

# In-Situ Soil Solutions

Working with Nature for Better  
Stormwater Management

**OCTOBER 30, 2025** 12 PM – 1 PM

Many bioretention designs replace native soils with engineered media and use underdrains to move water quickly, but this reduces the practice's ability to slow, cool, and clean runoff. This webinar will explore how working with existing soils and native plants can cut costs and improve stormwater management. Drawing on years of practical experience, we will hear from an expert how using "in-situ" soils without underdrains is often more cost-effective, requiring less excavation, hauling, and soil replacement, while also providing better treatment and reducing runoff volumes. Mike Clar, P.E. (Ecosite, LLC), a leading expert in this approach, will share insights and highlight the advantages of this innovative method over conventional practices.

**You'll learn when this approach is feasible, the benefits it provides, and how to apply it in your next project.**

## Thanks for joining!

If you need assistance, use chat or email,  
Sadie Friesen at [sfriesen@cbtrust.org](mailto:sfriesen@cbtrust.org).





*Empowering People.*

**RESTORING NATURE.**

## About the Chesapeake Bay Trust

The Chesapeake Bay Trust is a nonprofit grantmaking organization dedicated to improving the Chesapeake, Coastal Bays, and Youghiogheny watersheds. Our mission is to restore and protect our natural resources by focusing on three core objectives: environmental education, community outreach, and on-the-ground restoration.

Each year, the Trust awards millions of dollars in grants to support healthier local communities and a cleaner environment. We engage more than 250,000 individuals annually who are making a positive impact on our waterways and the natural resources of our region.

**We believe that empowering people to take action is the key to protecting forests, streams, rivers, bays, wildlife, and more—right in their own communities.**



# IN-SITU BIORETENTION WORKSHOP



## Material Covered:

- **What is it?**
- **Why use In-situ**
- **How do you use?**
- **Obstacles to use**





**Chesapeake  
Bay Trust**

Empowering people. Restoring nature.

**ECOSITE**

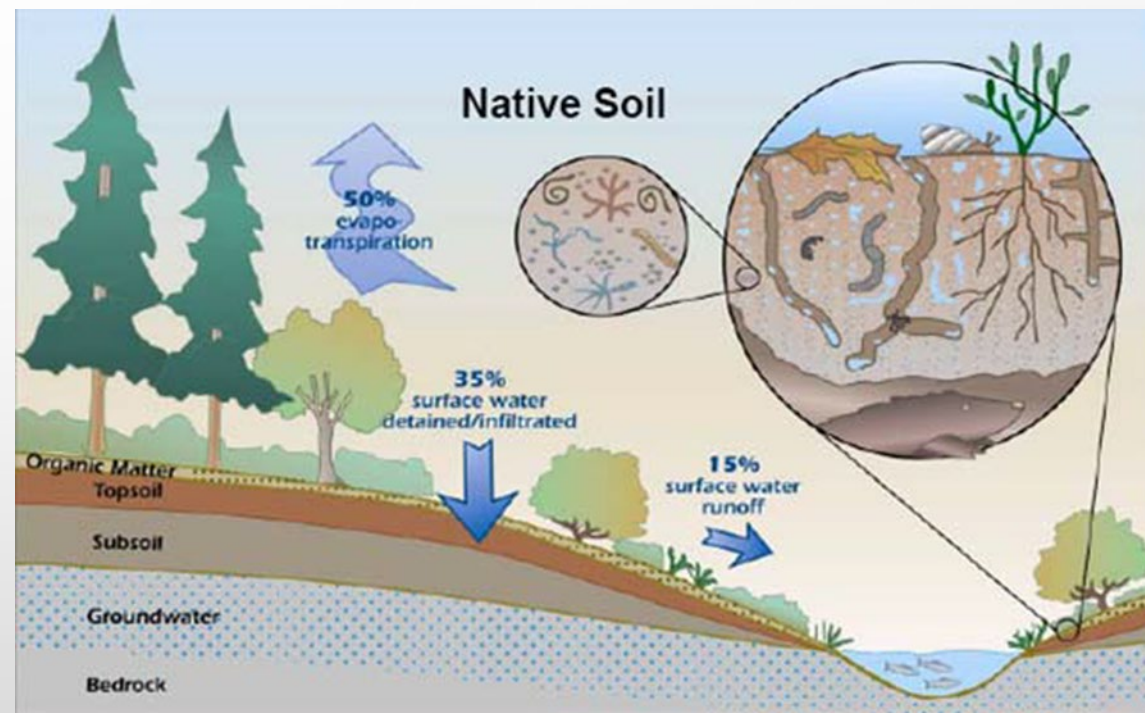
## **What is In-situ Bioretention:**

- **An improved ecologically sustainable approach to bioretention practice**
- **Reduces construction costs by 50% or more which enables grant funds to build more practices and treat more area**
- **Provides greater runoff volume control**



