Determining Cost and Treatment Effective Soil and Plant Combinations in Bioretention Cells for Storm Water Management in the Piedmont Region of Georgia

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Purpose of Research

- Assess environmental performance of bioretention cells on site
- Determine cost-minimizing combination of bioretention cells
- Identify educational opportunities for students at Rockdale Career Academy

Background

- Impacts of storm water runoff
  - Stream flow
  - Stream morphology
  - Biological health
  - Water quality
- Returning to pre-development stream conditions can be cost prohibitive.
- Handling and treating storm water runoff before it reaches streams is a less expensive option

Background

- Benefits of managing storm water runoff
  - Hydrologic
  - Habitat
  - Human health
  - Recreational
  - Property values

Background

- Pollutant Removal Capability for BMPs

BMP Type	Typical Pollutant Removal (%)				
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals
Detention Basin	30-65	15-45	15-45	<30	15-45
Retention Basin	50-80	30-65	30-65	<30	50-80
Constructed Wetland	50-80	<30	15-45	<30	50-80
Porous Pavement	65-100	65-100	30-65	65-100	65-100
Grassed Swales	30-65	15-45	15-45	<30	15-45
Filter Strips	50-80	50-80	50-80	<30	30-65
Sand Filters	50-80	<30	50-80	<30	50-80
Bioretention Cell	**80-90**	**50-80**	**60-80**	**No data**	**80-99**

Background

- BMP Initial Costs

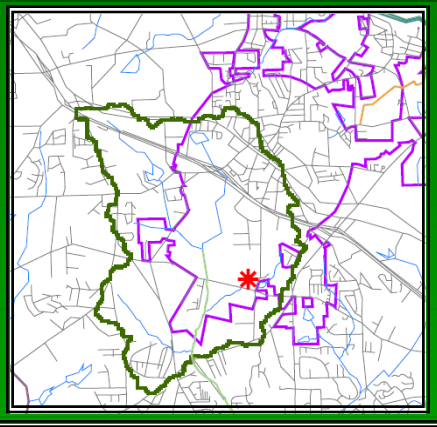
BMP Type	Typical Cost (1997)		Typical Cost (2007)	
	($/cubic foot)		($/cubic foot)	
	low	high	low	high
Retention/Detention System	0.50	1.00	0.64	1.28
Constructed Wetland	0.60	1.25	0.77	1.60
Grassed Swales	0.50	0.50	0.64	0.64
Filter Strips	0.00	1.30	0.00	1.66
Sand Filters	3.00	6.00	3.84	7.68
Bioretention Cells	5.30	5.30	6.79	6.79
	Typical Cost (2001)		Typical Cost (2007)	
	($/square foot)		($/square foot)	
Porous Pavement				
Asphalt	0.50	1.00	0.64	1.28
Concrete	2.00	6.50	2.56	8.32
Grassed Pavers	1.50	5.75	1.92	7.36

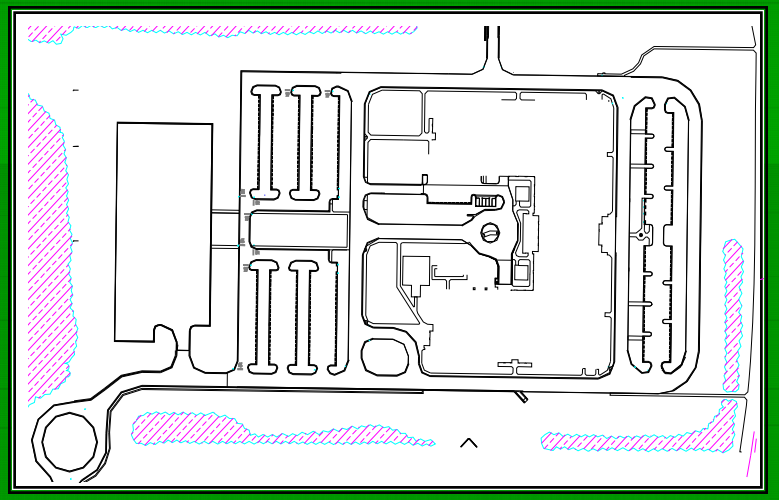
Case Study Description

Rockdale Career Academy

Case Study Description

- Rockdale Career Academy
  - Located in Almand Branch watershed
  - 42 acre site
  - Multiple BMP systems
  - Six bioretention cells and two grassed swales designed for research





