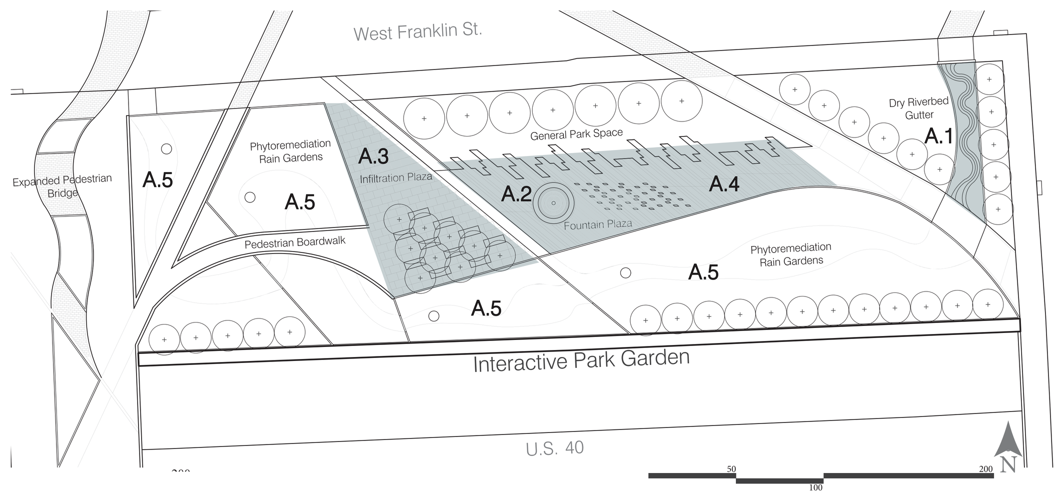
Phytoremediation Plant List

	Agropyron smithii	Agrostis castellana	Bouteloua gracilis	Buchloe dactyloides	Cerastium arvense	Cynodon dactylon	Elymus Canadensis	Festuca arundinacea	Lupinus albus	Vicia spp.	Helianthus annuus	Pteris vittata	Betula pendula	Gleditsia triacanthos
Copper		Phytoextraction, Phytostabilization								Phytoextraction, Phytostabilization	Phytoextraction, Phytostabilization			
Lead		Phytoextraction, Phytostabilization								Phytoextraction, Phytostabilization	Phytoextraction, Phytostabilization			Phytoextraction
Mercury		Phytoextraction, Phytostabilization								Phytoextraction, Phytostabilization	Phytoextraction, Phytostabilization			
Nickel		Phytoextraction, Phytostabilization								Phytoextraction, Phytostabilization	Phytoextraction, Phytostabilization			
Zinc		Phytoextraction, Phytostabilization								Phytoextraction, Phytostabilization	Phytoextraction, Phytostabilization			
Polyaromatic Hydrocarbons (PAHs)	Rhizodegradation		Rhizodegradation	Phytoextraction, Rhizodegradation	Phytoextraction	Phytoextraction, Rhizodegradation	Phytoextraction, Rhizodegradation	Phytoextraction, Rhizodegradation					Rhizodegradation	
Dioxins/furans														
Petroleum Products	Rhizodegradation		Rhizodegradation	Phytoextraction, Rhizodegradation	Phytoextraction	Phytoextraction, Rhizodegradation	Phytoextraction, Rhizodegradation							
Nutrients (Nitrogen, Phosphorous)										Phytoextraction				
Pesticides														
Arsenic									Phytostabilization			Phytoextraction		