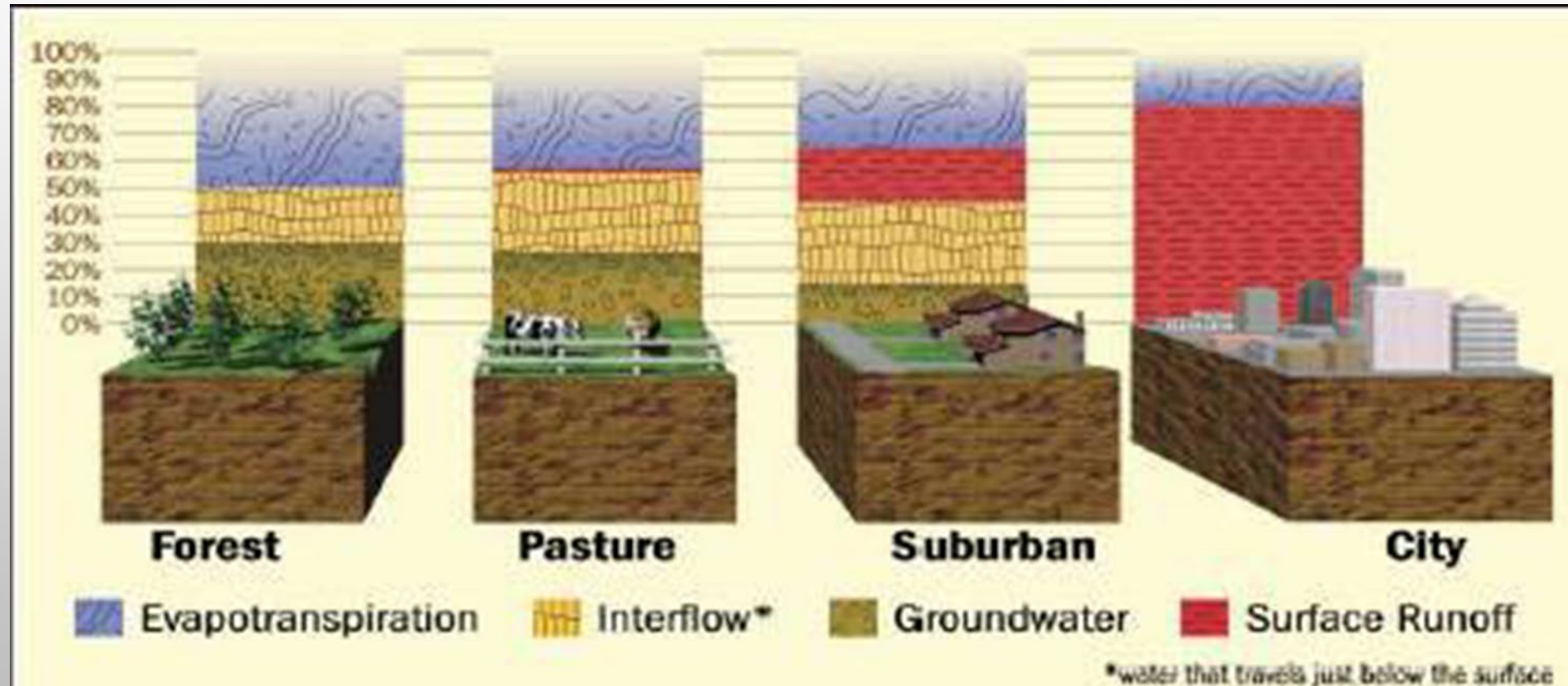
### Why Use In-situ Bioretention:

- ❖ Use Ecological engineering & Landscape Ecology principles
- ❖ Provide high rates of water infiltration and retention
- ❖ Minimize surface water runoff and erosion
- ❖ Trap sediments, heavy metals and excess nutrients, and biodegrade chemical contaminants
- ❖ Encourage vigorous protective vegetative cover
- ❖ Support beneficial soil life that fight pests and disease and supply plant nutrients, reducing need for fertilizers and pesticides that may contaminate receiving waters





### How to get suburban and city sites to function like a forested soil





## **BACKGROUND**

- **Bioretention developed in 1993 in PG County, MD (Clar, 1993)**
- **Has become one of the most widely used BMP in US**
- **Has become identified as a preferred site practice for green building design and LEEDS certification**
- **Original concept consists of excavating existing soils and replacing with either natural or artificial “soil media”.**
- **There are many situations where the existing soils may not need to be totally removed but instead can be augmented **in-situ** to provide a more sustainable and low cost approach to bioretention**



## **DESIGN GUIDANCE**

**Design Criteria.** In general, the in-situ bioretention facility design must conform to the guidelines provided in MDE 2000 & MDE 2007 bioretention guidance.

- ❖ **Guidance is provided on the following design parameters:**
  - allowable ponding depth,
  - minimum width and length parameters,
  - depth and type of soil/filter media,
  - design of bioretention as infiltration practices,
  - selection of appropriate plant material



## **DESIGN GUIDANCE CAVEAT**

**Important to note that design parameters are not all science based, but often based on subjective opinion and preferences of regulatory agencies.**

**Caveat applies to all design parameters:**

- allowable ponding depth,
- minimum width and length parameters,
- depth and type of soil/filter media,
- design of bioretention as infiltration practices,
- selection of appropriate plant material



## **DESIGN GUIDANCE**

### **❖ DEPTH & TYPE OF SOIL/FILTER MEDIA**

- The initial objectives were to provide a well-drained soil and a suitable growth medium for the plant materials**
- The initial guidelines for soil materials were based on the properties of the natural soil textural classifications listed in Table 1 (Clar, McCuen, 1983).**
- Three soil textural classifications were selected, loamy sand, sandy loam and loam.**



### TECHNICAL BASIS FOR INFILTRATION RATES

❖ **2 primary drivers for F rates: ponding depth (d) & dewatering period (T).**

**(d) can range from 6 – 24 in.**

**(T) can range from 24 – 72 hrs**

- **At 72 hrs can dewater up to 6 “ of ponding in a clay loam (F value of 0.09 in/hr)**
- **At 48 hrs can dewater up to 8 in of ponding in a sandy clay loam ( F value of 0.17 in/hr)**
- **At 24 hrs, can dewater up to 6 ‘ ponding in a silt loam ( F value of 0.17 in/hr)**