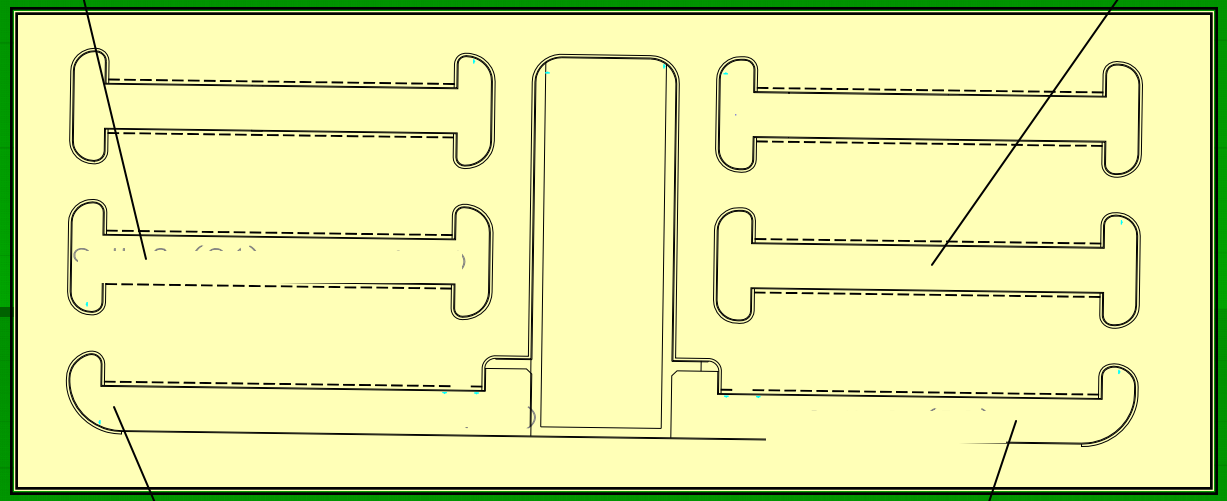
Treatment Design

- 2X2 treatment block
  - 2 soil mixes
  - 2 plant mixes
- Randomly assigned to 4 locations
- Due to natural ridge in 2 locations, ended up with 6 cells instead of 4

Case Study Description

- Study Site

Cell B5c/G4
•Experimental Cell (40% topsoil, 40% sand, 20% engineered soil and plant mix A)
•0.68 ac watershed
•2296 ft³ WQ volume



Cell B7
•Control Cell (40% topsoil, 20% sand, 40% engineered soil, plant mix B)
•0.60 ac watershed
•2229 ft³ WQ volume

Cell B5d/G3
•Experimental Cell (40% topsoil, 40% sand, 20% engineered soil, plant mix B)
•0.76 ac watershed
•2369 ft³ WQ volume

Cell B8
•Control Cell (40% topsoil, 20% sand, 40% engineered soil, plant mix A)
•0.73 ac watershed
•2275 ft³ WQ volume

