

# Peculiarities of Pervious: Hydrologic Function in the Urban Landscape

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# Overview

Standard Construction Practices Decouple Form and Function of Urban Landscape

Connectivity and Runoff Production Vary in Space and Time

Equifinality in Watershed Discharge

Hydrologic Function not Reliably Predicted from Form

Variable Urban Source Areas

# Disturbed Urban Soils

- Styles of Development
- Intensity of Disturbance





# Sustainable Urban Soils

- Disturbed Compacted Soil from “standard development practices”
- Form & Function Decoupled





Standard Landscape Development Practices



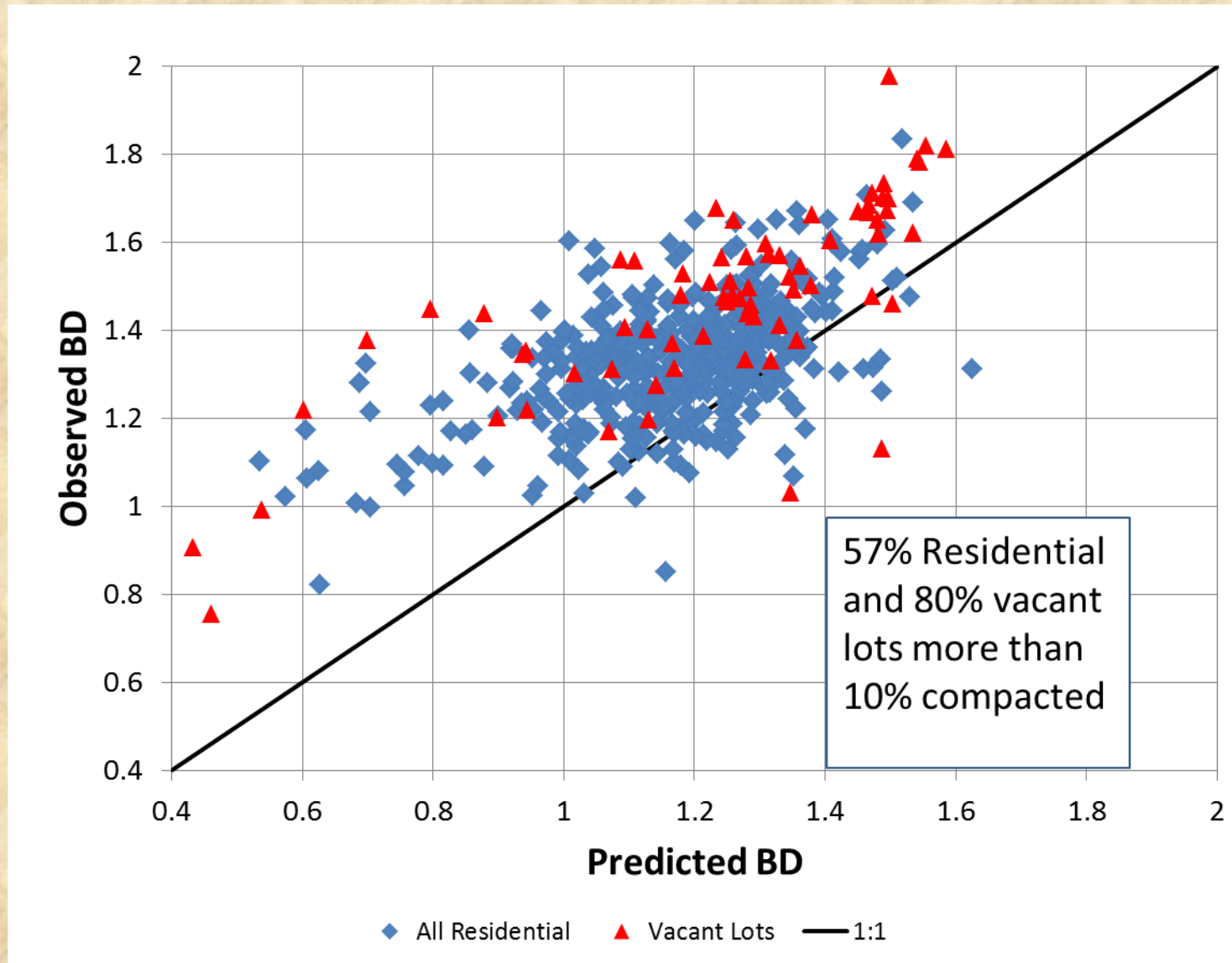






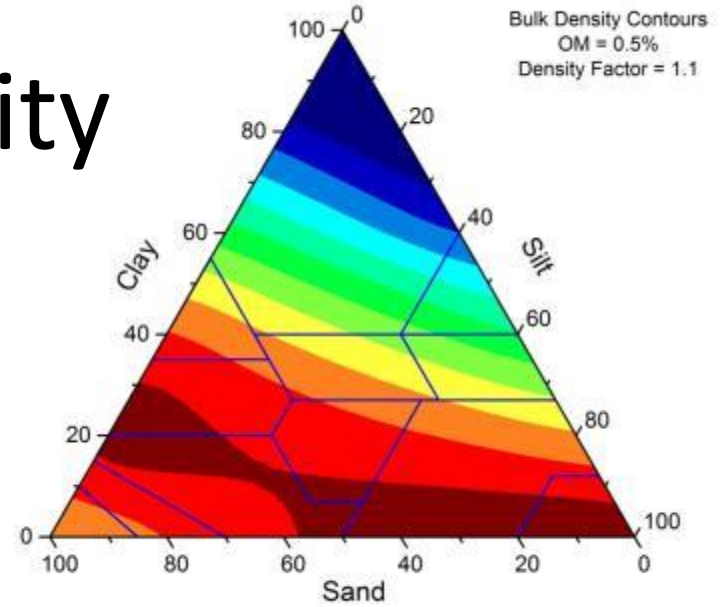
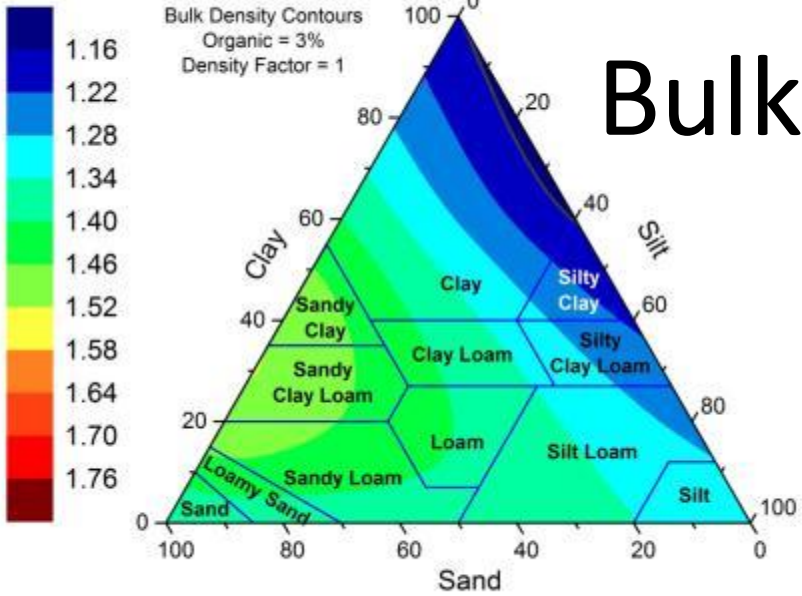


