Restoring Stormwater Services in Compacted Urban Soils

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Central Ohio Stormwater Roundtable #2
27 July 2023
Via WebEx

Superior Sustainable Turf

Sparse	**Plant vigor**	Dense
Low	**Infiltration Rate**	High
Limited	**Plant Available water**	High
High	**Bulk Density**	Low
Low	**Organic Matter**	High
Limited	**Plant avail. nutrients**	Abundant, organic
Shallow	**Root depth / density**	Deep, dense
Low	**Bacterial / Fungal Activity**	High / Active

Standard Site Preparation & Topsoiling

Suburban Subsoiling

Disturbed Compacted Urban Soils

Disturbed Compacted Urban Soils

Missing Urban Horizons (Herrmann et al. PNAS 2018)

Disturbed Compacted Urban Soils

Missing Urban Horizons (Herrmann et al. PNAS 2018)

Adjusted HSG in Ohio (Rainwater Manual App. 9)

Cuyahoga Sustainability Network

Disturbed Compacted Urban Soils

Disturbed Compacted Urban Soils

Cuyahoga Sustainability Network

Root-Limiting Bulk Density

“Perched soil ecosystem” in an anthropogenic soil profile

Standard Grading Practices Decouple Form and Function

NEH 630.0702 Disturbed Soils

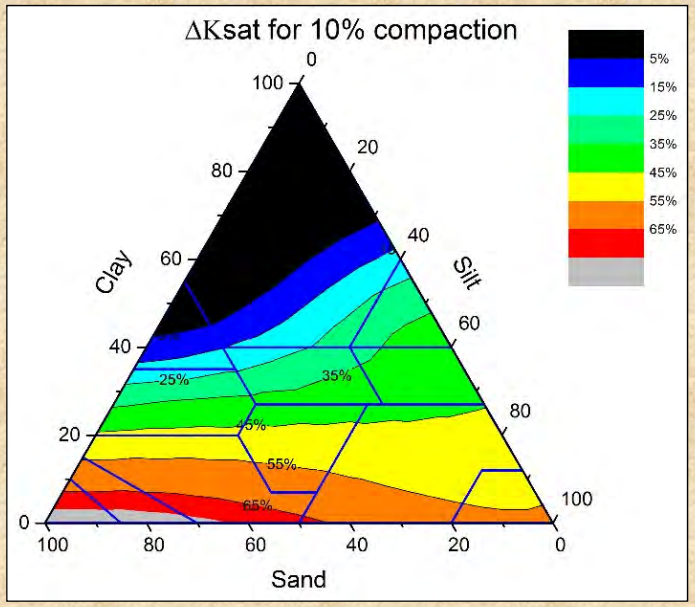
As a result of construction and other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, ***nor can any supposition based on the natural soil be made that will accurately describe the hydrologic properties of the disturbed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

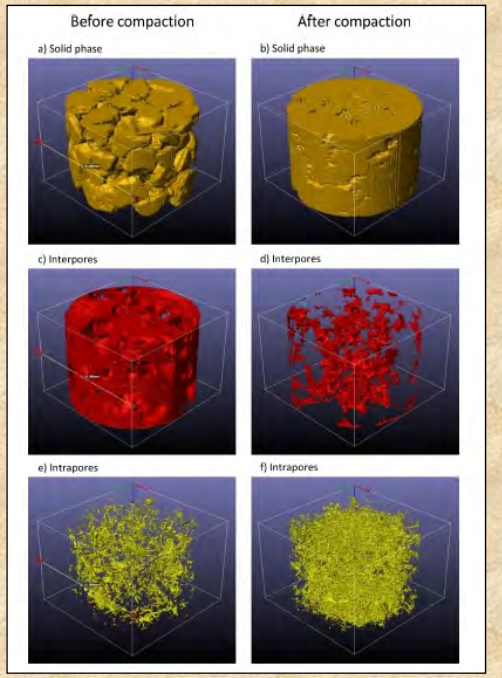
How Compacted are Urban Soils?

