Stormwater Research at Saint Anthony Falls Laboratory and its Application to Construction:

Benefits and Challenges of Infiltration

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Agenda

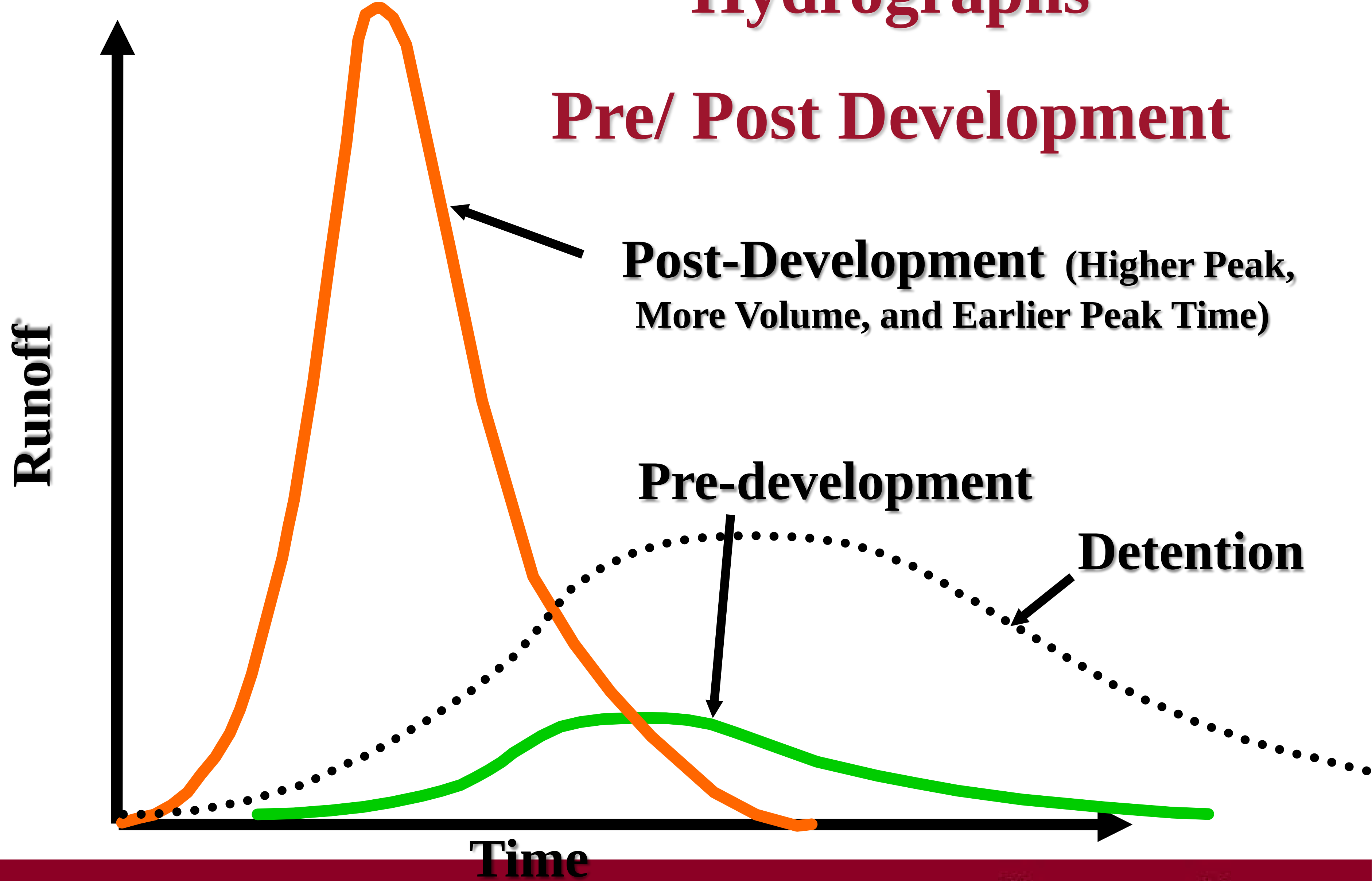
- Impacts of Soil Compaction and Impervious Areas on Runoff
- Benefits of Infiltration
- Challenges of Infiltration
- Some Answers to Challenges
  – Infiltrating into Compact Soil
  – Compact Soil in Rain Gardens
  – Infiltrating in MnDOT Swales
- Take Home Messages