# Relative Compaction - Baltimore Urban Soils

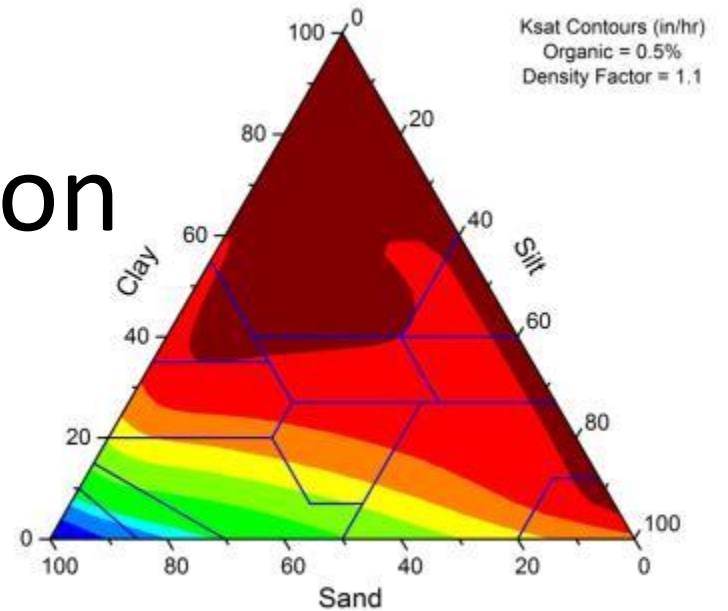
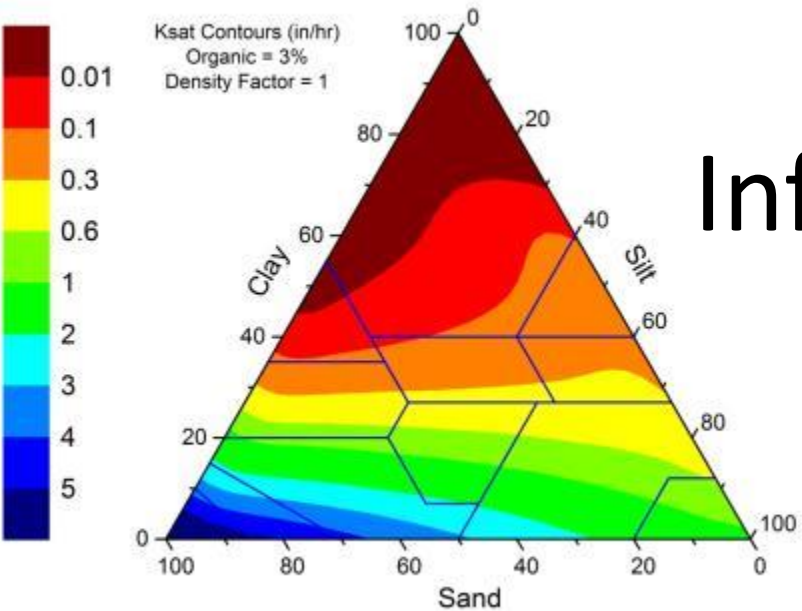