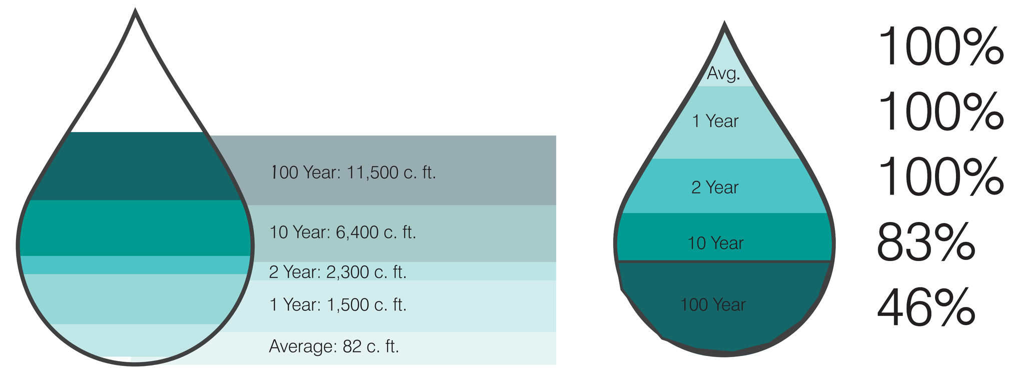
Phytostabilization Phytoextraction Rhizodegradation

Sources:
http://www.superorg.net/archive/proposal/plant%20species%20phyto.pdf

Features of Interactive Park Garden



Runoff Capabilities

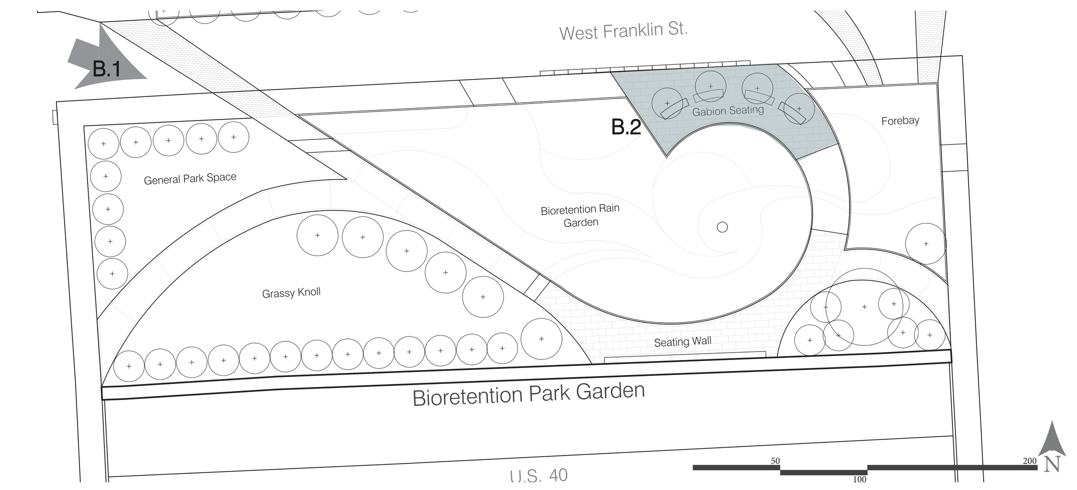


The weirs of the Interactive Park Garden can collectively hold 5,300 c. ft. of runoff. Overflow of this garden during rain events that generate more than 5,300 c. ft. of runoff enters a raised drain after cascading through each weird and ponding at a depth of 9 inches. Water the percolates through the soil and enters the perforated pipe is stored in a 1,300 c. ft. cistern to be used for irrigation and fountain features.