Impacts of Soil Compaction and Impervious Area

Figure 2.1 Differences in Annual Water Budget from Natural Land Cover to Urbanized Land Cover (Source: May, University of Washington)

Hydrographs

Pre/ Post Development



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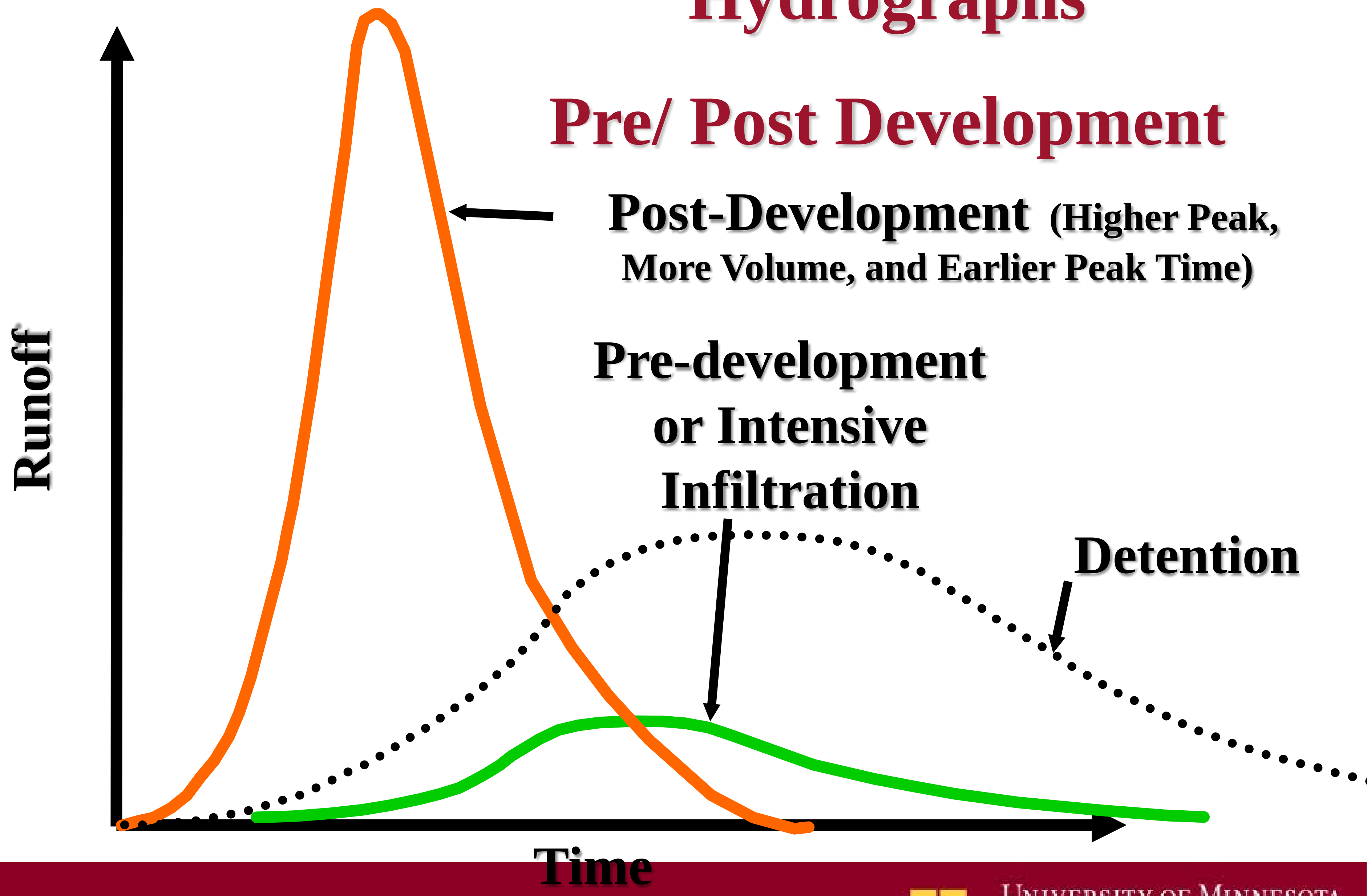
Geomorphological Impacts