# Bulk Density

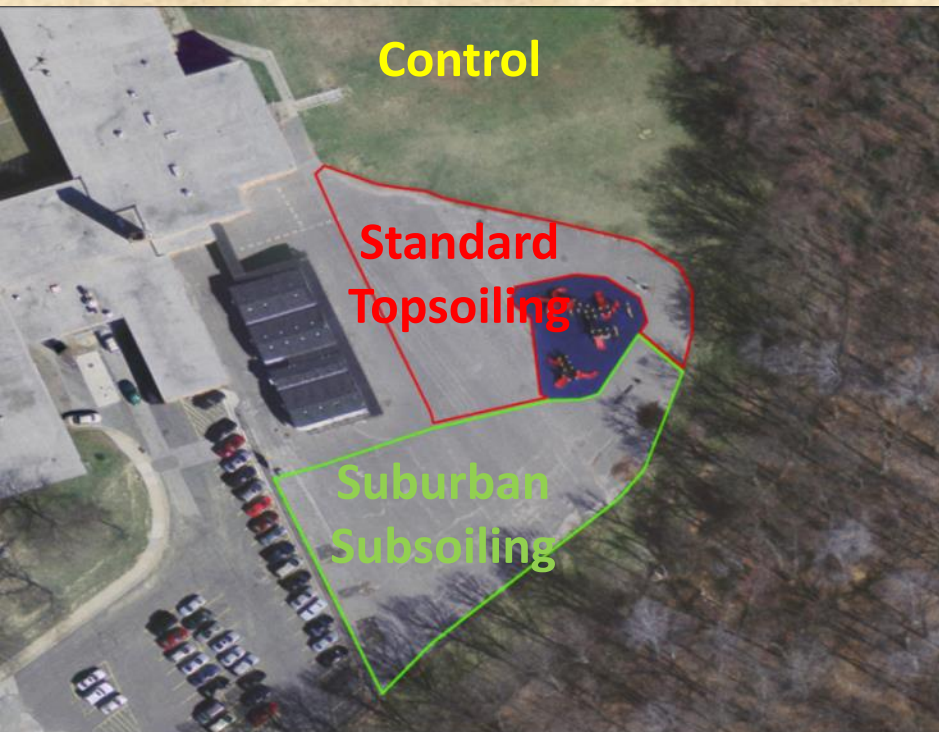


# Infiltration



# Yorkwood Elementary School

Baltimore City impervious area removal project

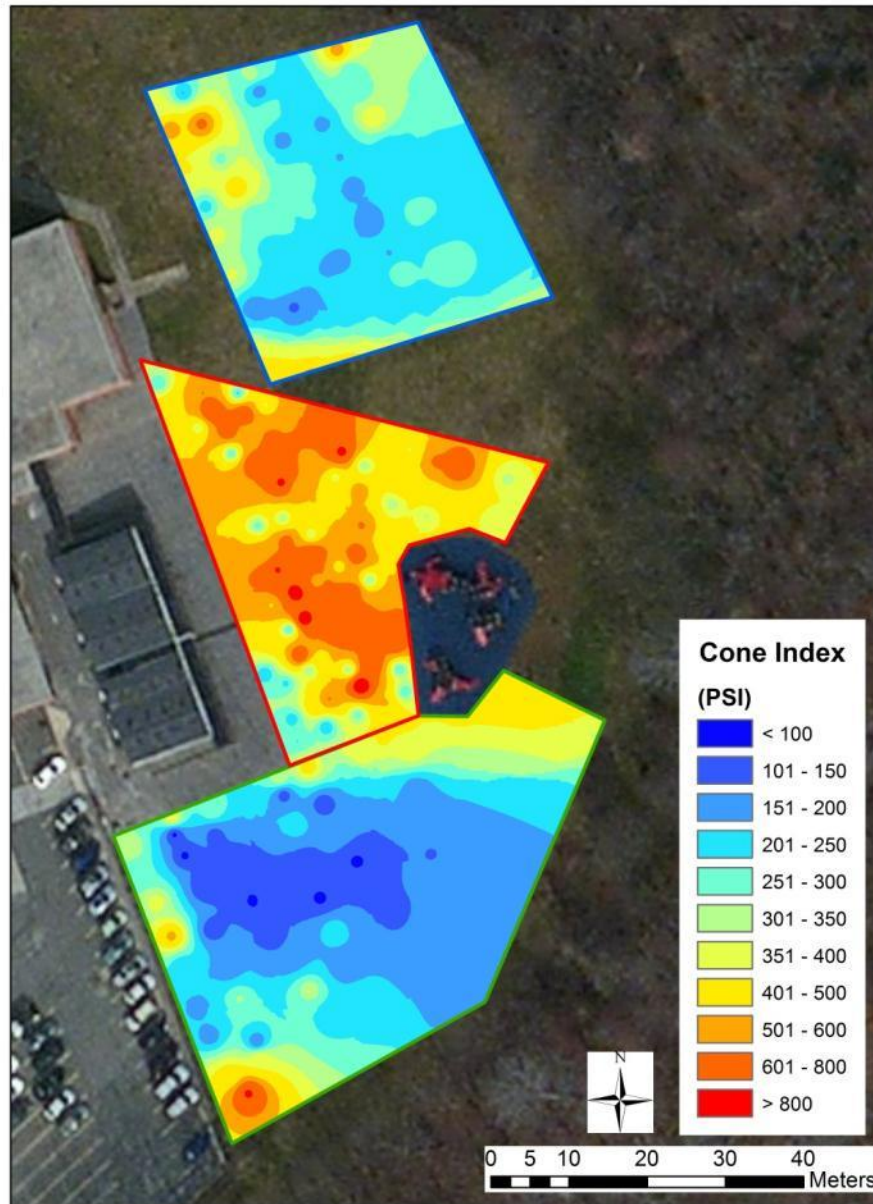




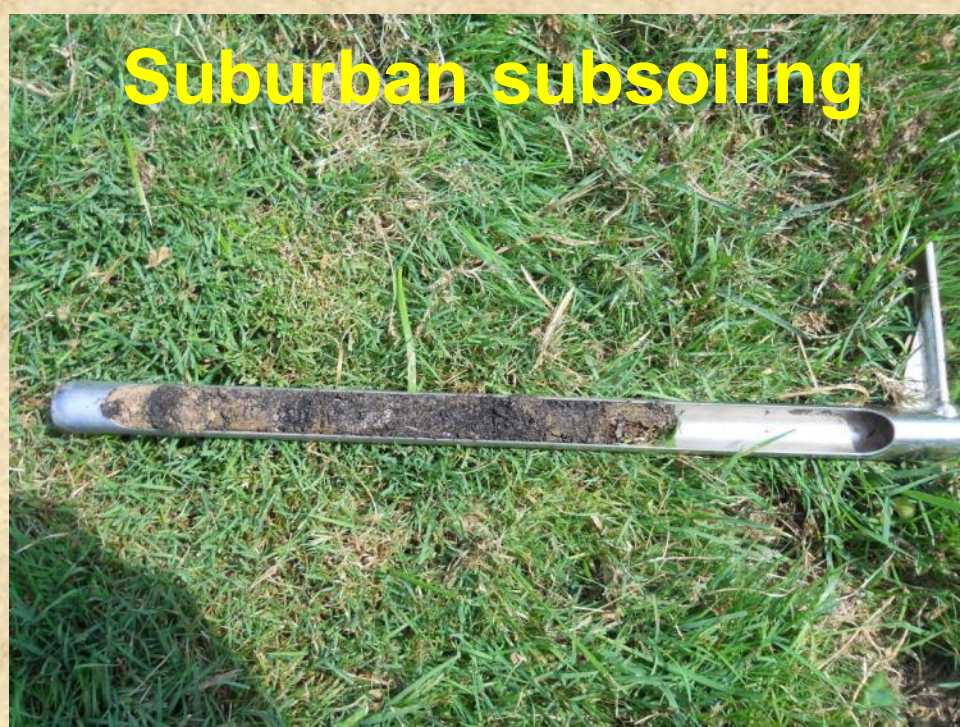
**Control**

**Standard  
Topsoiling**

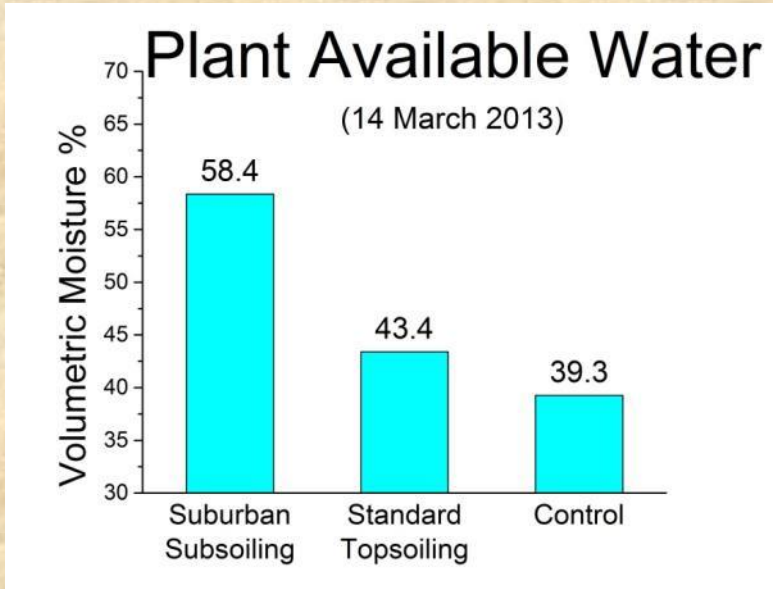
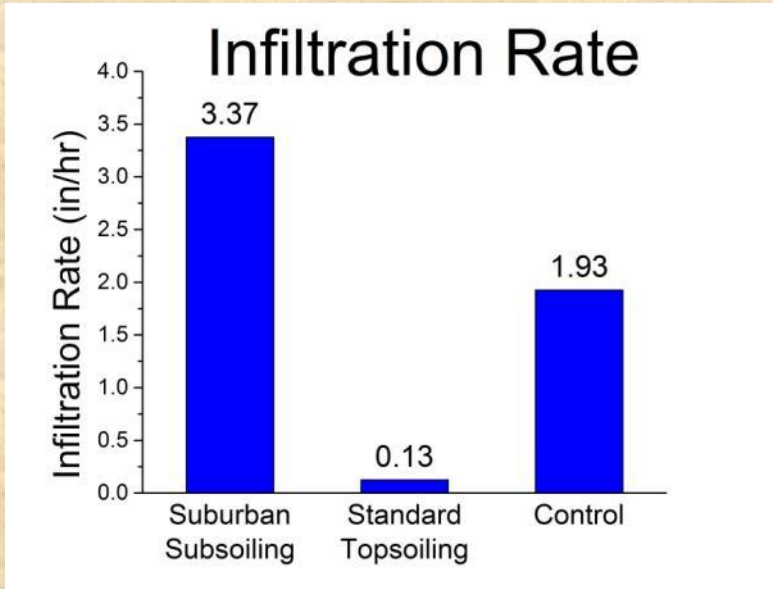
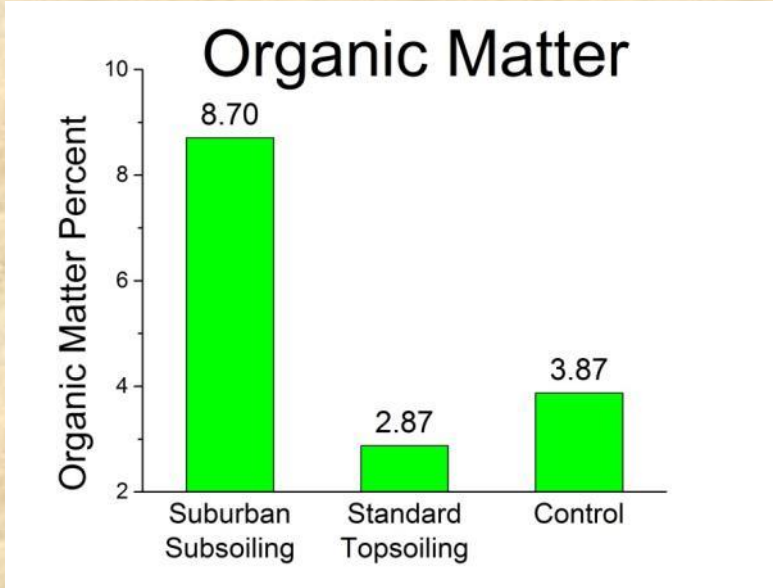
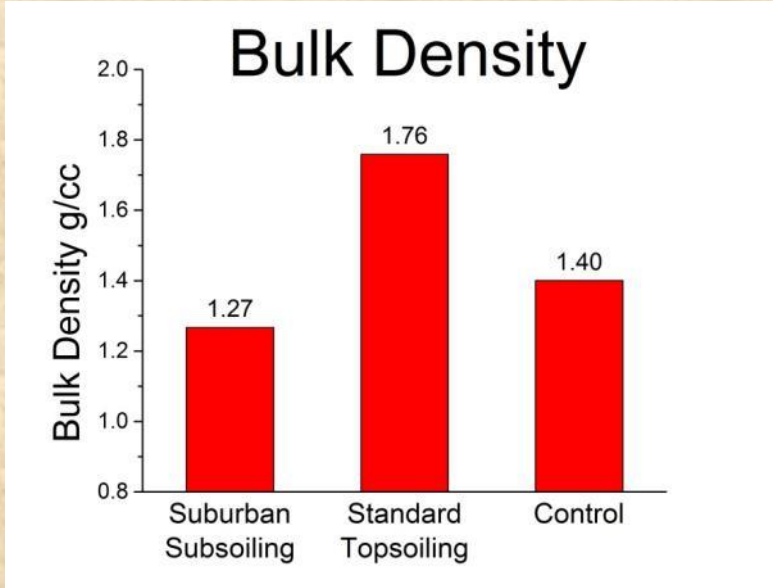
**Suburban  
Subsoiling**