Case Study Description

Bioretention Installation

November 2005-May 2006

August 2006

May 2007

November 2006

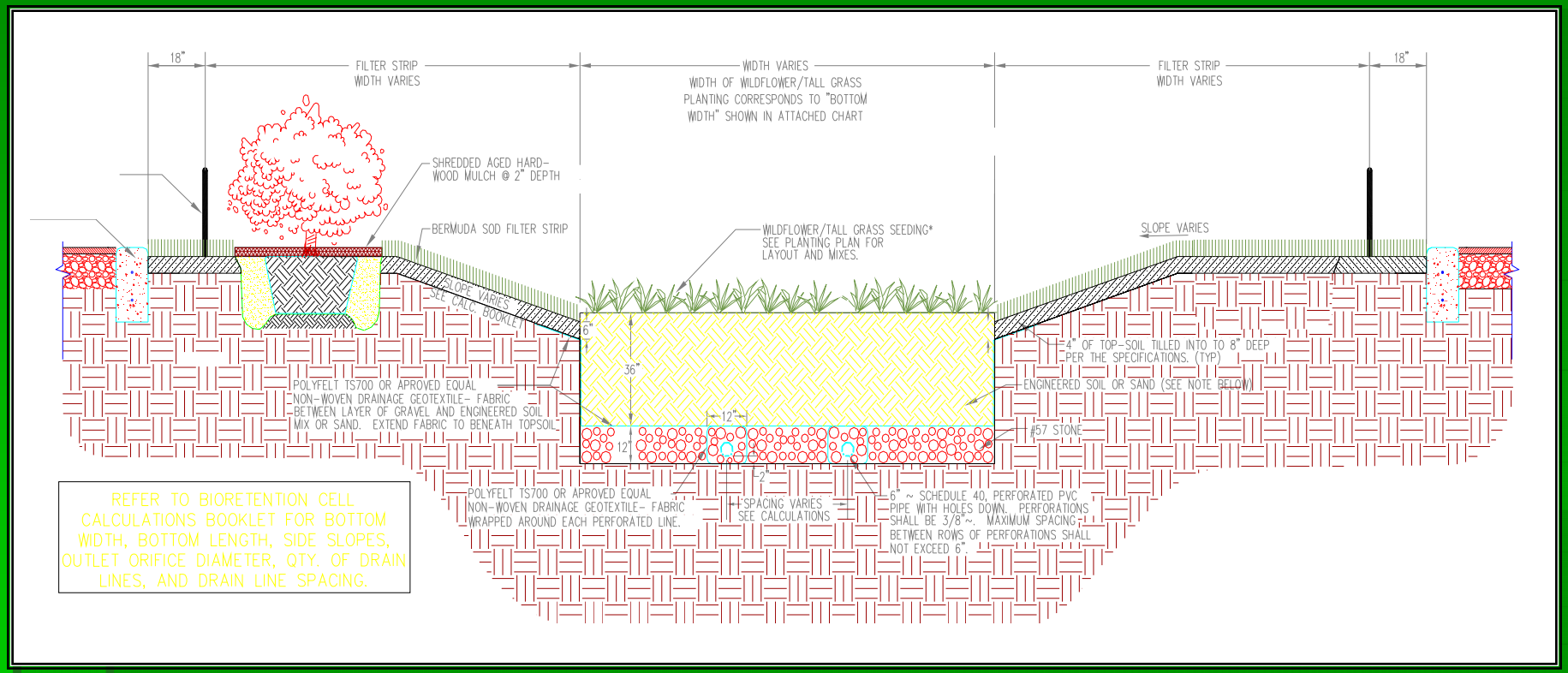
Cost Minimization Model

- Min $\Sigma X_i * C_i$
- Subject to volume and treatment constraints
  - Need to meet or exceed required volume treated
  - Need to meet or exceed pollutant removal requirements
    - On weighted average

Constraints

- $\Sigma X_i * V_i = V \geq V_{min}$
- $\Sigma w_i * X_i * L_i \geq L_{min}$
  - Where $w_i = V_i / V$
  - Repeat for copper, zinc, TSS, and TP
- Solve via integer programming

Case Study Description



Results

Water Quality

P8 Model - Predicted Pollutant Removal

WQ Parameter	Sand 20 Mix A	Sand 20 Mix B	Sand 40 Mix B Small	Sand 40 Mix B Large	Sand 40 Mix A Small	Sand 40 Mix A Large
Lead (% Reduction)	58.9	63.5	64	62.2	67	66.3
Copper (% Reduction)	58.2	62.9	63.6	61.4	66.3	65.7
Zinc (% Reduction)	35	41.1	44.2	39.7	46.2	46.1
Suspended Solids (% Reduction)	59.2	63.7	64.1	62.6	67.3	66.6
TKN (% Reduction)	38.7	44.8	46.3	43.9	50.3	49.4
Total Phosphorus (% Reduction)	38.9	45	46.4	44.2	50.5	49.6

Conclusions and Recommendations

Conclusions

- Water Quality
  - The experimental bioretention cells at the Rockdale Career Academy, (40% topsoil, 40% sand, and 20% engineered soils) remove pollutants just as effectively as the control bioretention cells (40% topsoil, 20% sand and 40% engineered soils)

Conclusions

- Costs
  - The experimental cells at the Rockdale Career Academy cost less overall (and per cubic foot of runoff handled) to reduce pollutants to a target level than the control bioretention cells.

Educational Component

- Cost Minimization Concept and Application
  - Business Decision & Management
- Water Quality Monitoring
  - Environmental Science
- Maintenance
  - Horticulture & Landscape Design
- Conduct projects to determine…
    - Effects of plants on bioretention function
    - Effects of maintenance on bioretention function
    - Effects of drought on bioretention function
    - Effects of extended wet periods on bioretention function
    - Long term performance of bioretention cells