	Compacted BD > NBD*	> 5% Compaction	> 10% Compaction	Number of Samples
Residential Yards	87%	86%	55%	470
Vacant Lots	94%	89%	81%	72
Athletic Fields	99%	95%	78%	151

***Native Bulk Density**

How Does Compaction Change Infiltration?





from: **Menon et al. (2015) Soil and Tillage Research, 150. 147 - 157.**

Understanding the dynamic transitions between saturated and unsaturated conditions

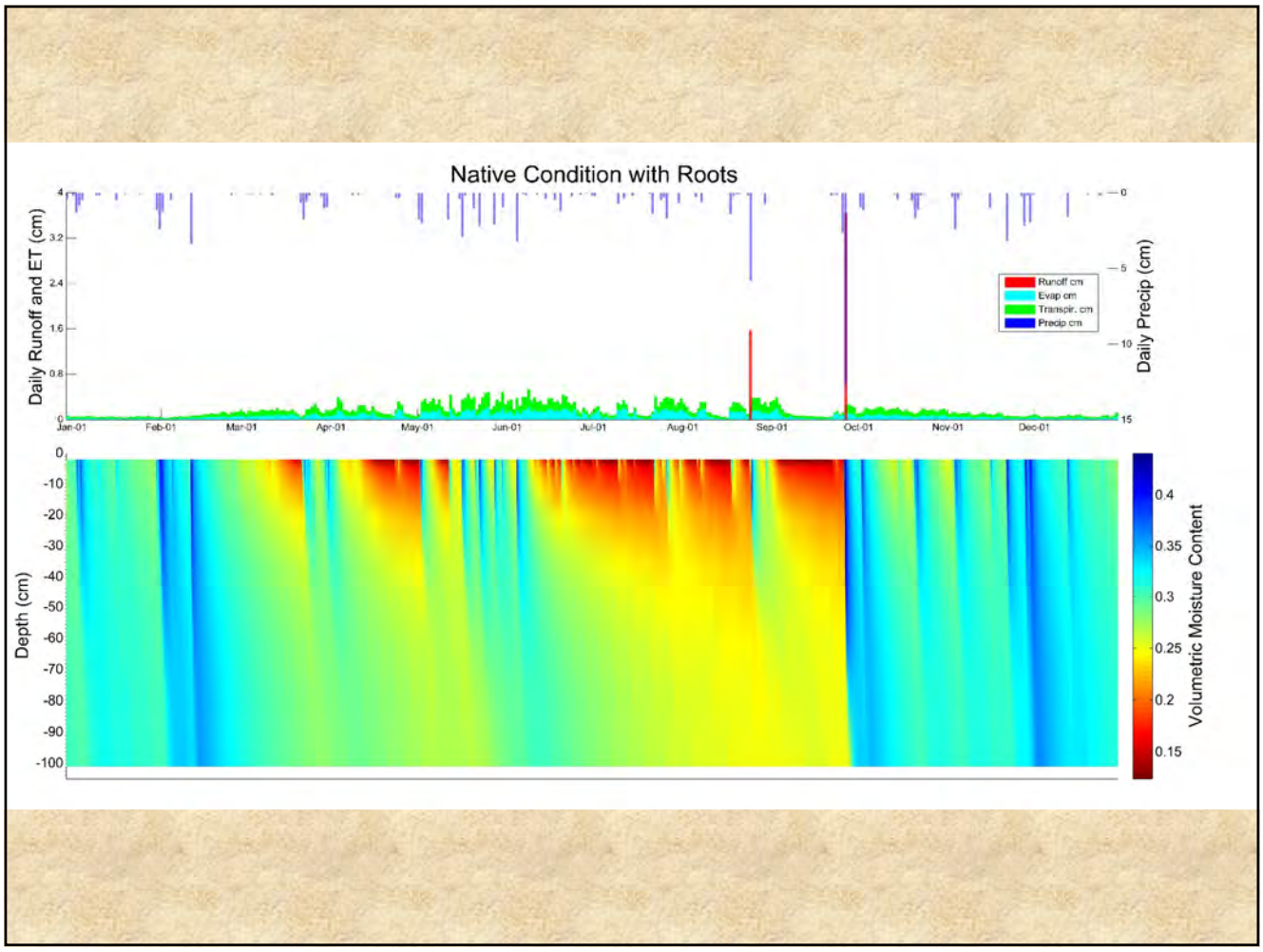
Model-based approach to understand dynamics of water movement through soil profile