# Characterizing Hydrologic Function

Soil HSG + Landuse = Hydrologic Function

Table 2-2a Runoff curve numbers for urban areas <sup>1/2</sup>

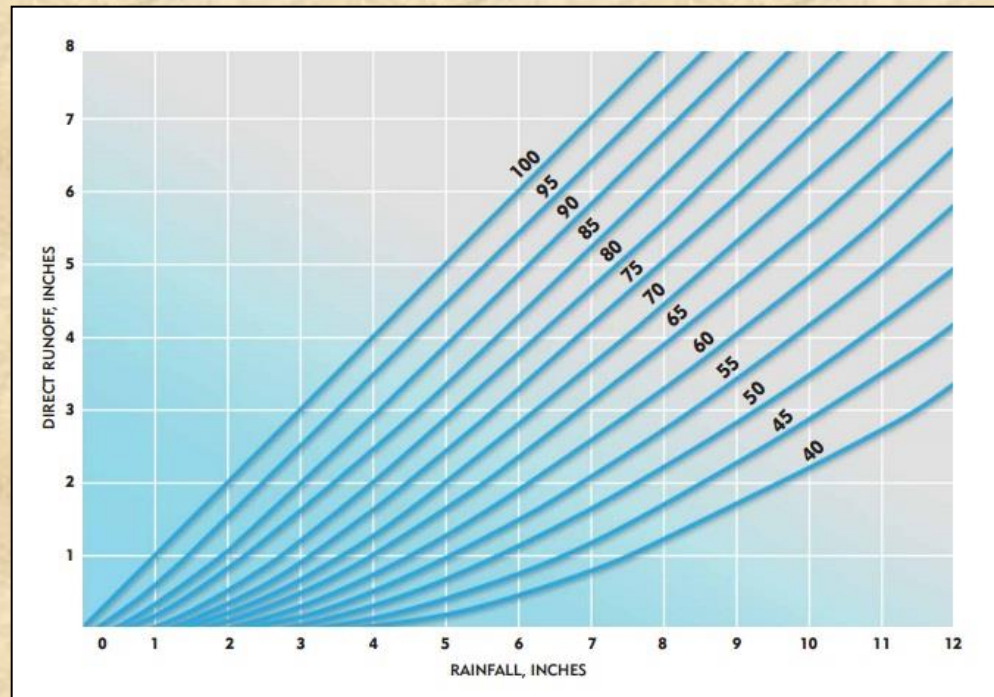
Cover description	Average percent impervious area <sup>3/4</sup>	Curve numbers for hydrologic soil group			
		A	B	C	D
<b>Fully developed urban areas (vegetation established)</b>					
Open space (lawns, parks, golf courses, cemeteries, etc.) <sup>3/8</sup> :					
Poor condition (grass cover < 50%) .....		68	79	86	89
Fair condition (grass cover 50% to 75%) .....		49	69	79	84
Good condition (grass cover > 75%) .....		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way) .....		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way) .....		98	98	98	98
Paved; open ditches (including right-of-way) .....		83	89	92	93
Gravel (including right-of-way) .....		76	85	89	91
Dirt (including right-of-way) .....		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) <sup>3/8</sup> .....		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) .....		96	96	96	96
Urban districts:					
Commercial and business .....	85	89	92	94	95
Industrial .....	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses) .....	65	77	85	90	92
1/4 acre .....	38	61	75	83	87
1/3 acre .....	30	57	72	81	86
1/2 acre .....	25	54	70	80	85
1 acre .....	20	51	68	79	84
2 acres .....	12	46	65	77	82

**Developing urban areas**

Newly graded areas (pervious areas only, no vegetation) <sup>3/8</sup> .....

	77	86	91	94
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Idle lands (CN's are determined using cover types similar to those in table 2-2c).



Sustainable Sites Initiative (SSI)



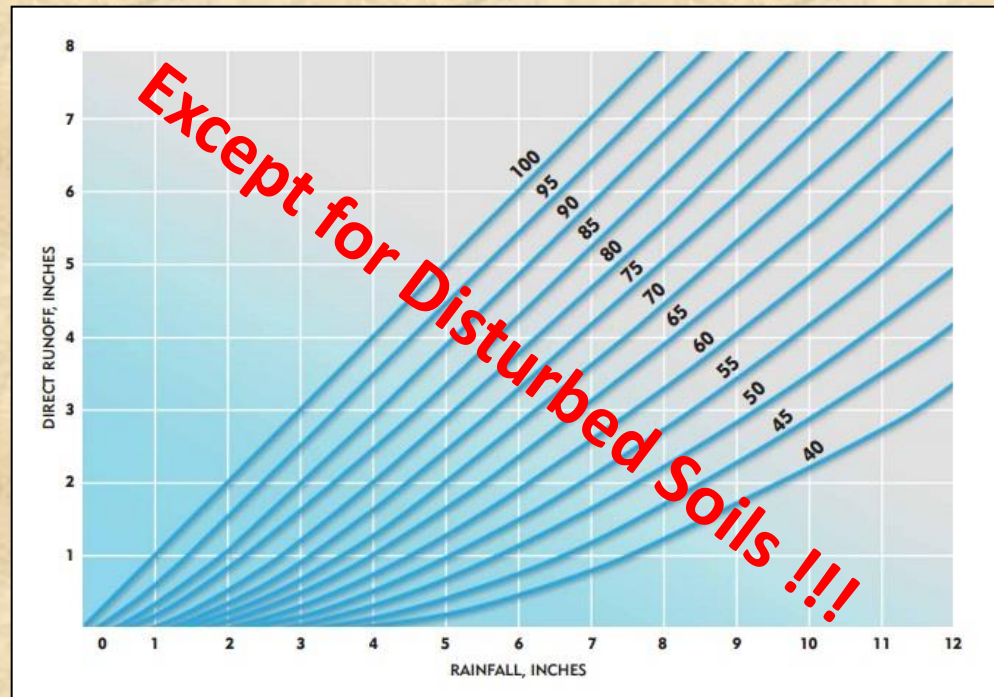


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Sustainable Sites Initiative (SSI)

# Infiltration Capacity & Performance

$\Delta$ HSG &  $\Delta$ CN *not enough!*

## NEH 630.0702 Disturbed Soils

As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, *nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed soil.* In these circumstances, *an onsite investigation should be made* to determine the hydrologic soil group.

.....

HSG	A	B	C	D
Impermeable layer 20-40" deep	> 5.67	>1.42	>0.14	≤0.14
Impermeable layer > 40" deep	>1.42	>0.57	>0.06	≤0.06

- **Infiltration + Drainage**: Depth to Shallowest Confining Layer
- A/D Soils
- BMP vs. Soil profile Infiltration



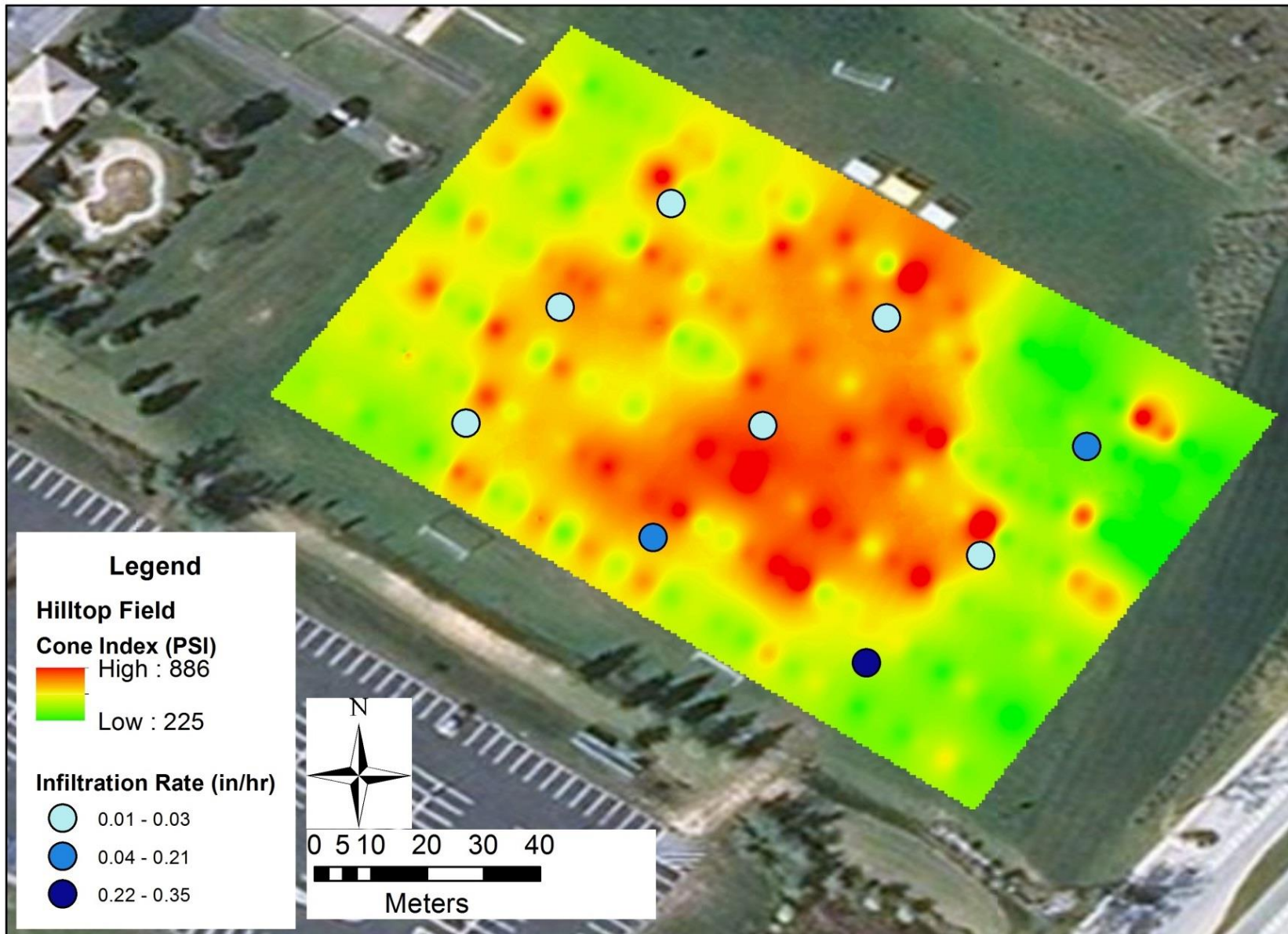
# Characterizing Infiltration: Hilltop Athletic Field