Benefits of Infiltration

- Volume Reduction – a high % of the WQ storm and smaller can be infiltrated.
- Reduced Peak Flow
- Filtration through soil – remove solids, bacteria and nutrients and metals associated with solids.
- Temperature control through GW recharge – important for trout streams
- Increase base flow in streams

Hydrographs

Pre/ Post Development



Infiltration Practices

- Infiltration Basins
- Underground Infiltration Chambers
- Infiltration Trenches
- Swales
- Filter Strips
- Bio-infiltration Practices
- Tree Trenches
- Permeable Pavement




Challenges to Infiltration

- Can pollute Groundwater
  - Cl^-
  - NO_3^{-2}
- Failure to Infiltrate
  - Need expertise in soil profiling
  - Different kind of excavation and grading

Infiltrating Into Compacted Soils

- Collaborators: Dr. John Nieber and Nick Olson

- In cooperation with Three Rivers Park District
- Funding: Minnesota Pollution Control Agency and the Center for Urban and Regional Affairs, University of Minnesota

ThreeRivers PARK DISTRICT

Minnesota Pollution Control Agency

CURA

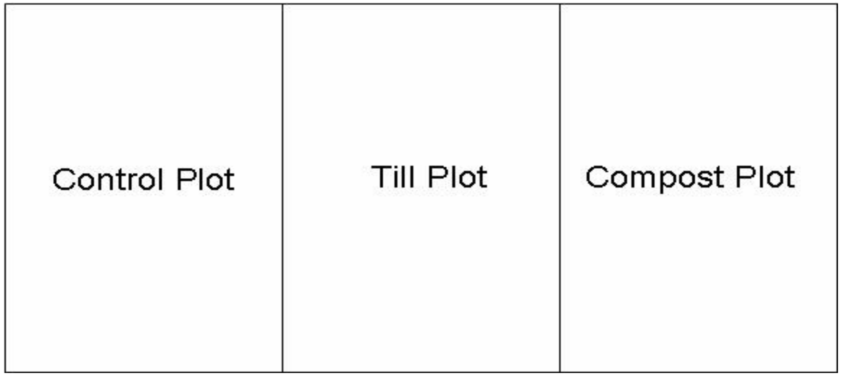
Stormwater Problem- Soil Compaction

Land development requires the use of large equipment to grade and stabilize soil to provide strong foundations. The land can become impervious and increase stormwater runoff.