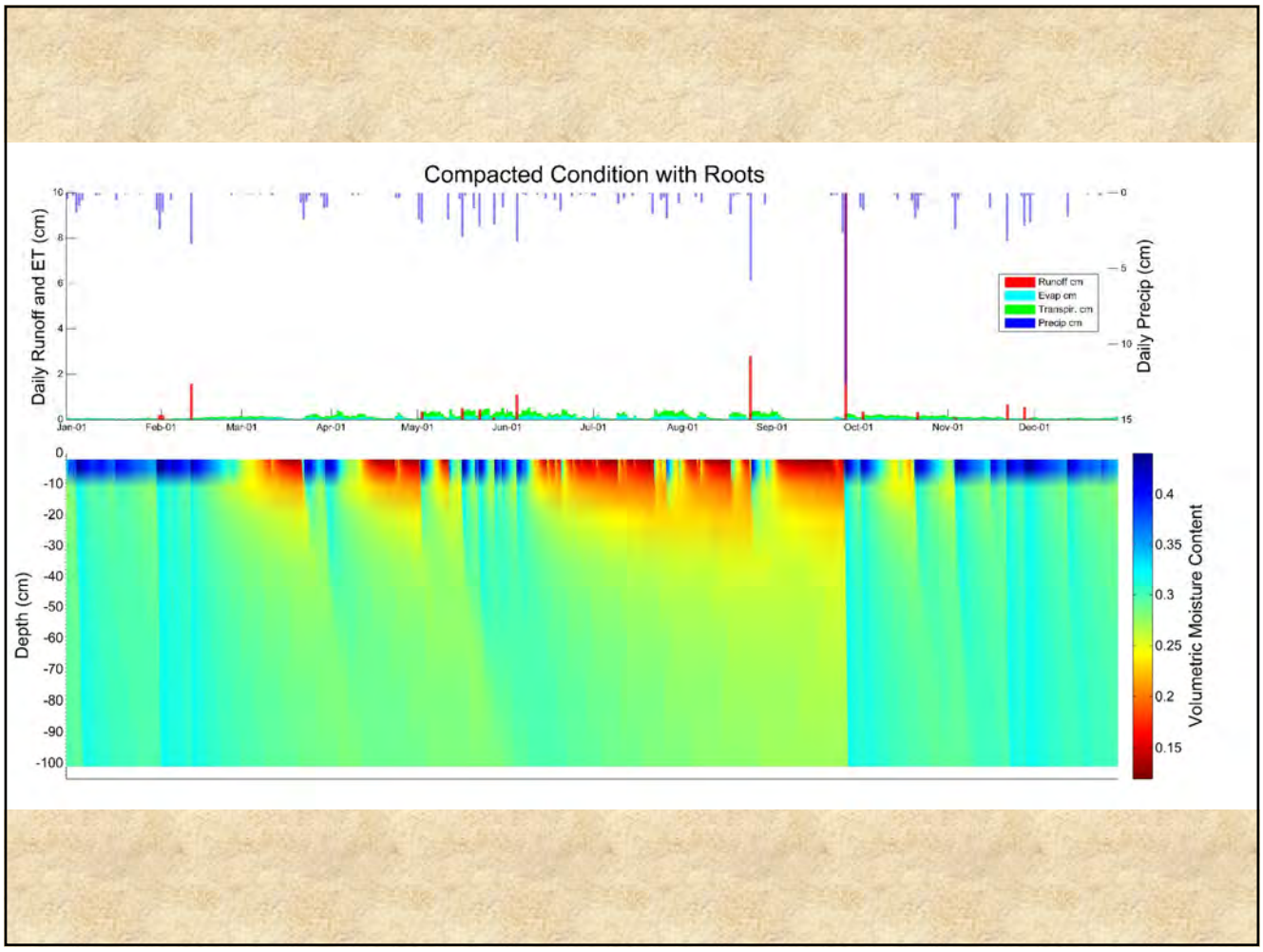
Field-based modeling – SHA Taneytown & Baltimore DPW Yorkwood School

1-meter soil column and idealized "soil profile endpoints"