## Open Space in Good Condition – Conservatively Assume D Soils



**Table 2-2a** Runoff curve numbers for urban areas <sup>1/</sup>

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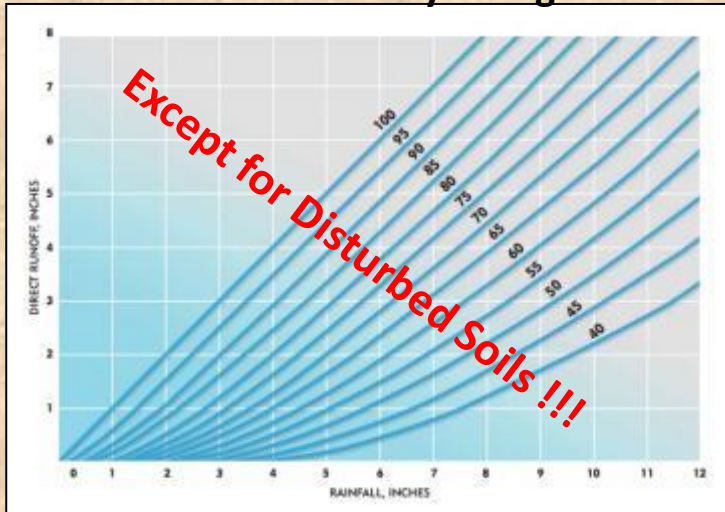
# Profile of a Disturbed Soil



08/15/2010 19:00

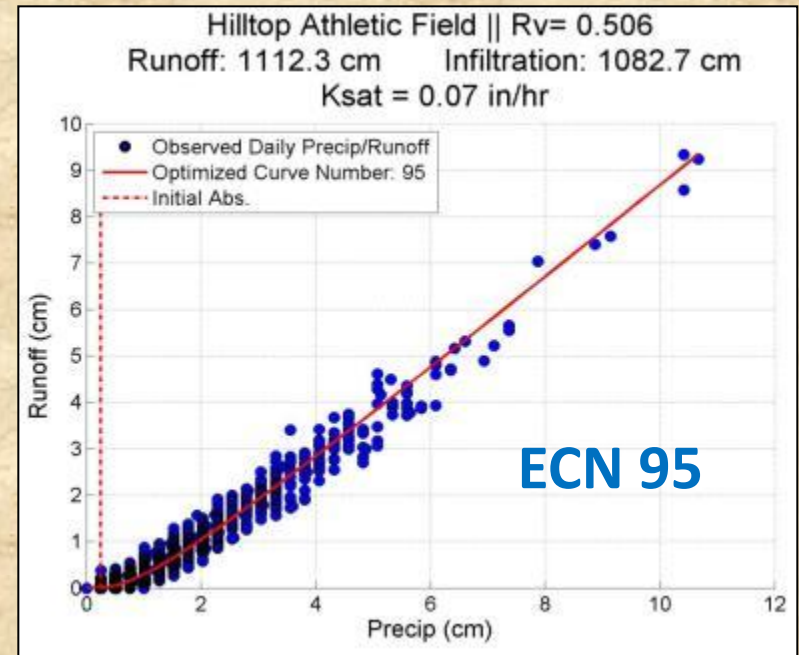
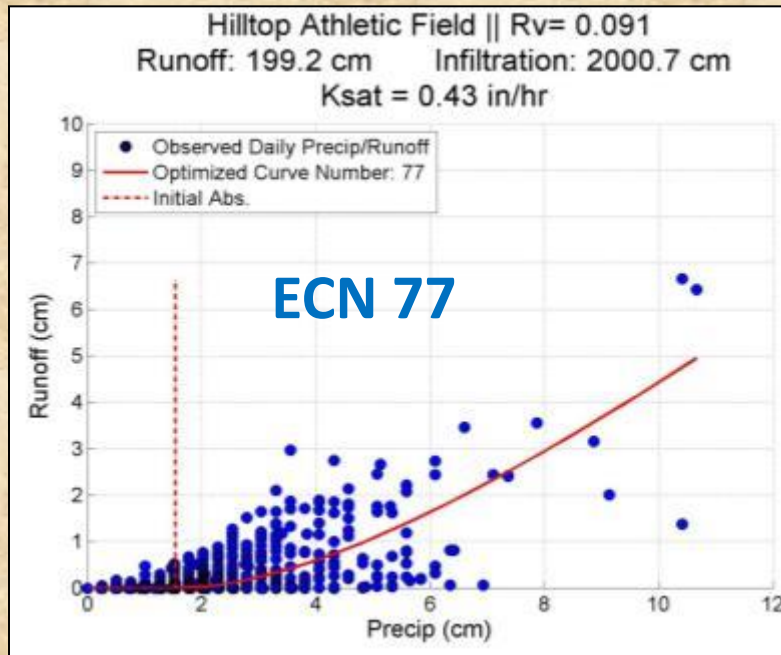
# Characterizing Hydrologic Function: ECN

Soil HSG + Landuse = Hydrologic Function



## 24 Year Continuous Simulation

Greenbelt, MD  
1984 – 2007  
15 minute rainfall

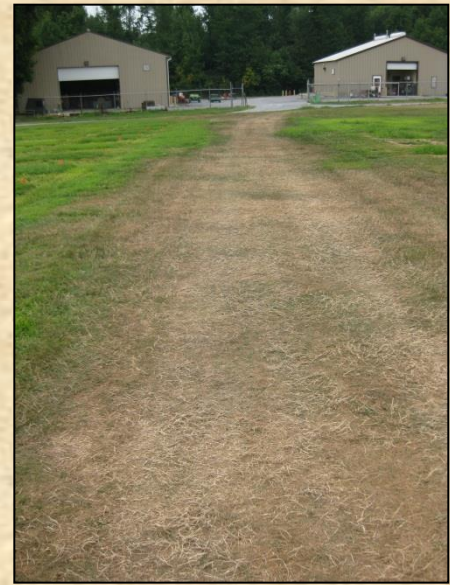






Oregon Trail near Baker Oregon

## “Natural” Solutions



Paint Branch, MD Turf Grass Research Center



Santa Fe Trail near Ft. Dodge KS Outside  
of Dodge City ~130 years old.



Hunt Valley Recreational Fields



# Simple Solutions & Urban Infiltration

*Tree Roots Decompact Urban Soils*



*“Even grows on pavement”*



Open space in Good condition on D soils?