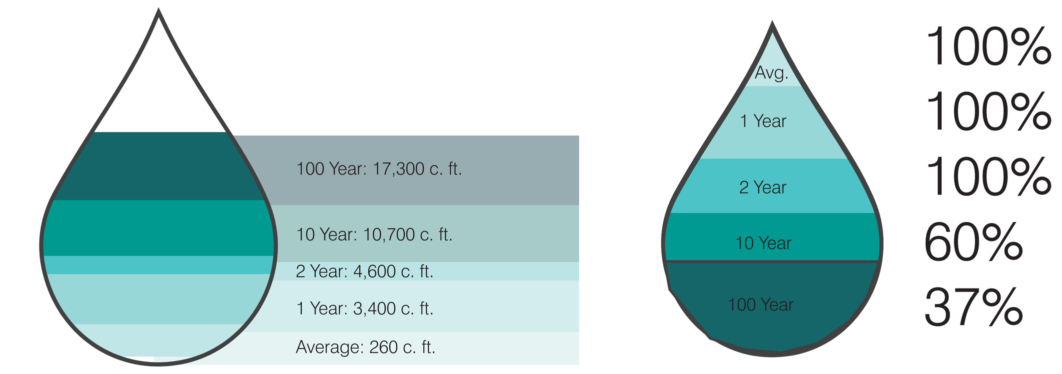
Total Amount of Runoff Diverted from Drains: 5,300 c. ft.

Sources:
http://www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

Features of Bioretention Park Garden



Runoff Capabilities



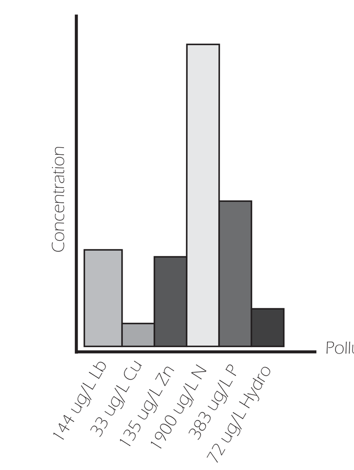
The large central garden of the Bioretention Park Garden can collectively hold 6,400 c. ft. of runoff. Overflow of this garden during rain events that generate more than 6,400 c. ft. of runoff enters a raised drain after ponding to a depth of 9 inches. Water the percolates through the soil and enters the perforated pipe is stored in a 1,300 c. ft. cistern to be used for irrigation.

Total Amount of Runoff Diverted from Drains: 6,400 c. ft.