**So why is min F rate typically set at 0.52 in/hr?**

**Table 1. Maximum Allowable Ponding and Storage Depths (Inches)**

Soil Texture	Hydrologic Soil Group	F* (in/hr)	Max Allowable Ponding Time (hrs)			Max Allowable Storage Time (hrs)			Remarks
			24	48	72	24	48	72	
<i>Sand</i>	A	8.27	198	397	595	496	992	1489	
<i>Loamy Sand</i>	A	2.41	58	116	174	145	290	434	
<i>Sandy Loam</i>	B	1.02	24	49	73	61	122	183	
<i>Loam</i>	B	0.52	13	25	37	31	62	93	
<i>Silt Loam</i>	C	0.27	6	13	19	16	32	49	
<i>Sandy Clay Loam</i>	C	0.17	4	8	12	10	20	31	
<i>Clay Loam</i>	D	0.09	2	4	6	5	11	16	Ponding depth limited
<i>Silty Clay Loam</i>	D	0.06	1.4	3	4	4	7	11	“
<i>Sandy Clay</i>	D	0.05	1.2	2.4	4	3	6	9	“
<i>Silty Clay</i>	D	0.04	0.96	1.92	3	2	6	7	“
<i>Clay</i>	D	0.02	0.48	0.96	1.44	1	2	4	“

F\* is the saturated hydraulic conductivity rate as reported by Rawls, Brakensiek and Saxton, 1982 (See Table 2)



- ❖ Ayres (2009) reported that measured F rates at sites (10), greatly exceeded (> 3x) the F rate expected based on soil texture alone (Rawls,1982), presumably because of biological activity in the soil which maintains soil structure infiltration rate
- ❖ Additional field testing required to verify
- ❖ How can we use this knowledge to improve design and ease restrictions on soil types

**Note: Site BP with F rate of 0.2"/hrrr**

Table 2: Measured vs predicted infiltration rates at bioretention cells measured by Ayers (2009)

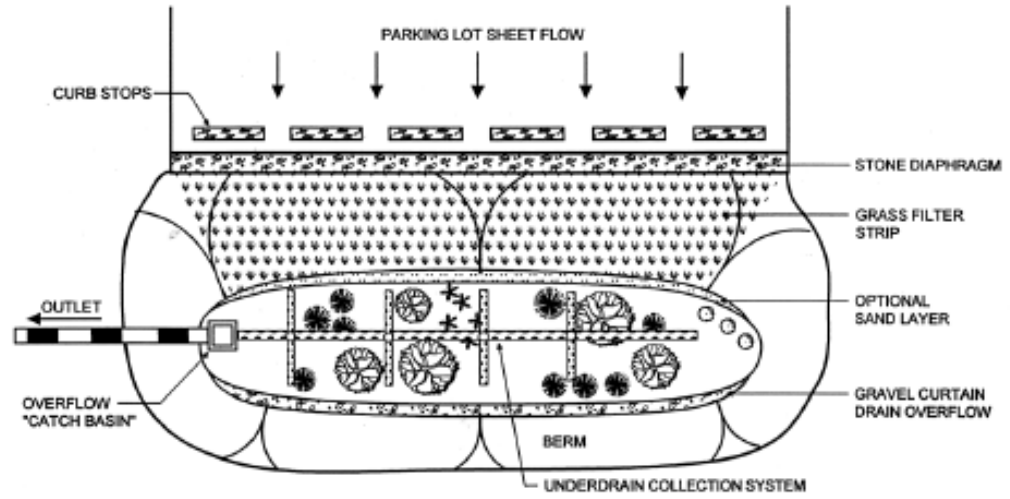
Site name	Soil	Predicted infiltration rate based on Rawls et al 1982 (inches per hour)	Measured infiltration rate (inches per hour)	Age at time of measuring infiltration rate
BP	53% sand, 23.5 % silt, 23.4% clay	0.2	3.15	7 years
NWHS	51.4% sand, 34.2 % silt, 14.4% clay	0.6	2.165	5 years
LRH	46.4% sand, 33.3% silt, 20.3% clay	0.5	3.15	10 years