# Conclusions – and simple solutions

Decoupled Urban Form and Function

Variable Urban Source Areas

Space-Time Heterogeneity in Runoff/Load Production

Equifinality in Urban Watershed Discharge

Hydrologic *Function* not Reliably Predicted from Form



*“...there is always a well-known solution to every human problem — neat, plausible, and wrong.”*

**- H.L. Mencken**

Thanks!



# What Matters for Stormwater?

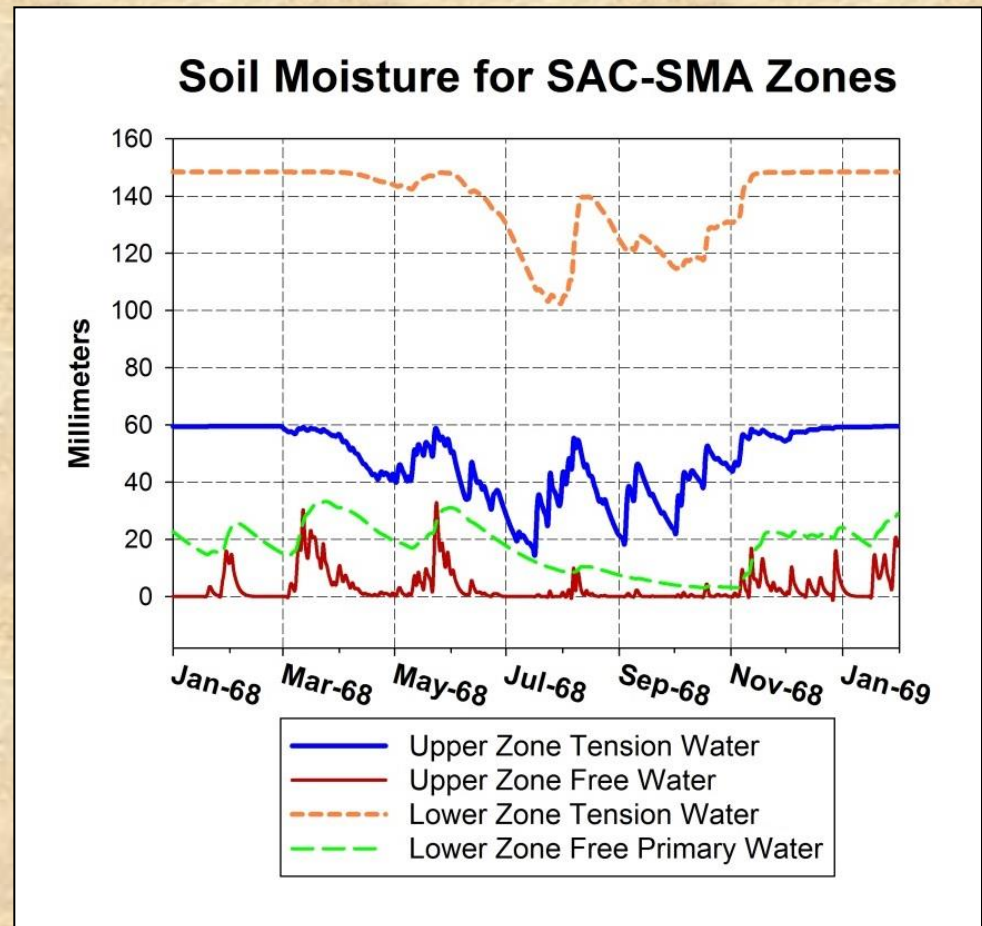
➤ Infiltration Capacity  $K_s$

Why  $K_s$ ?

What about . . . .

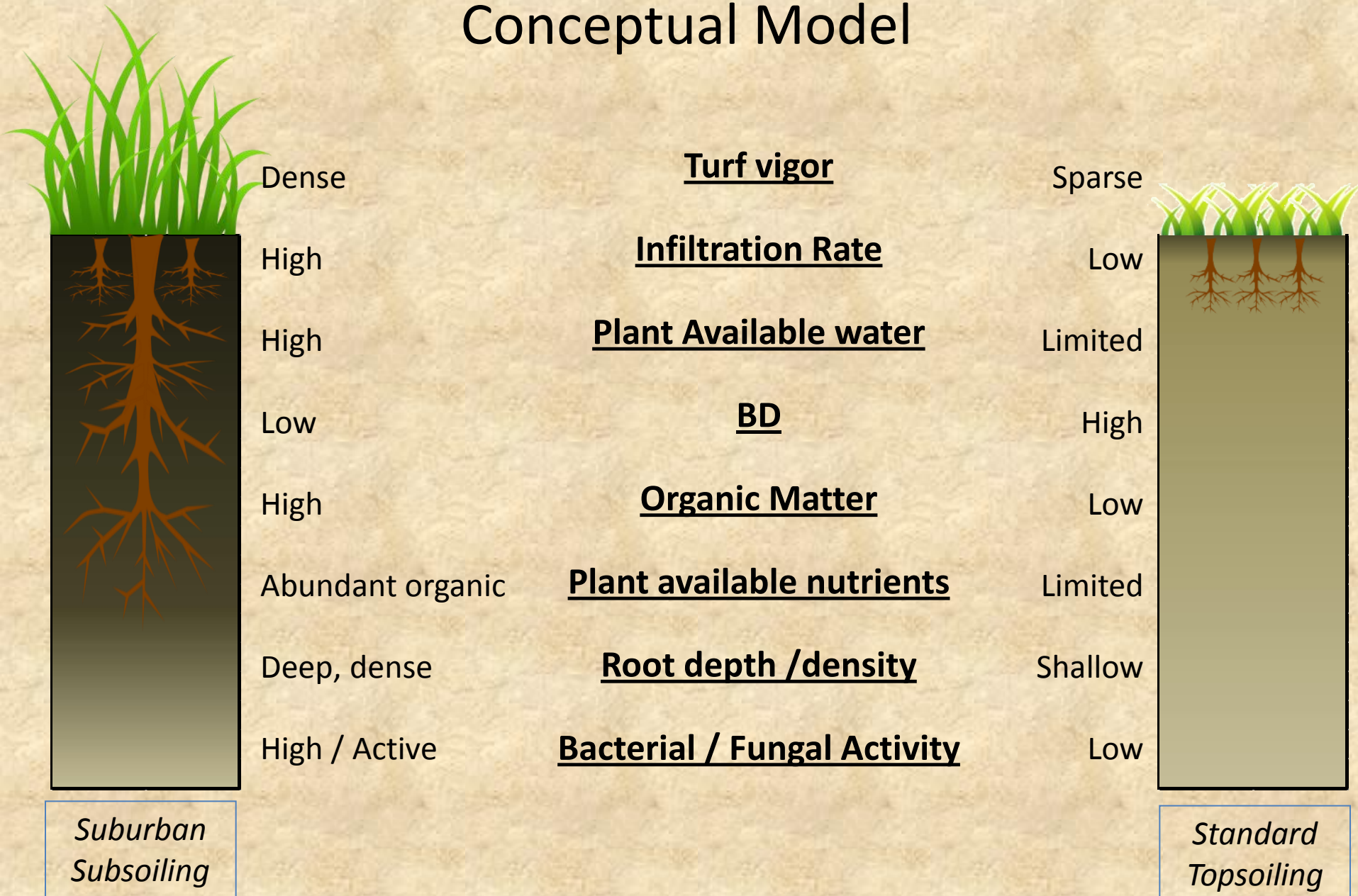
Dry thirsty soil?