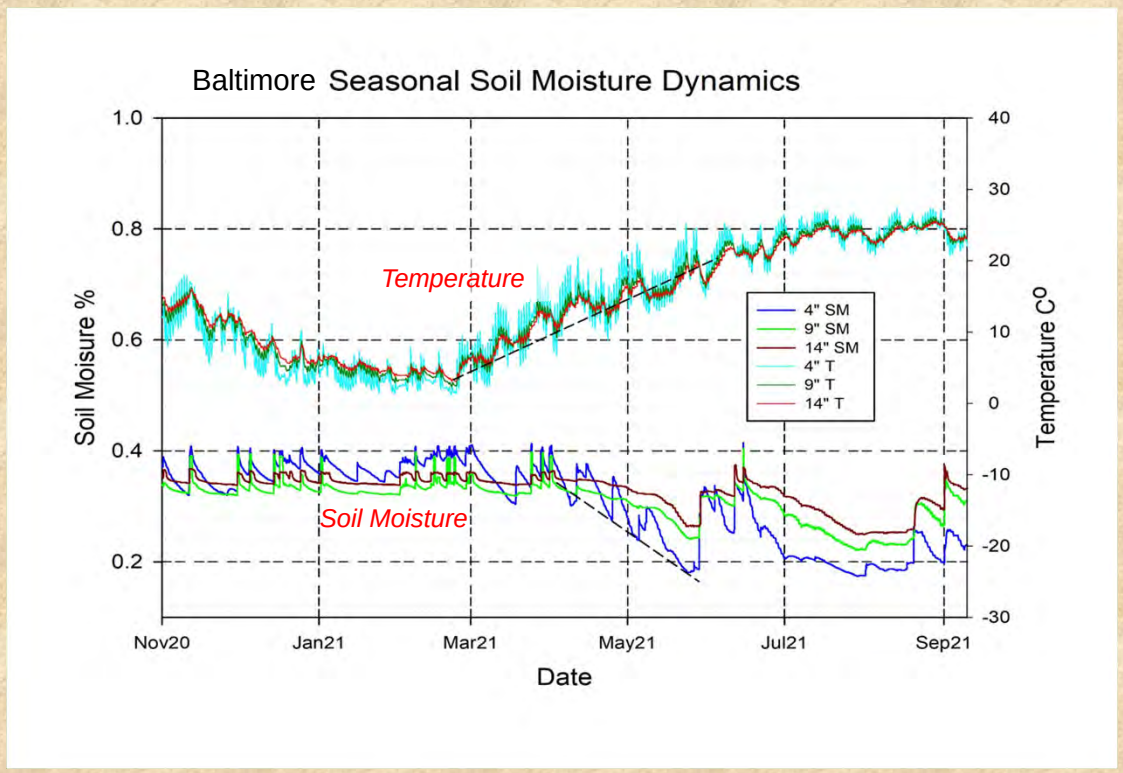
- **Healthy profile**: Native Bulk density 5% organic matter
- **Topsoiled profile**: 10cm of "topsoil" (NBD & 3% OM,) over 90 cm of fill (10% compaction & 0.5% OM)
- **Suburban Subsoiled profile**: deep ripping 20-24 in.(50-60 cm) and 6-9 inches of decompaction & amendment (NBD &5% OM).

Consistent Model-based description can give us site specific information for a ***stormwater credit***.


Native Condition with Roots
Daily Runoff and ET (cm)
Daily Precip (cm)
Runoff cm
Evap cm
Transpir. cm
Precip cm
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Depth (cm)
Volumetric Moisture Content


Compacted Condition with Roots
Daily Runoff and ET (cm)
Daily Precip (cm)
Runoff cm
Evap cm
Transpir. cm
Precip cm
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Depth (cm)
Volumetric Moisture Content