- Reduce Pore Size
- Hard Pan Layers
- Poor Infiltration
- Poor Plant Growth

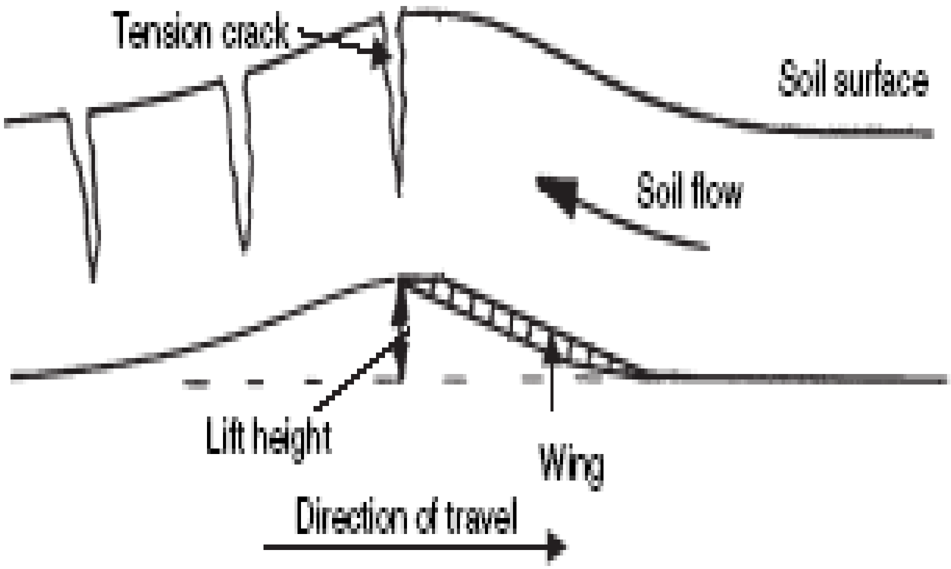
Research Objectives

- How much does tilling improve soil infiltration?
- How much does compost addition improve soil infiltration?
- At what level of soil compaction does infiltration become hindered?



Soil Remediation- Tillage

Tilling is a common practice in agriculture that is used to reduce the amount of water needed for plants and improve plant growth.



A winged tine of a tiller uplifting a soil to produce tension cracks (Spoor, 2006).

- Pros
  - Breaks surface seal
  - Break hardpan layers
  - Improves infiltration
- Cons
  - Macropore reduction
  - Benefit degrades
  - Equipment size

Soil Remediation- Compost Addition

Compost addition involves adding organic matter to the soil to create more aeration and provide nutrients. Different lifts may be created.

Addition of compost to soil (image by denvergov.org)

- Pros
  - Decreases bulk density
  - Increase water holding capacity
  - May also provide a longer term solution?
- Cons
  - Material availability
  - Nutrient leaching
  - Amount needed?

Remediation Procedure

- Subsoiler →
  - Deep Tillage: 22”-24”
  - 12” rip spacing
  - Ripped one direction

- Spading ←
  - Depth: 16-18”
  - Helps level surface after tilling
  - Mixed 3” of compost in soil

Lake Minnetonka Regional Park

Clifton E. French Regional Park

Maple Lakes Park

Field Research

- Initial Testing
  - Measured K_{sat} using Modified Philip-Dunne Permeameter (MPD)
  - Visual Observations
  - Bulk Density Samples

Can get several Infiltration Measurements at Once!

Infiltration Rate Results

L. Minnetonka Regional Park

Ratio of Geomeans: Year 2 /Year 1

Control
1.90

Till
2.20

Compost
5.66

C.E. French Regional Park

Ratio of Geomeans: Year 2 /Year 1

Control
2.29

Till
1.31

Compost
3.36

Maple Plains Park

Ratio of Geomeans: Year 2 /Year 1

Control
0.71

Till
2.32

Compost
8.92

Cost of remediation in an urban setting?

	Compost Amendment				Existing Development	
Activity	**Units**	**Cost / Unit**	**Total Cost**	**Acres Amended**	**Cost / Acre**	**Cost / Lot (0.06 acre of lawn)**
Tillage and Spading (hrs)	15	$70	$1,050	0.074	$14,189	$936
Intersite Travel (hrs) *	6	$70	$420	0.074	$5,676	$140
Compost (yards)	84	$13	$1,092	0.074	$14,757	$974
Compost Mobilization (site) *	3	$260	$780	0.074	$10,541	$260
Turf Establishment (hrs)	15	$35	$525	0.074	$7,095	$468
Total					**$52,257**	**$2,779**
	Till Amendment					
Tillage and Spading (hrs)	15	$70	$1,050	0.074	$14,189	$936
Intersite Travel (hrs) *	6	$70	$420	0.074	$5,676	$140
Turf Establishment	10	$35	$350	0.074	$4,730	$312
Total					**$24,595**	**$1,389**

Estimates provided by Randy Lehr (TRPD)