Seasonal Capillarity



# A tipping point of sustainability?

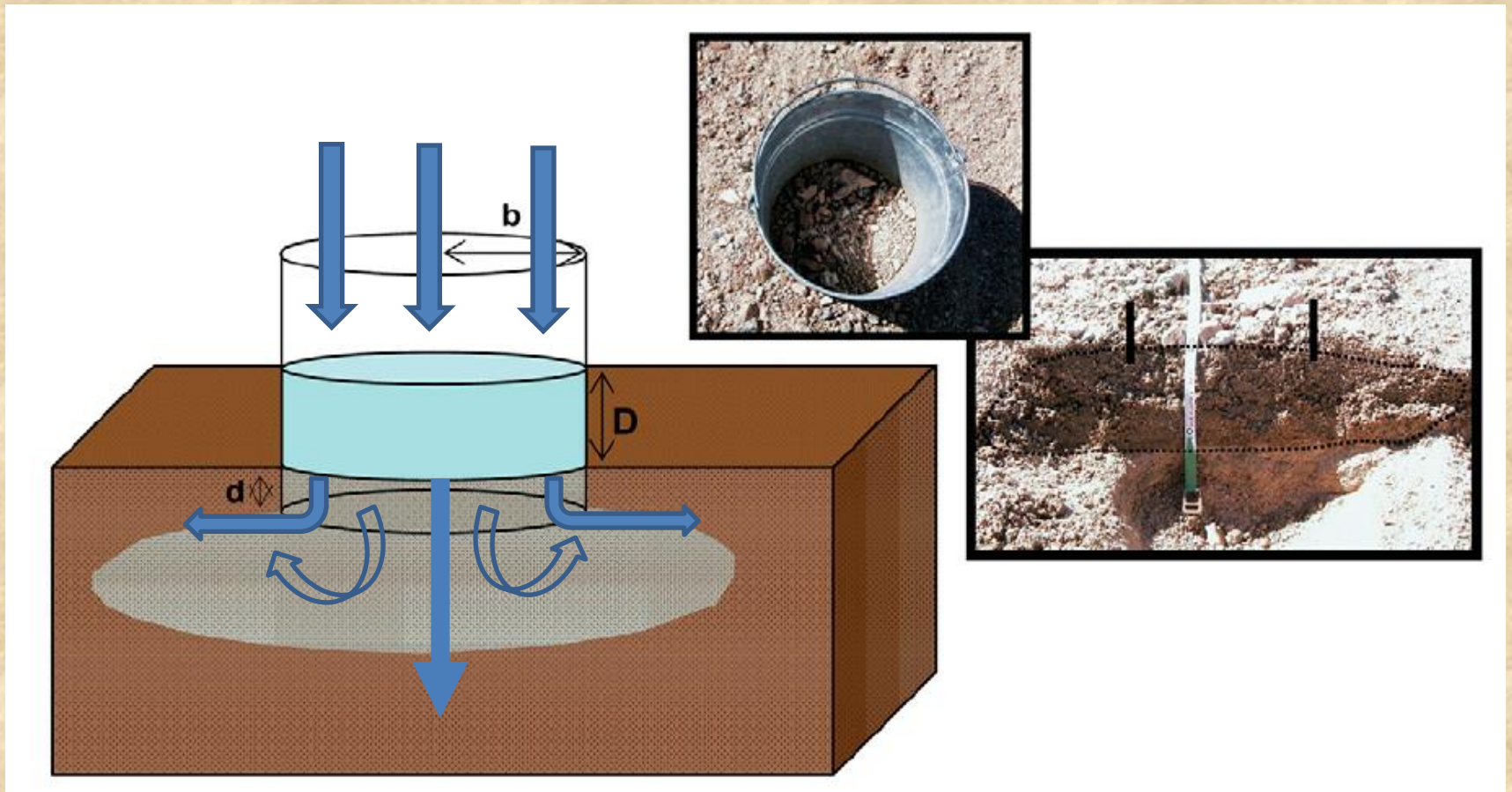
## Conceptual Model



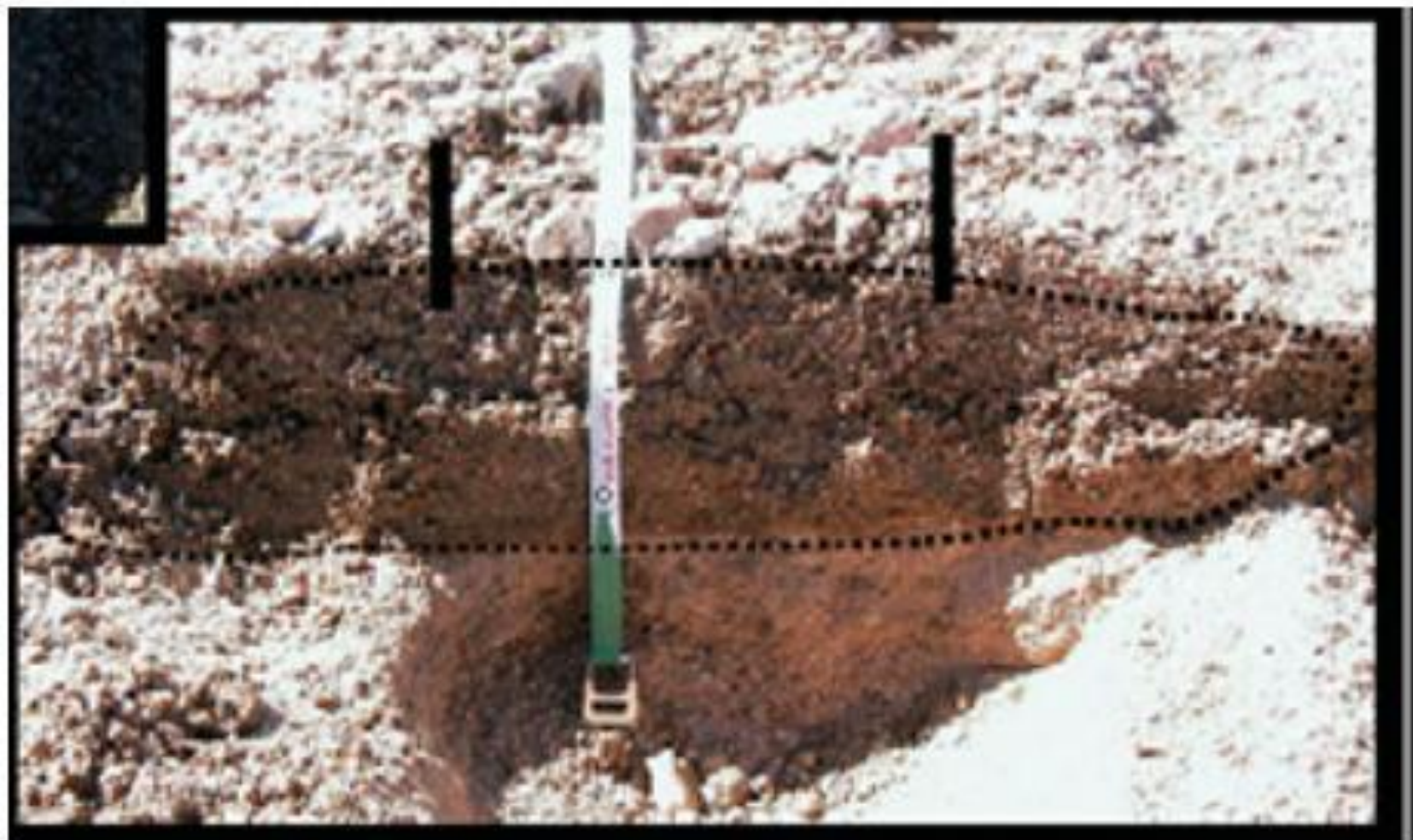


# What is infiltration?

Movement of water from surface into the subsurface



Account for: geometry, pressure head, lateral flow, capillarity, soil moisture





Enhanced  
Water Holding  
Capacity and  
Plant Available Water

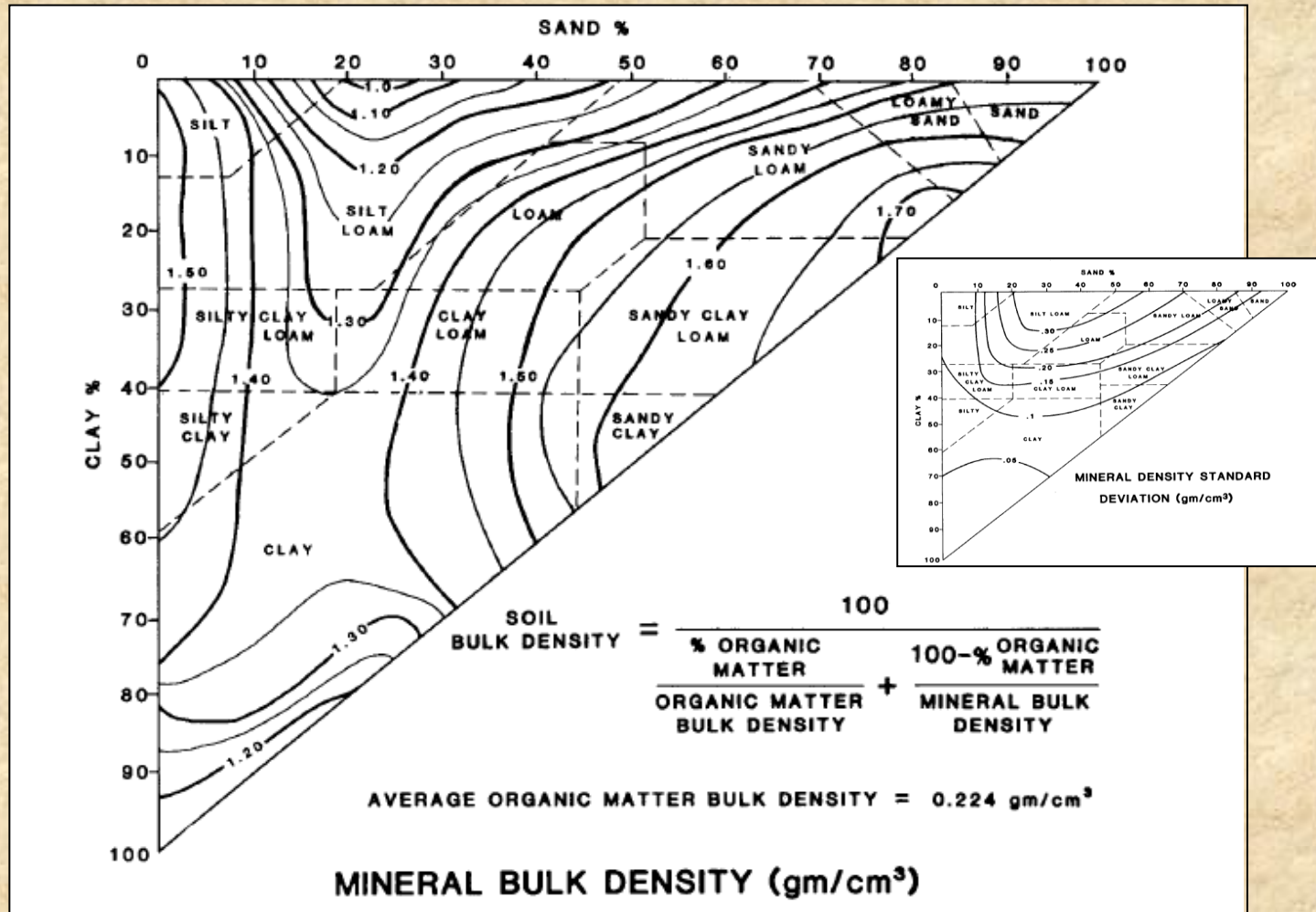
Healthier  
Deeper-Rooted  
Drought Resistant  
Turf

Yorkwood Elementary Soil Moisture Survey



# So What Can We Do?

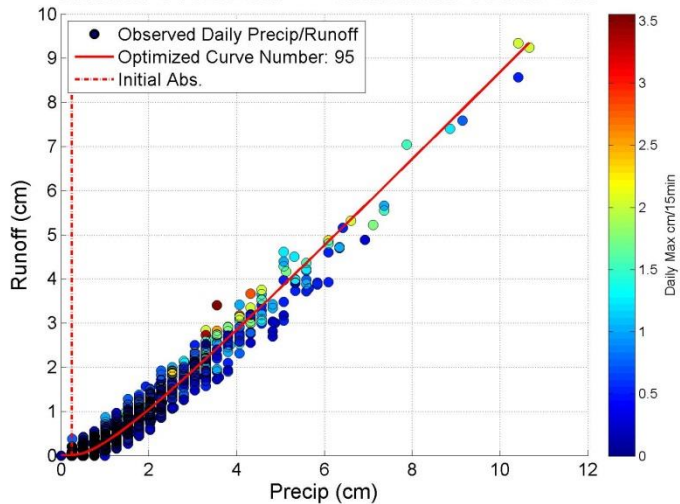
## Soil Decompaction and Amendment





Hilltop, Observed Compacted Condition || Rv= 0.506

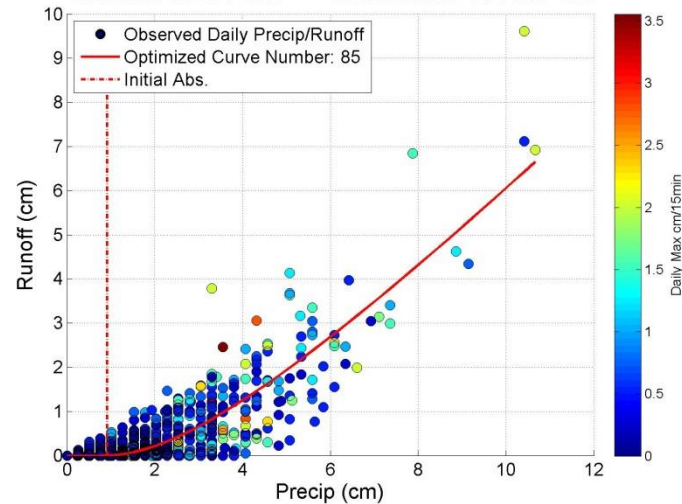
Runoff: 1112.3 cm      Infiltration: 1082.7 cm



**CN - 95**

Hilltop - 10cm Amendment || Rv= 0.150

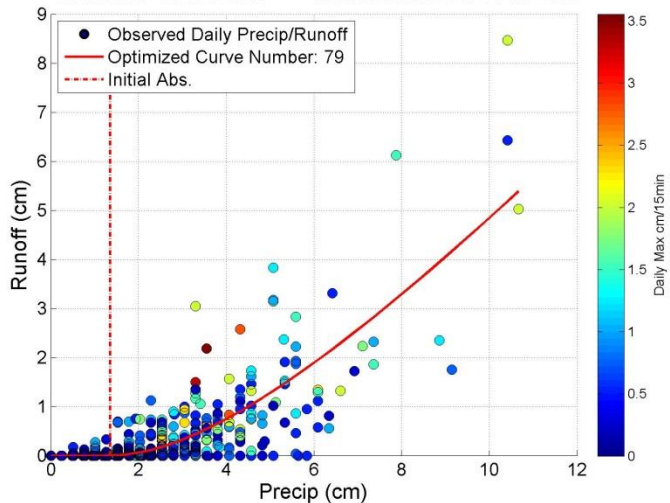