Performance Monitoring



Suburban Subsoiling

adapt agricultural subsoiling practices to urban landscapes

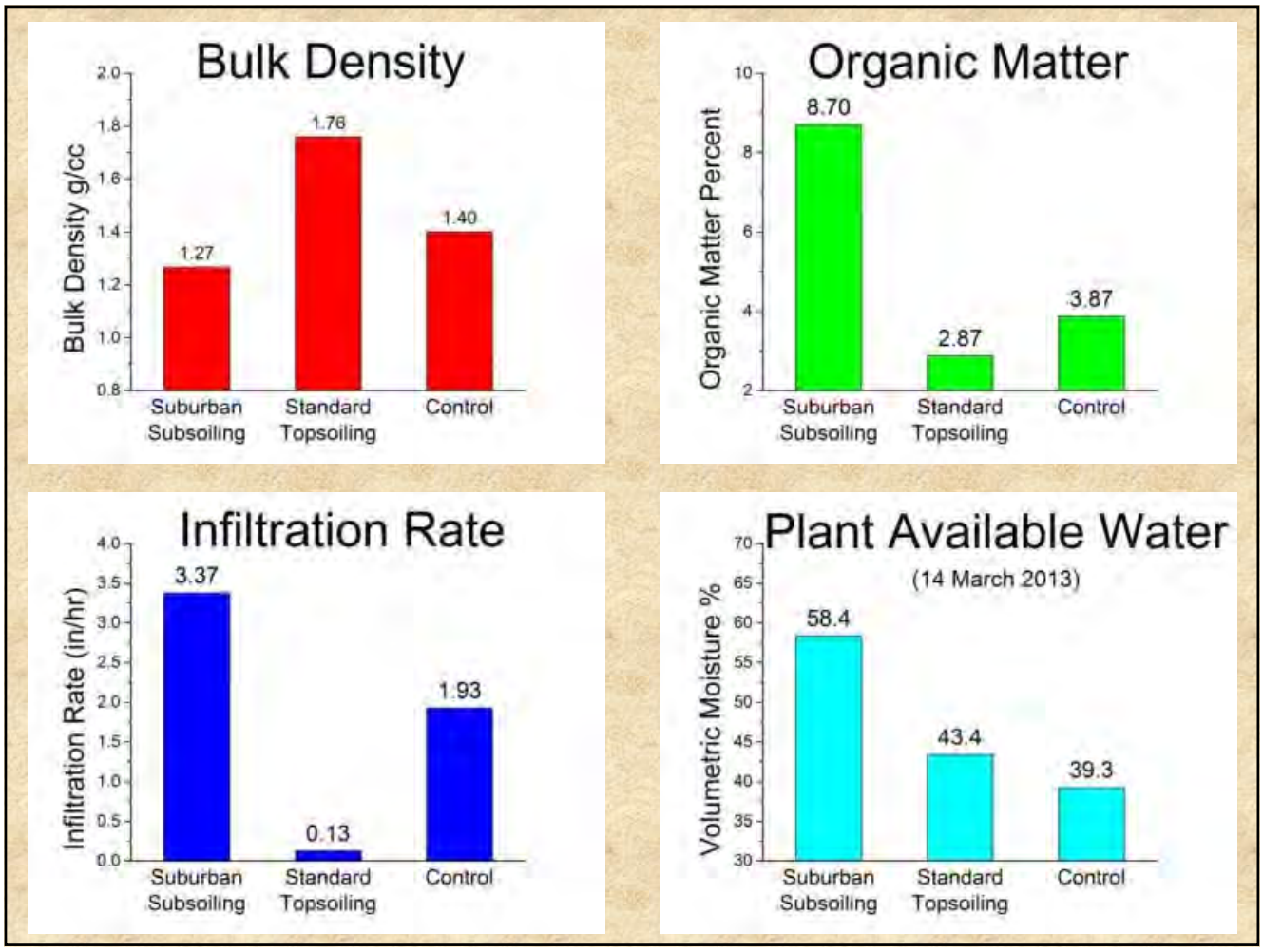
Yorkwood Elementary School

Baltimore City impervious area removal project

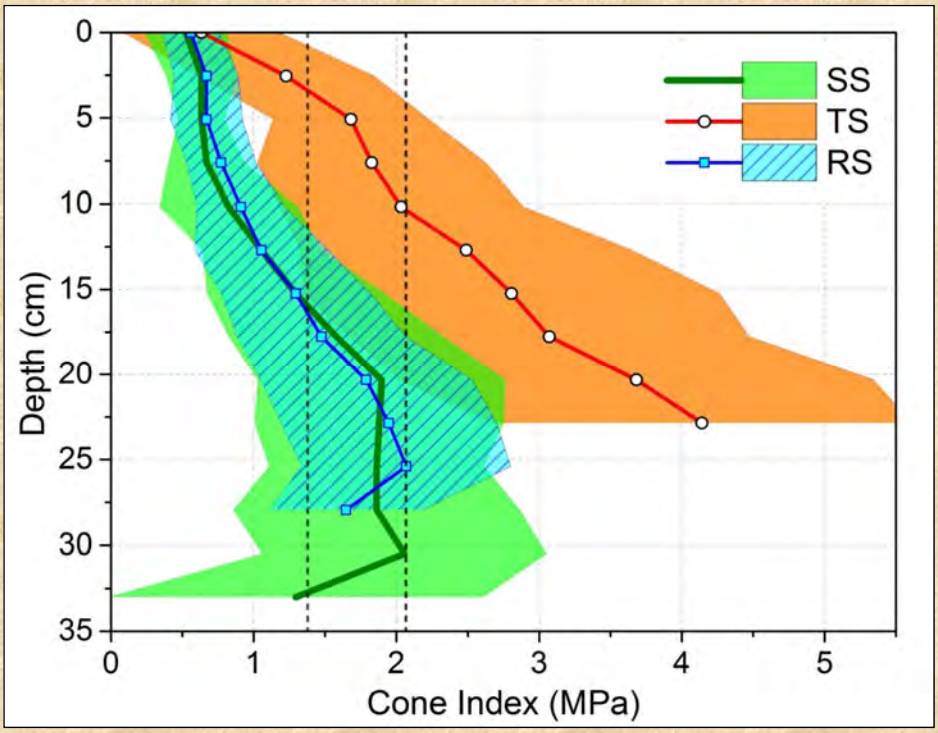
Suburban Subsoiling

- Deep ripping
- Compost amendment

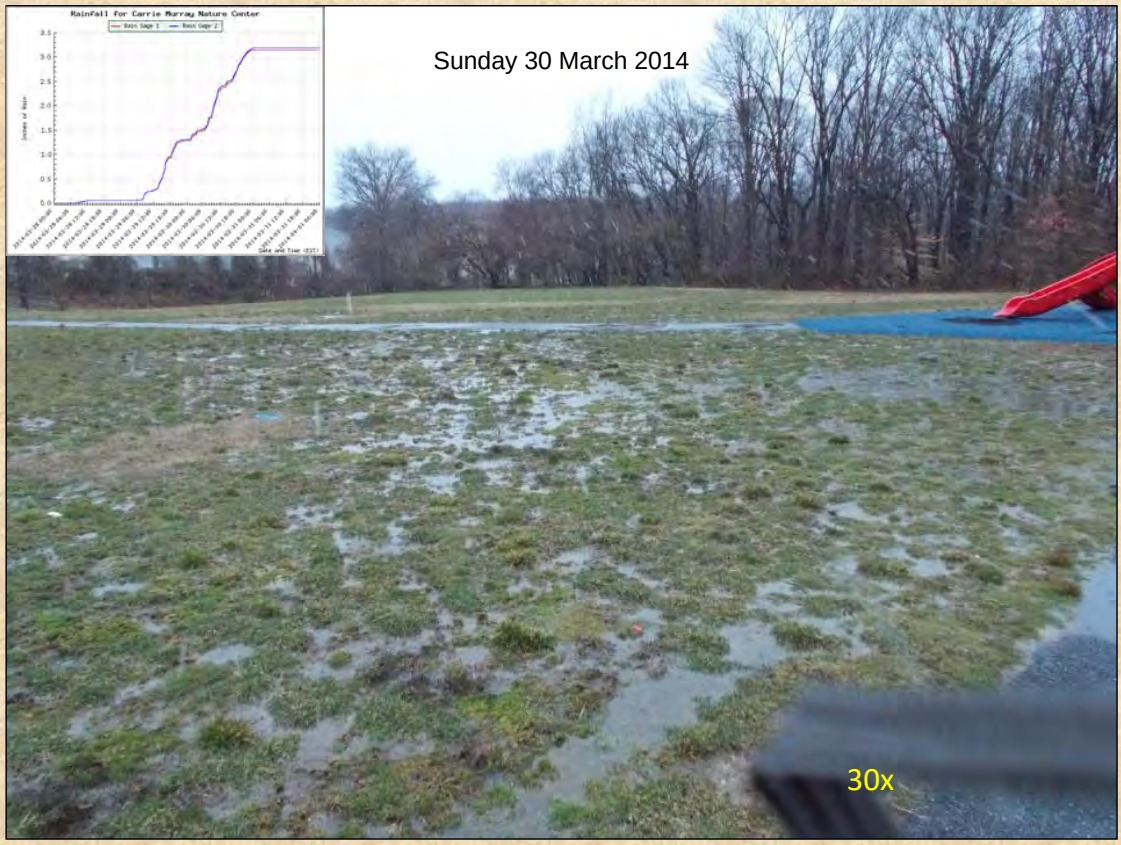

Standard topsoiling
Suburban subsoiling


Bulk Density
Bulk Density g/cc
2.0
1.8
1.6
1.4
1.2
1.0
0.8
1.27
1.76
1.40
Suburban Subsoiling
Standard Topsoiling
Control
Organic Matter
Organic Matter Percent
10
8
6
4
2
8.70
2.87
3.87
Suburban Subsoiling
Standard Topsoiling
Control
Infiltration Rate
Infiltration Rate (in/hr)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.37
0.13
1.93
Suburban Subsoiling
Standard Topsoiling
Control
Plant Available Water
(14 March 2013)
Volumetric Moisture %
70
65
60
55
50
45
40
35
30
58.4
43.4
39.3
Suburban Subsoiling
Standard Topsoiling
Control

Soil Strength - Cone Index Profiles



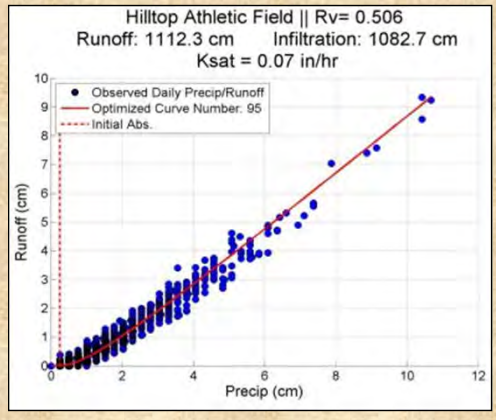

Sunday 30 March 2014


Rainfall for Carrie Murray Nature Center