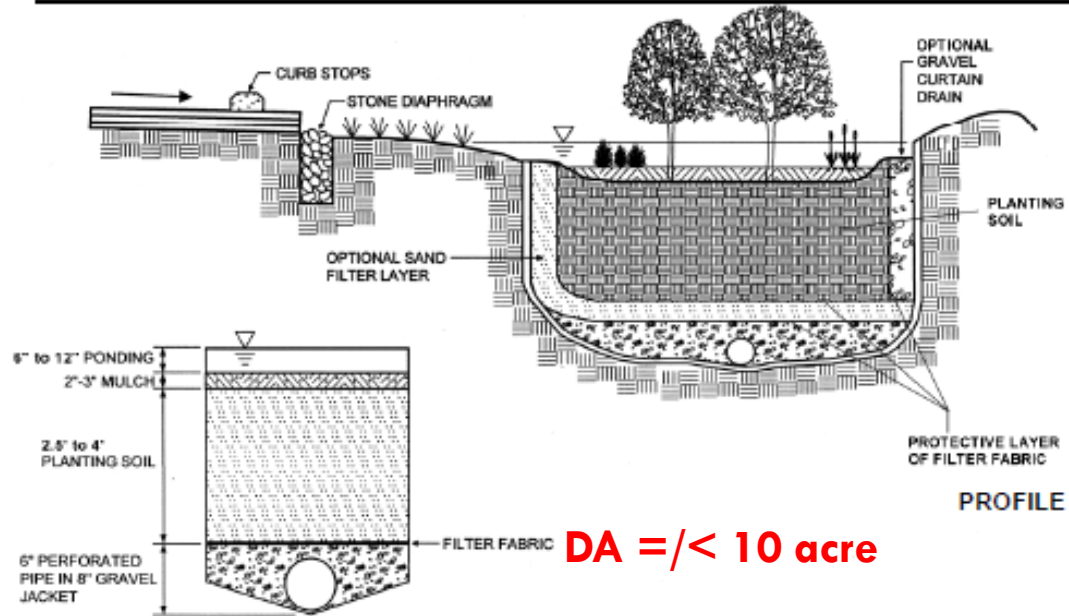
## **DESIGN GUIDANCE**

### **Frequent design Modifications (Bells & Whistles)**

- **under-drains,**
- **manufactured filter media (Bioretention soils),**
- **chimney drains,**
- **various combinations of gravel jackets.**
- ❖ **Some of these modifications are worthwhile while others have the potential to undermine the intent of the original design.**
- ❖ **In many instances these bells and whistles add substantially to either the material or construction cost and become a roadblock to the use of these practices**



PLAN VIEW



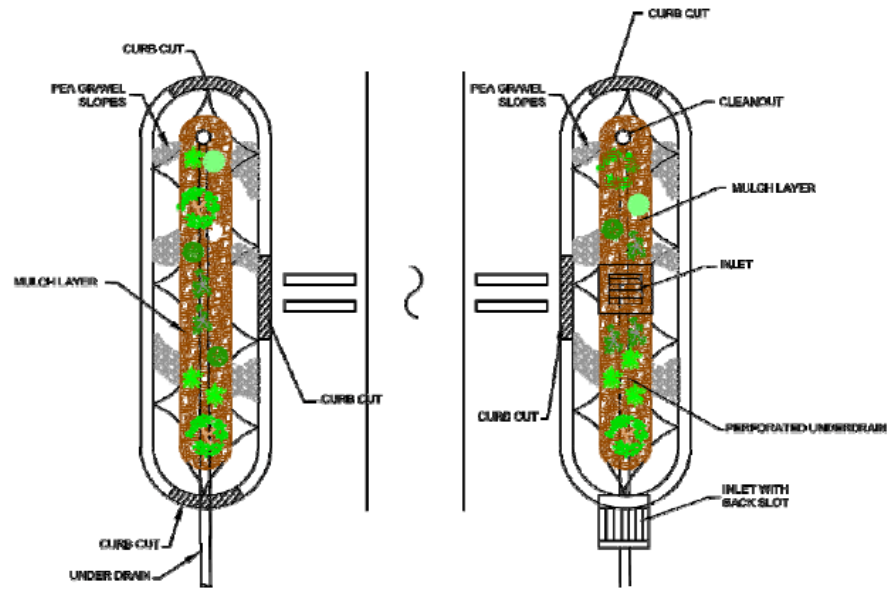
PROFILE

DA = /< 10 acre

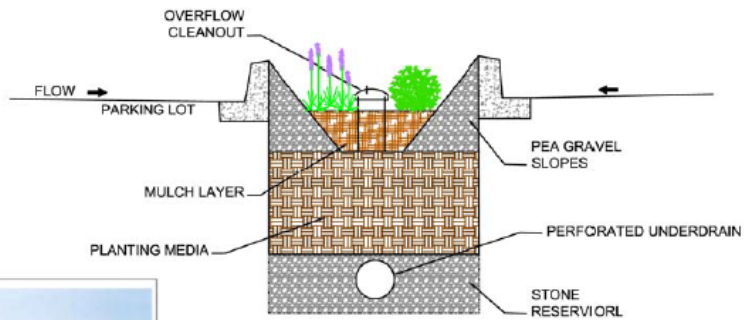
TYPICAL SECTION

Bioretention combines open space with stormwater treatment.

Figure 5.15 Micro-Bioretentation (Variation 2 - Parking Lot)