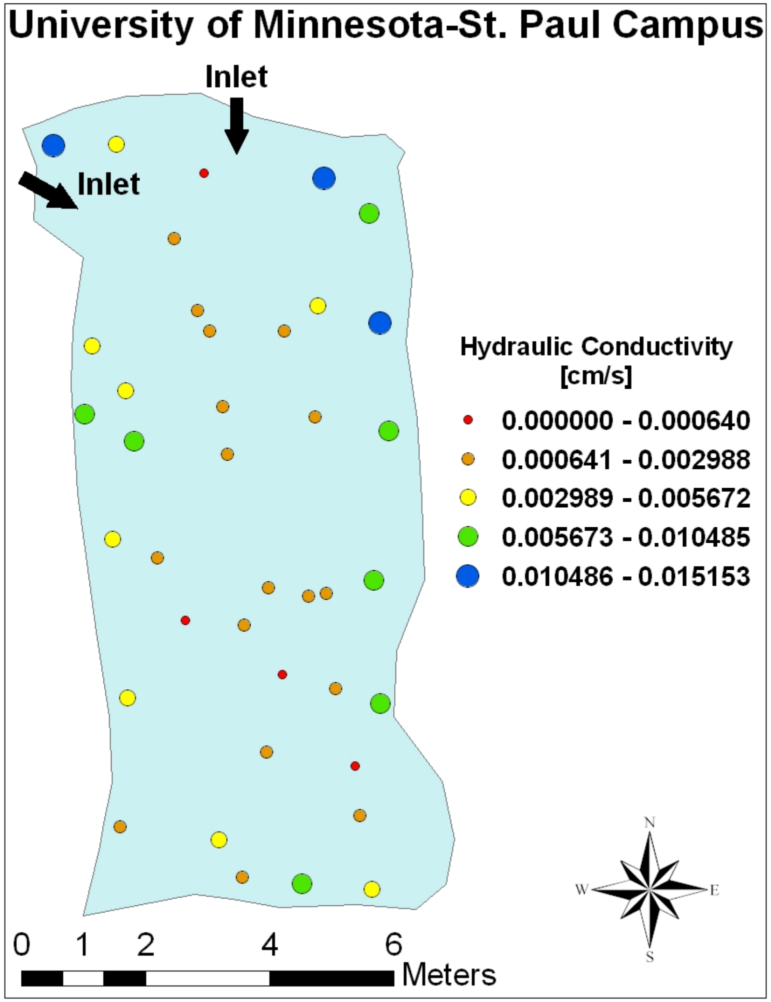
Compact Soil in Rain Gardens

Collaborators: Dr. John Nieber, Brooke Asleson and Rebecca Nestingen
Funding: Metropolitan Council