Runoff: 329.8 cm      Infiltration: 1871.3 cm



**4" Amendment: CN 85**

Hilltop - 20cm Amendment || Rv= 0.075

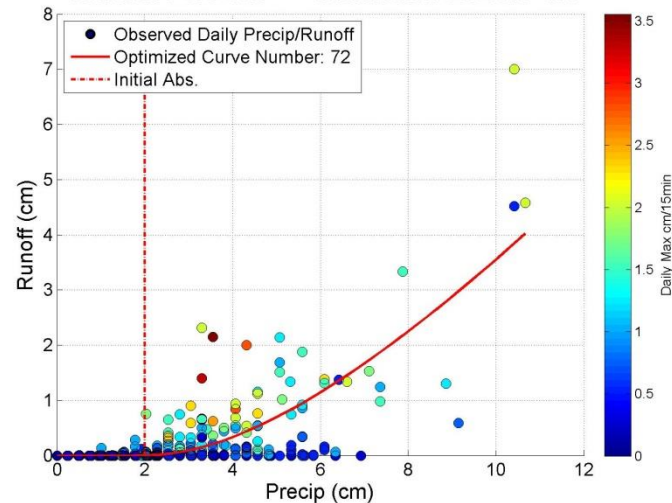
Runoff: 165.0 cm      Infiltration: 2037.0 cm



**8" Amendment: CN 79**

Hilltop - Spading || Rv= 0.036

Runoff: 78.8 cm      Infiltration: 2123.8 cm



**6" Amendment + 24" ripping: CN 72**

# Quantifying Hydrologic Services

Treatment	ECN	ELU
Native soil	69	Open Space Fair Cond. B-soils
Existing Condition	95	85% impervious commercial D-soils
10 cm Amendment	85	Gravel road & ROW B-soils
20 cm Amendment	79	Fair/Poor Open Space B/C soils; 1 acre residential C soils
15 cm Amendment + 24" ripping	72	1/3 acre residential B soils

Stormwater Credits

Regulatory Compliance

Yorkwood Elementary School Baltimore, MD



# Criteria for Credits

- Site Specific (soil, BD, OM, Drainage)
- Field Acceptance and Verification
- Performance Monitoring
- Routine Maintenance