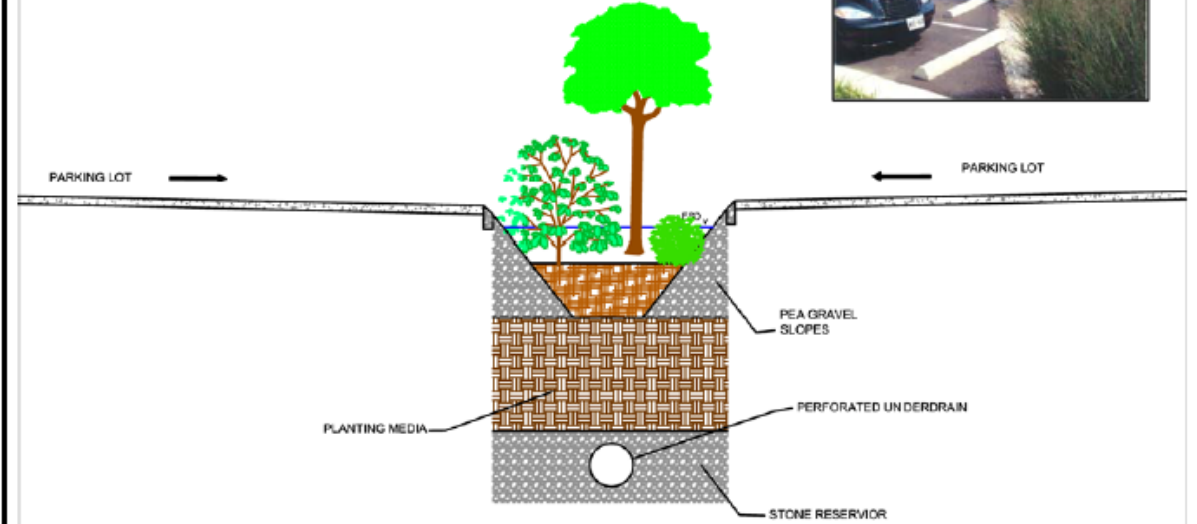
Plan View



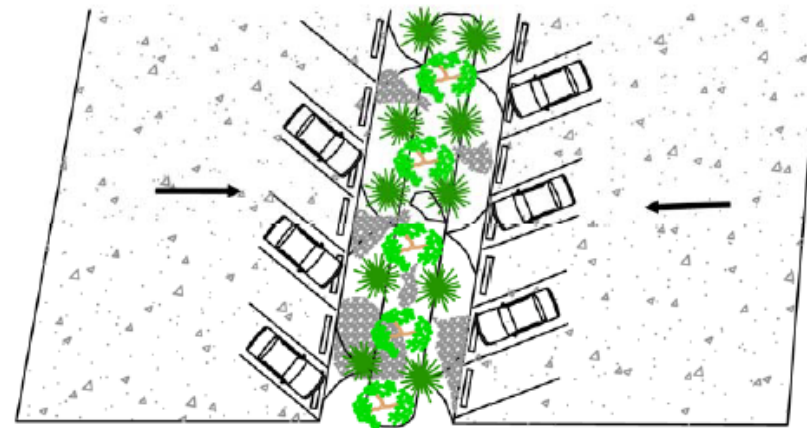
Section

Figure 5.16 Micro-Bioretentation (Variation 3)

DA = 0.5 / < acre, recommended



Profile



Plan View

# Rain Garden

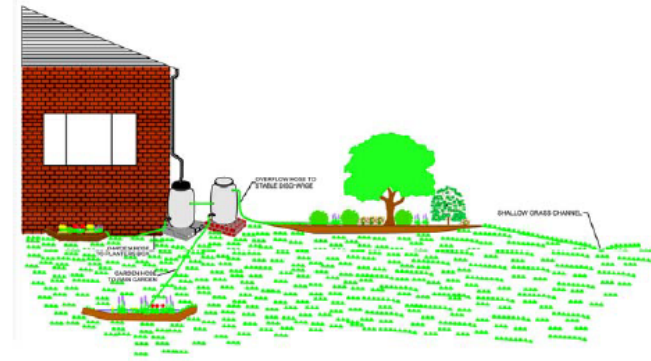
*The maximum drainage area to a rain garden for all other applications shall be 10,000 ft<sup>2</sup>. (0.25 ac)*

*The surface area ( $A_f$ ) of rain gardens shall be at least 2% of the contributing drainage area.*

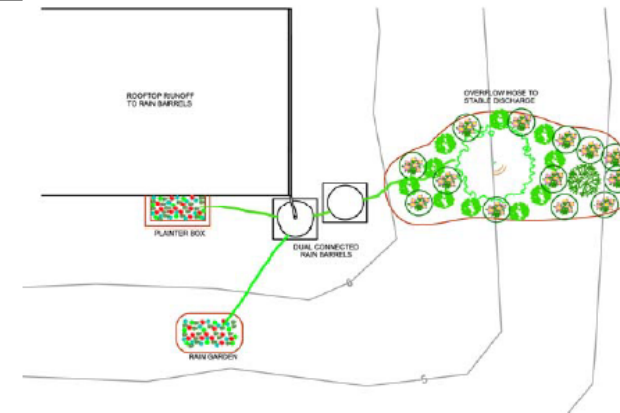
**Surface ponding depth of 6 inches or less.**

**Rain garden should be located in full to partial sun, at least two feet above the seasonal high water table and be 12 to 18 inches deep.**