Sunday 30 March 2014
30x

Stormwater Credits

Stormwater Credits

- Soil physics modeling simulates *site-specific* *soil-specific* soil profiles.
- Distinct "types" of soil profiles : **Healthy**, **Topsoiled**, **Suburban Subsoiled** for each USDA soil texture
  - Fit an "Effective Curve Number (ECN)" to model-simulated storm P-Q pairs
  - Runoff reduction credit computed with simple familiar Curve Number computations.



Stormwater Credits

Credit = f(texture, profile “type”, SubSub depth)

Clay Loam runoff reduction: 76% (1-year) & 70% (2-year)

	Topsoiled 10 cm	SS 6-inch	ΔQ (in)	TS - SS6
TEXTURE	ECN	ECN	1-yr storm 1.98 in	2-yr storm 2.69 in
Clay				
Clay Loam	*91*	*72*	0.89	1.06
Loam				
Loamy Sand				
Sand				
Sandy Clay				
Sandy Clay Loam				
Sandy Loam				
Silt				
Silty Clay				
Silty Clay Loam				
Silty Loam				

Stormwater Credits

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	Topsoiled 10 cm	SS 6-inch	ΔQ (in)	TS - SS6
TEXTURE	ECN	ECN	1-yr storm 1.98 in	2-yr storm 2.69 in
Clay	93	88	0.29	0.32
Clay Loam	*91*	*72*	**0.89**	**1.06**
Loam	73	60	0.24	0.34
Loamy Sand	56	38	0.02	0.07
Sand	36	30	0.00	0.00
Sandy Clay	94	79	0.85	0.97
Sandy Clay Loam	88	72	0.64	0.78
Sandy Loam	70	50	0.23	0.37
Silt	86	58	0.78	1.02
Silty Clay	89	76	0.61	0.73
Silty Clay Loam	88	67	0.81	1.00
Silty Loam	87	62	0.81	1.03

Won't Compacted Soils Heal?

Oregon Trail near Baker Oregon

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

Paint Branch, MD Turf Grass Research Center

Hunt Valley Recreational Fields

ICC Mitigation project with Montgomery Parks

Conclusions

- Pervasive Legacy of Disturbed Compacted Urban Soils
- Natural endpoint from standard specifications
- *Decoupled Form & Function*
- ***Specify*** *Superior Sustainable Turf*
- Suburban Subsoiling Restores Soil Profile
- Align Contractor, Developer & Owner interests with Specifications, Credits, and Life-Cycle Costs
- Restores Infiltration and Stormwater Services
- Stormwater BMP from Superior Sustainable Turf

Specify Superior Sustainable Turf

Sparse	**Plant vigor**	Dense
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Thanks!

Questions?