Sources:
http://www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

Pollutants in Runoff

EPA 1983 Study of Pollutant Concentration in Stormwater Runoff

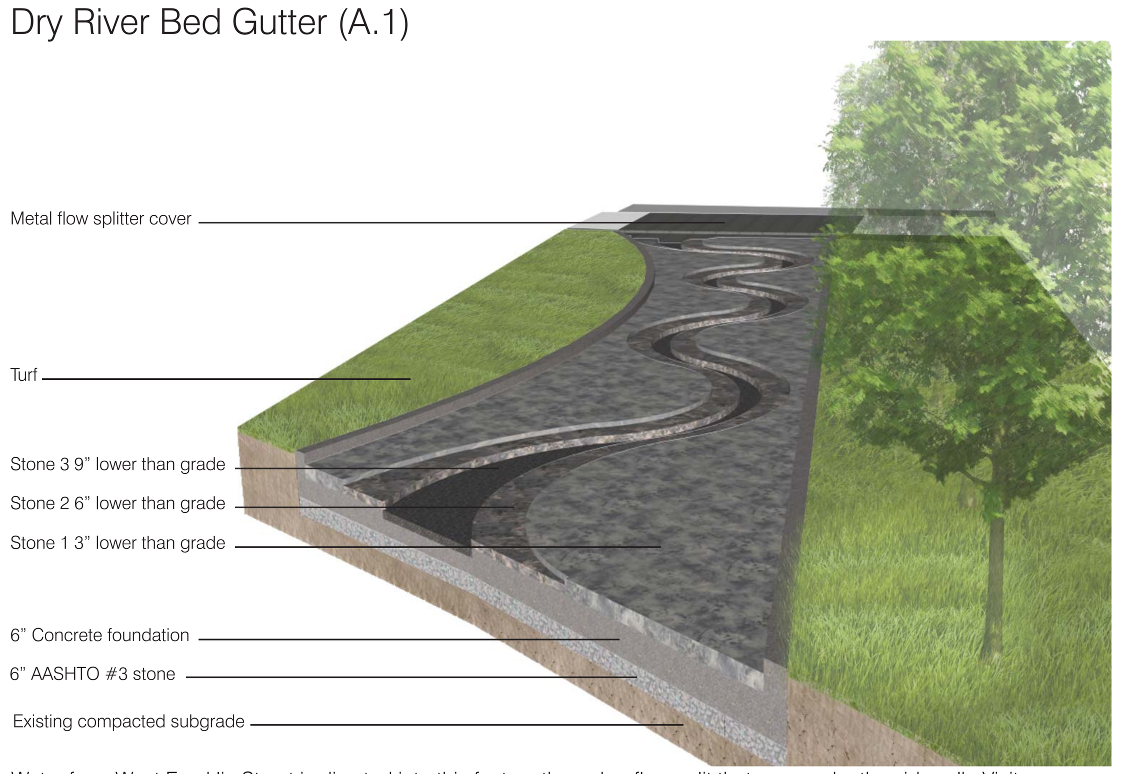


Types of Pollutants Found in Stormwater Runoff

- Solids
- Oxygen Demanding Substances
- Nitrogen
- Phosphorous
- Petroleum Hydrocarbons
- Metals
- Synthetic Organics

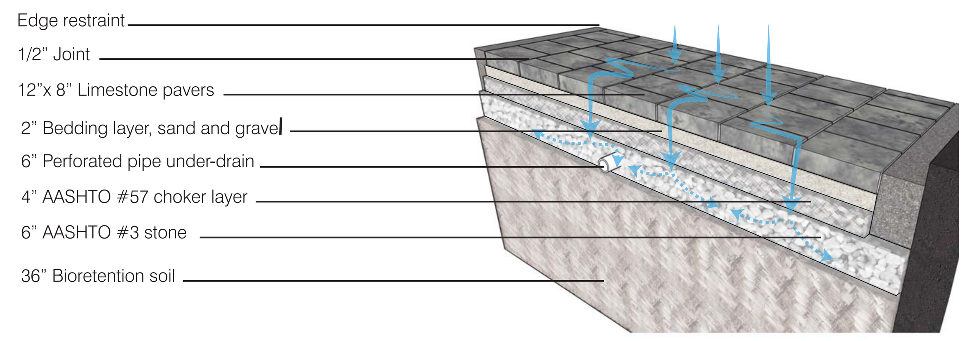
Sources:
https://fortress.wa.gov/ecy/publications/publications/0603041.pdf

Dry River Bed Gutter (A.1)



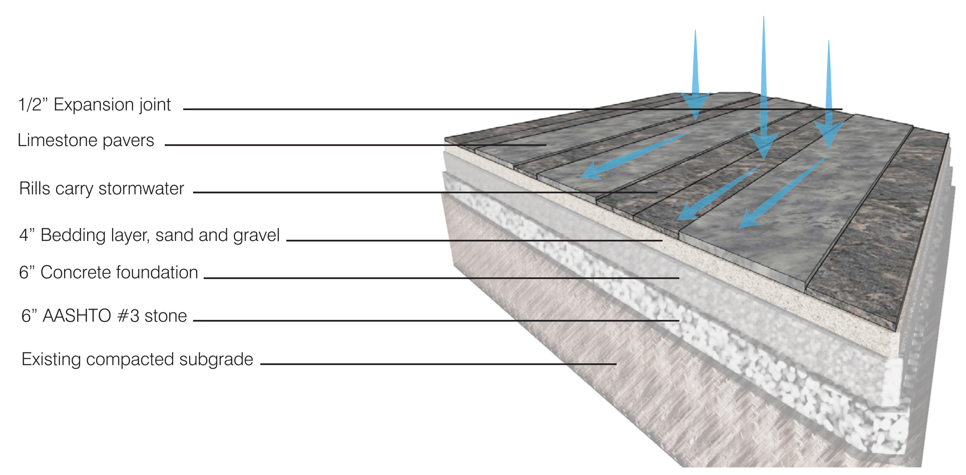
Water from West Franklin Street is diverted into this feature through a flow split that runs under the sidewalk. Visitors can see the amount of runoff diverted in the Interactive Park Garden's dry riverbed gutter. More runoff increases the level of water, marking the size of the rainfall event. The smallest rill fills first, gradually filling the larger rills until the entire gutter is full. This gutter empties into the final weir of the phytoremediation garden. At maximum capacity, the flow split cuts off any additional water from entering the gutter or garden and runoff enters the existing traditional gray infrastructure.