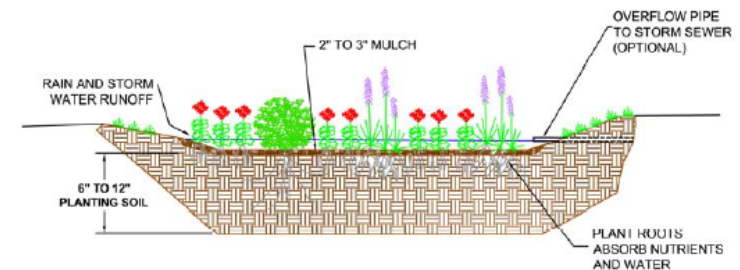
Figure 5.17 Rain Garden



Section



Plan View



Section



## DESIGN QUESTIONS

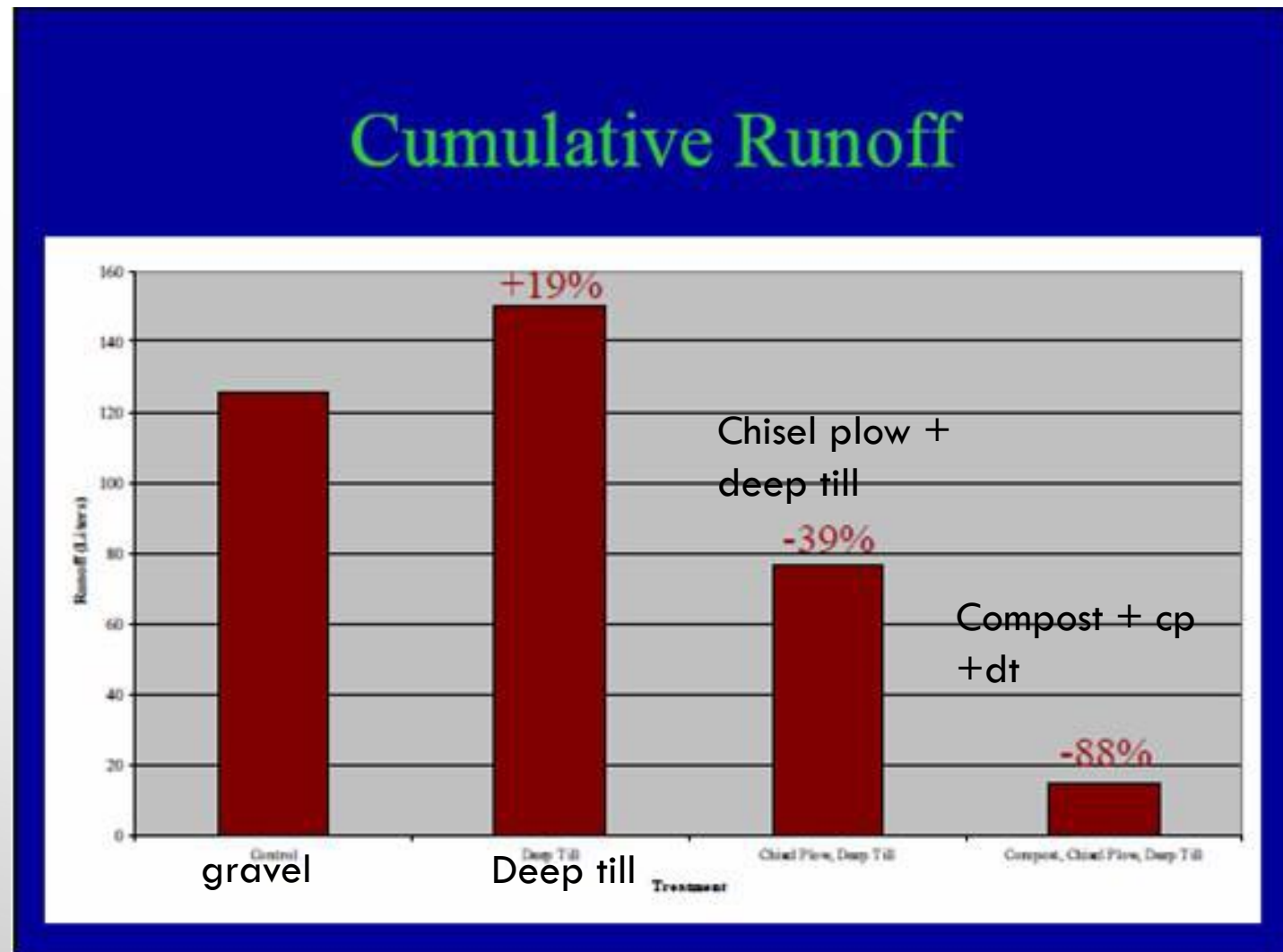
- ❖ What to do if a site contains good natural soils such as those included in the specifications.
- ❖ Situation where we are excavating and removing perfectly good natural soils such as sand loams, loamy sands or loams and replacing these soils with manufactured media is in conflict with sustainability criteria
- ❖ In these situations recommend using in-situ bioretention design approach which consists of excavating the bioretention site area for the required ponding depth, mixing 3-4 inches of well-aged organic material such as composted, leaf mulch, or double shredded pine fines, and planting the vegetation.
- ❖ This approach will meet the new design objective of simplicity of design, high life cycle and low construction and maintenance costs. (i.e. ecological engineering & landscape ecology)



## **DESIGN QUESTIONS**

- ❖ **Moderately and Poorly Drained Soils.**
  - **What do we do on sites with moderately or poorly drained soils?**
  - **Do we excavate and replace with engineered bio-soils?**
- ❖ **Recent research such as illustrated in Figure 1 (Balousek, 2003) indicates that the infiltration properties of soils can be improved through physical treatment (i.e., ripping and soil chiseling), addition of organic materials and addition of native plant materials.**
- ❖ **Professor Frank Gouin, Dean, School of Horticulture, UMD gave us the approach to use.**

- Ongoing research such as illustrated in Figure 1 (Balousek, 2003) indicates that the infiltration properties of soils can be improved through physical treatment (i.e., ripping and soil chiseling), addition of organic materials and addition of native plant materials.





## DESIGN QUESTIONS

- ❖ **Are there soils that are not suited for In-situ?**
- ❖ **Still developing this data, but so far these soil types have been identified;**
  - **Hydric soils with high water tables (use wetland BMPs)**
  - **Heavy clays subject to slippage failure**
    - **Marlboro clay**
    - **Christiana clay**
    - **Howell clay**
  - **Sallow soils underlain by rock**
  - **Soils contaminated with toxics**



## **GOUIN IN-SITU APPROACH**

- ❖ **The porosity of compacted soils and clay soils can be improved considerably by incorporating organic matter deeply into the soil.**
- ❖ **Soil compaction is often the primary cause of plant failures in landscapes. The roots of plants cannot penetrate soils with greater than 85% compaction. Thus, if roots cannot grow, plants cannot survive and thrive.**
- ❖ **The best source of organic matter is mature compost. Mature compost is not only rich in plant nutrients and humic acid but contains high concentration of lignins which resist decomposition.**
- ❖ **Because the nutrients exist as organics, the bodies of micro-organisms, they are released slowly through a process known as mineralization.**
- ❖ **The humic and fulvic acids in the compost assist in granulating clay particles while the lignins in the compost reduce the bulk density of soils and have a wicking action on gravitational and capillary waters.**



### GOUIN IN-SITU APPROACH

#### METHOD

- First, test soil to determine if liming materials are needed to adjust the pH and to provide additional calcium
- The liming materials are applied first followed by an equivalent of 50 dry tons of mature compost per acre over the area to be treated.
- Fifty dry tons is equivalent to approximately 4 cubic yards per 1,000 sq. ft.
- The soil should not be tilled unless it is dry
- The amendments should be rototilled into the soil as deeply as possible, a minimum of six inches. Immediately following tilling, sub-soil using a chisel sub-soiler adjusted to penetrate the soil a minimum of (14") or deeper.
- Sub-soil at (18" - 20") intervals traveling across the slope. Next sub-soil up and down the slope at the same depth and spacing.
- Next apply 25 dry tons of compost per acre, (2 c.y. per 1,000 sq. ft.) over the sub-soiled area and rototill again in preparation for planting.



## **DESIGN CRITERIA: INFILTRATION RATES**

### **❖ Permeable Soils:**

**Native soils with K values  $\geq$  0.52 "/hr, use field measured value (Note: Could improve)**

### **❖ Low Permeability Soils & Clays**

**When Gouin in-situ method is used use default value of 0.52"/hr (Note: Also could improve)**



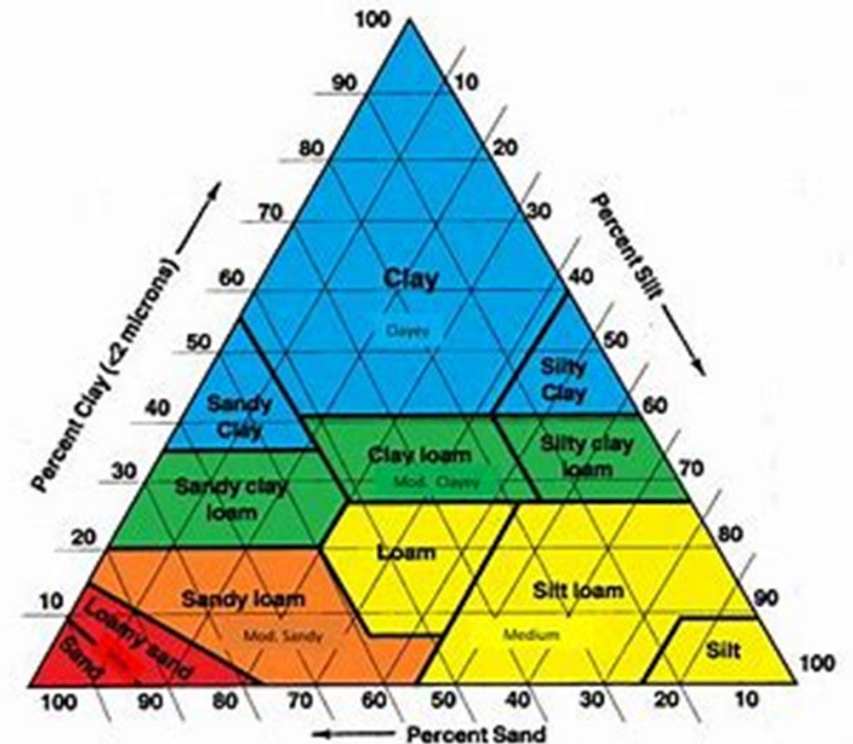
### OBSTACLES TO IN-SITU DESIGN

- ❖ **Regulatory agencies (State, County, tons) do not have guidance for this practice**
- ❖ **Sadly, I may currently be the only practitioner & source of guidance**
- ❖ **In-situ bioretention, based on ecological engineering & landscape ecology, is on the leading front of current technology. This technology is very new and we have much to learn**
- ❖ **2 approaches:**
  1. **Many in-situ practices disturb < 5,000 sf and are exempt from SWM control ( May still need E&S plan)**
  2. **Partner with local regulatory agency and create a demo project (i.e, Trust campus & City of Annapolis)**



### OBSTACLES TO IN-SITU DESIGN

- ❖ Many engineers are not trained or comfortable w/ design of infiltration practices
- ❖ There is a general opinion that HSG 'D' soils are not suited for infiltration
- ❖ Dr Davis at UMD recently tested some D soils in the Anacostia watershed and found that they met  $F=0.52$





## Determining Infiltration Rate

- ❖ Regulatory agencies typically establish infiltration testing methods
- ❖ Single ring and double ring test methods are most common
- ❖ For in-situ design, a mini-infiltrometer test is rapid and inexpensive (i.e. Turf-Tec International)





### LANDSCAPING & PLANT MATERIALS

**Landscaping Criteria.** Landscaping is critical to the performance and function of an in-situ bioretention area; key planting parameters are summarized below.

- **Dense vegetation (100% coverage)**
- **Native plant species a must.**
- **Vegetation should be selected based on hydric tolerance.**
- **Deep rooted native grasses a must**
- **A healthy mix of native perennials, minimum 3-species.**
- **A mixture of trees & or hardy shrubs & herbaceous materials recommended**
- **Signage must be provided identifying the facility to the public.**





### LANDSCAPING & PLANT MATERIALS

- ❖ Many bioretention practices are placed in roadside urban areas which present very stressful conditions for plant materials
- ❖ We have very little data on which plants do best
- ❖ I would like to encourage joint research between CBT, MDE and UMD on plant performance
- ❖ Great research project for grad LA students





## **MONITORING & MAINTENANCE**

❖ **Maintenance and Monitoring Criteria.** In general the inspection guidelines for in-situ bioretention facilities provided in MDE manuals ( 2000, 2007) should be followed. Key parameters and other unique criteria are summarized below.