Permeable Paving (A.3)



Runoff is able to filter through the pavers and enter the bioretention soil. This irrigates the tree planters, allows for more expansive root growth, and infiltrates stormwater. Water that enters the perforated pipe under-drain is carried to the underground cistern to be reused for irrigation and interactive water

Impermeable Paving (A.4)

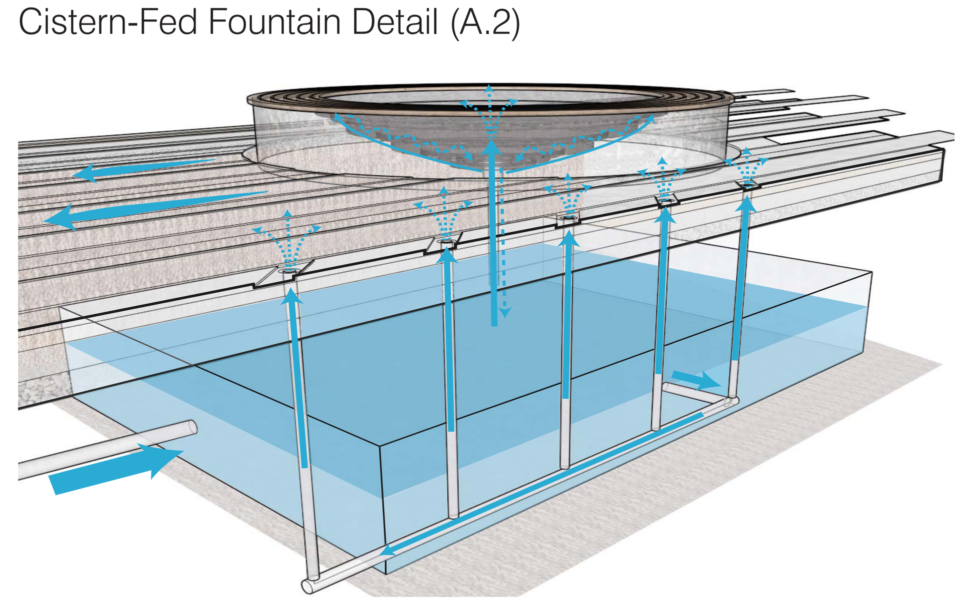


Runoff is not able to filter through the pavers and enter the bioretention soil. This is designed to transport runoff from the plaza and the adjourning park space directly to the nearest stormwater weir. Water percolates and is filtered within the bioretention garden, enters the percolated under-drain, and is then collected in the underground cistern to be reused for irrigation and interactive water features.

Cistern-Fed Fountain (A.2)