- **Inspect plants and structural components periodically (at least annually).**
- **Grasses shall be cut back in the spring before the emergence of new growth.**
- **Dead or diseased plant material shall be replaced.**
- **Remove sediment and clear debris from points of inflow.**
- **Replacement of mulch is not required where dense plant growth exists.**
- **Provide visual monitoring reports, from a registered professional, of the in-situ bioretention system semi-annually for 3-years.**

**NOTE: Document plants that have survived and thrive**



### O & M PRACTICES

- ❖ Due to simplicity of design, in-situ practices have minimal O&M requirements and lower costs

#### MAINTENANCE SCHEDULE FOR RAIN GARDEN AREAS

DESCRIPTION	METHOD	FREQUENCY	TIME OF YEAR
<i>SOIL</i> Inspect and Repair Erosion	Visual	Annually until plant materials provide stable cover	Spring and Fall
<i>ORGANIC LAYER</i> Remulch as needed until plants provide adequate ground cover	By hand	Annually until plant materials provide stable cover	Spring
<i>PLANTS</i> Removal and replacement of all dead and diseased vegetation considered beyond treatment	See planting specifications Mechanical or by hand	Twice a year	Mar. 15 – Apr. 30 and Oct. 1 –Nov. 30 Varies; Depends on insect or disease infestation
Watering of plant material shall take place at the end of each day for fourteen consecutive days after planting has been completed	By hand	Immediately after project completion	Whenever needed
Replace stakes after one year	By hand	Once a year	Only remove stakes in spring



### COST BENEFITS

- ❖ **In-situ construction & O&M costs are approximately 25-40% of conventional bioretention costs**
- ❖ **Excavation and soil disposal: 2 feet —instead of 5 feet (60% reduction)**
- ❖ **Eliminate need to bring in man-made bioretention soils ( \$100/cy)**
- ❖ **Generally eliminate need for stone reservoir and under drains**

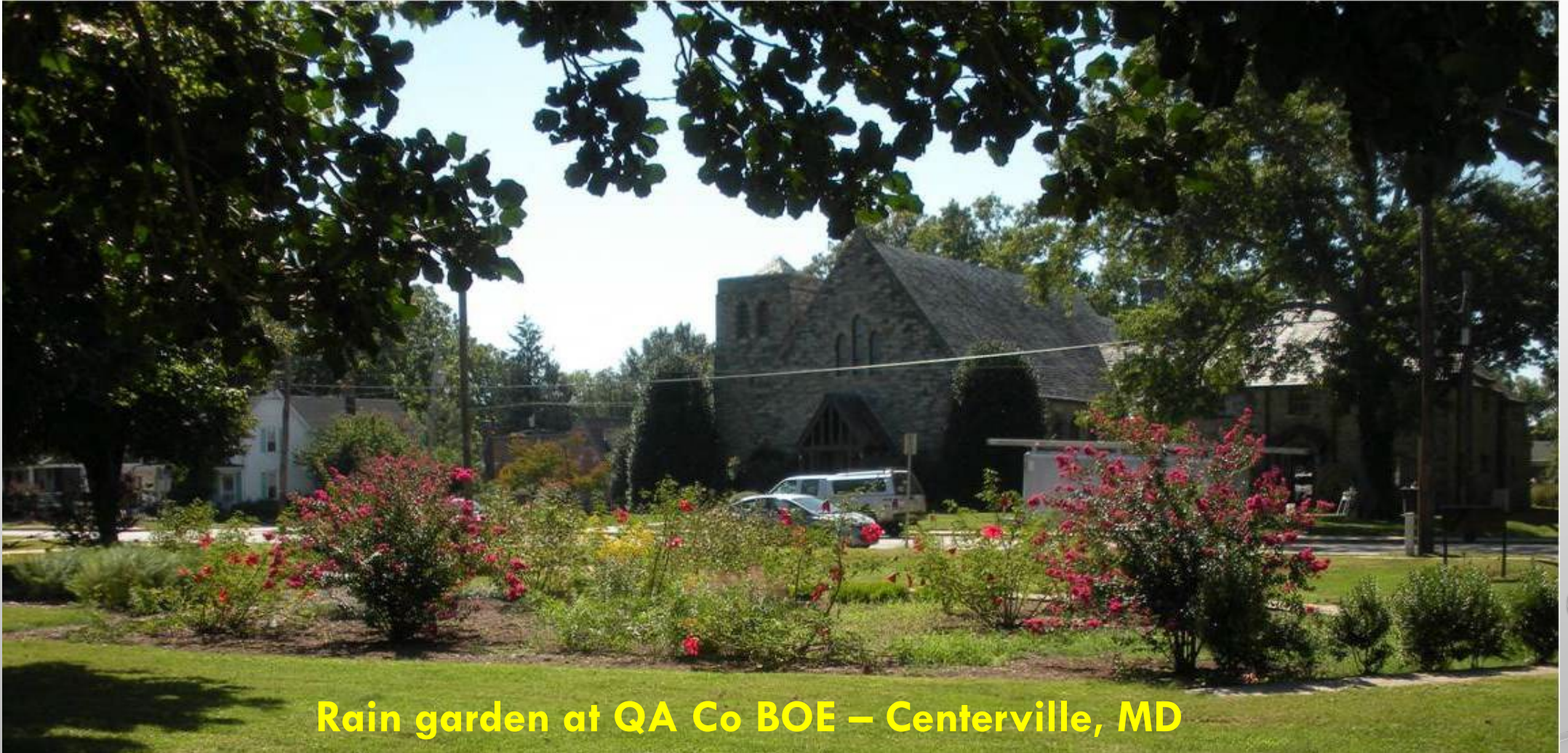




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**Rain garden at QA Co BOE – Centerville, MD**



## Questions for Mike?

- Raise hand
- Add to chat





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❖ **REFERENCES**

**Balousek**

**Clar**

**Clar, McCuen, 1983**

**Rawls, 1982**

**Ayres (2009**

**Gouin**

**MDE 200, 2005**

**Davis**