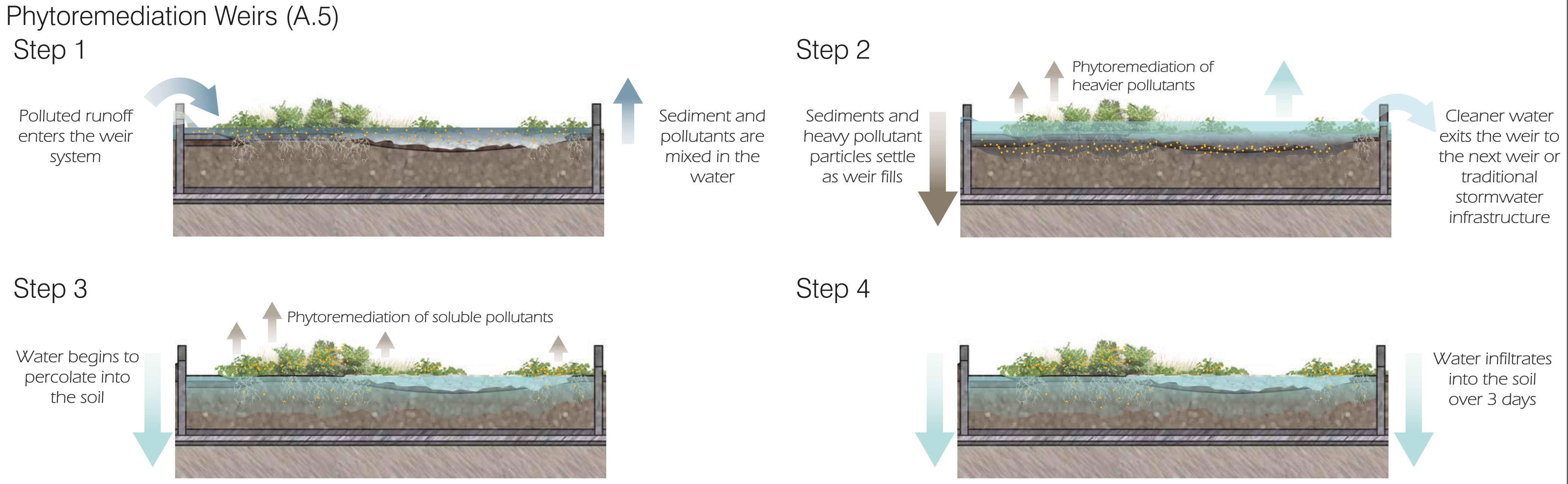
Storm events generate runoff that is captured, treated, and stored in an underground cistern. This water is then used for multiple hours after the storm event has ended to supply water to this sitting fountain and misting ports along the plaza. In dry periods, visitors can use the fountain as a sitting wall.

Cistern-Fed Fountain Detail (A.2)



The underground cistern can hold 1,300 cubic feet of runoff water. Solar powered pumps allow this stored water to be reused in the above ground fountain and misting ports.

Phytoremediation Weirs (A.5)

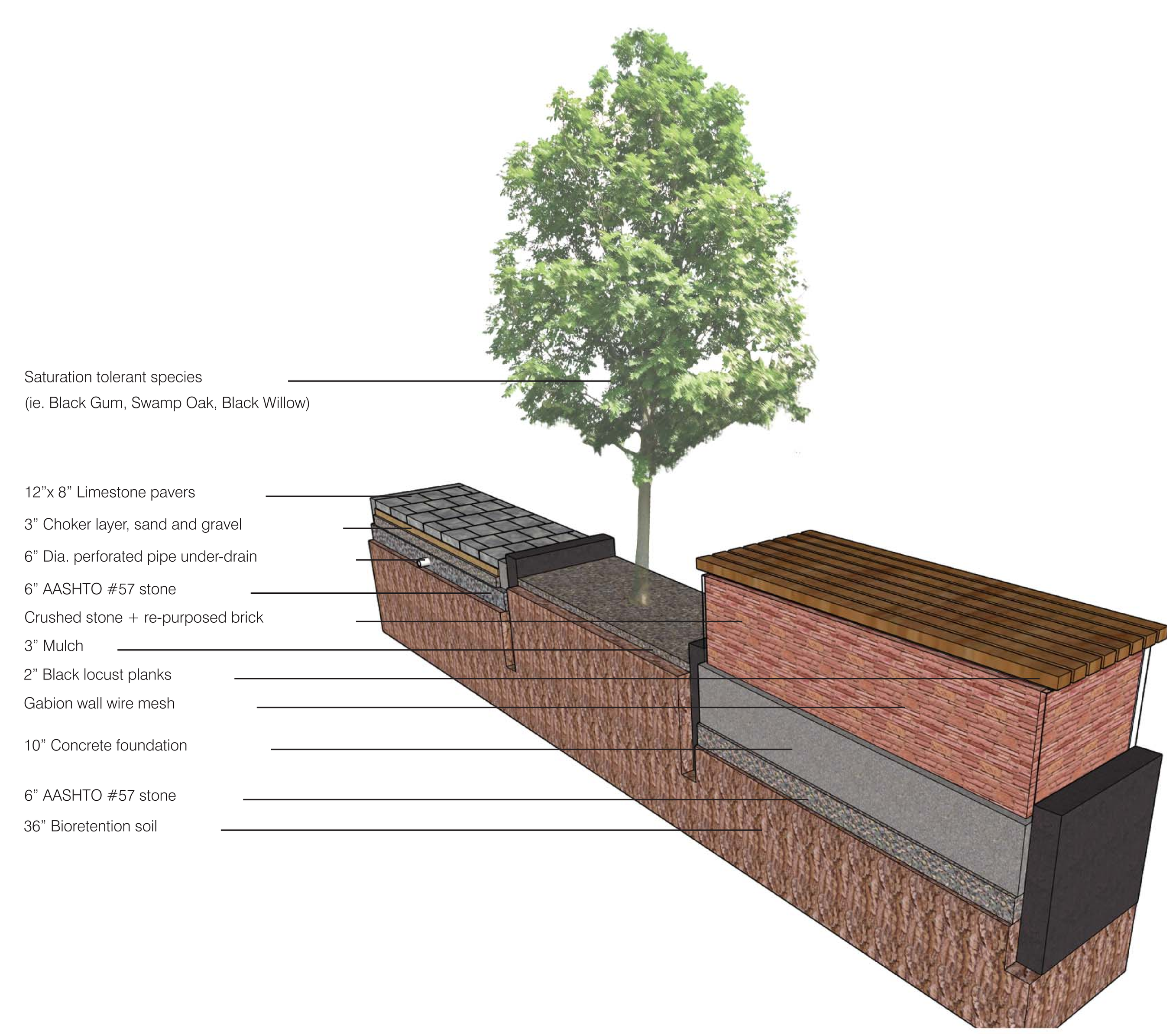


Bioretention Park Garden Perspective (B.1)

Numerous connections are made to Baltimore's cultural past in this garden park. Large, pale limestone boulders in the center of the bioretention garden represent the historic use of marble throughout the neighborhoods. Iron fencing notes the city's once prominent role in the iron industry. Re-purposed crushed brick can be found in the gabion seating walls and as a decorative feature in the bioretention dry stream-bed.

Paving patterns continue across the street to connect visitors visually to the park and to provide a notice to vehicles that there is a higher density of pedestrian activity. Water is not interactive here, although there are numerous opportunities for phytoremediation and runoff quality research studies. both through the BES and in coordination with local schools.

Gabion Seating Walls & Tree Planters (B.2)



Ecological Benefit to Baltimore's Urban Systems

	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI	Total
Trees Added	4	6	16	37	55	50	168 Trees
Water Bypassed from Drains	950 Ft^3	1,460 Ft^3	3,650 Ft^3	5,600 Ft^3	11,700 Ft^3	10,900 Ft^3	34,260 Ft^3
Park Space Created	-	-	-	-	1.5 Acres	.6 Acres	2.1 Acres
Impervious Surfaces Removed	2,100 Ft^2	1,000 Ft^2	6,700 Ft^2	14,400 Ft^2	-	-	24,200 Ft^2

Jessica Fegley_Prof.(s) Gorenflo & Kew
Date:4.24.15
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Department of Landscape Architecture
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