- What we don't want: ----------------→

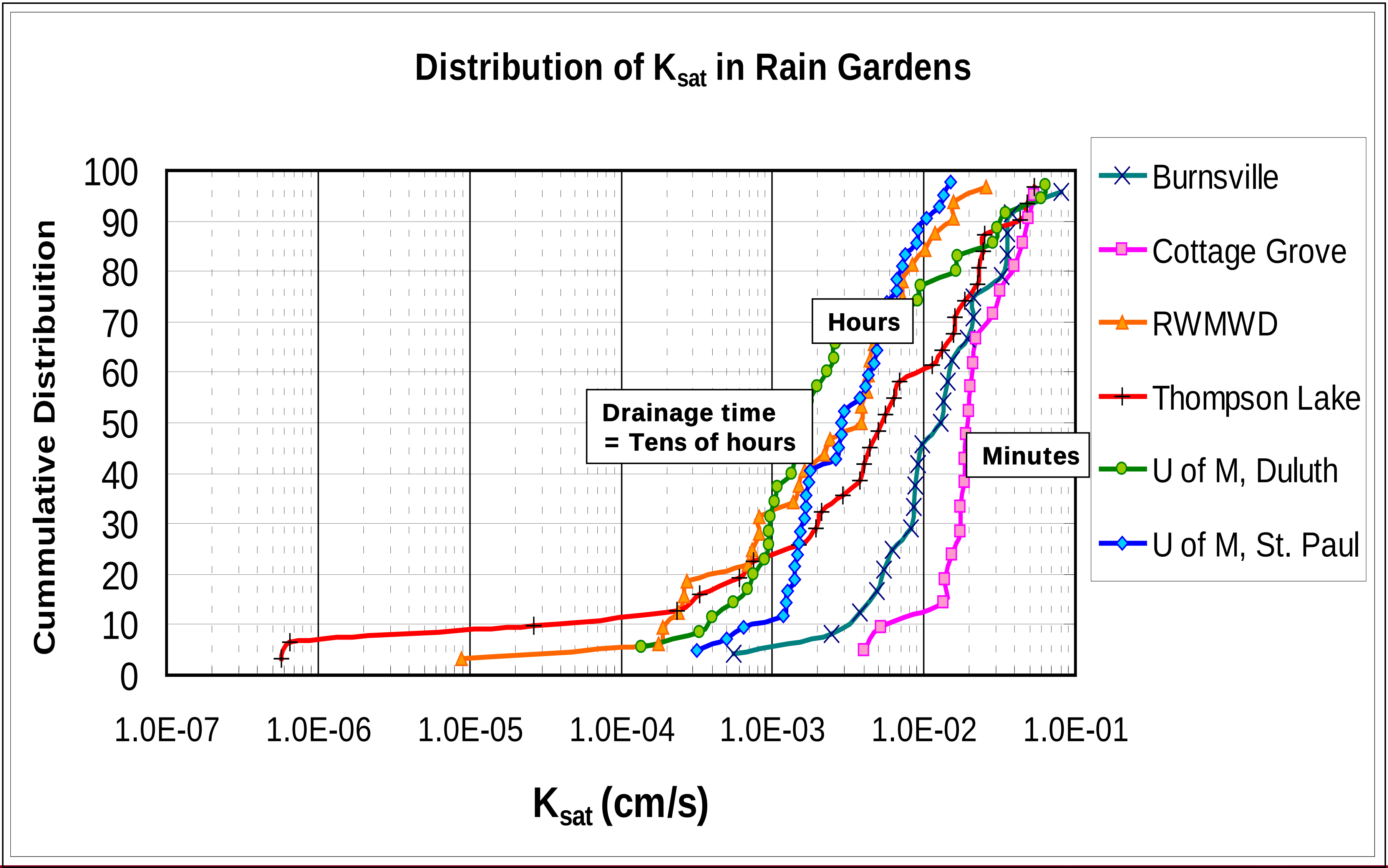
- What we do want: ------------------→

Variation of Infiltration Rates



Mean (cm/s) =	4.28E-03
Median (cm/s) =	2.88E-03
Cv =	0.88
Min. (cm/s) =	0.00E+00
Max. (cm/s) =	1.52E-02

Infiltration Capacity Test Results



Infiltration in MnDOT Swales

Collaborators: Dr. John Nieber, Maria Garcia-Serrana and Farzana Ahmed
Funding: MnDOT and Local Road Research Board

LRRB

DEPARTMENT OF TRANSPORTATION

- Detailed design specifications
- 12 in. of top soil with ~20% grade 2 compost.
- Allow for plant growth
  - Deep rooted grasses

Infiltration in MnDOT Swales

- Successful at infiltrating
  - Except where groundwater in high
  - Plants is the reason (macropores)
- Minimal maintenance

Infiltration in MnDOT Swales

	Soil Texture	HSG (based on soil texture)	Ksat (cm/h) (at 20°C) (estimated in the field)	HSG (based on Ksat)	Bulk Density (gm/cm3)	Porosity (%)	Average Initial Soil Moisture Content (Fall) (%)	Average Initial Soil Moisture Content (Spring) (%)	Slope	Av. Length studied (cm)
Hwy 51	loam/sandy loam	A / B	3.54 (1.44)*	A	1.12	0.56	0.15	0.30	5:1	406
Hwy 77	loamy sand	A	5.74 (0.94)*	A	1.18	0.56	0.15	0.20	5:1	407
Hwy 47	loamy sand/sandy loam	A	3.47 (1.29)*	A	1.21	0.54	0.12	0.27	5:1	779
Hwy 13	loam/sandy clay loam	B / C	4.14 (1.87)*	A	1.11	0.58	0.13	0.29	4:1	422

Influence of plants

Take Home Messages

- Infiltration must be considered first
- Infiltration has many benefits
  - Volume Reduction – a high % of the WQ storm and smaller can be infiltrated.
  - Reduced Peak Flow
  - Filtration through soil – remove solids, bacteria and nutrients and metals associated with solids.
  - Temperature control through GW recharge – important for trout streams
  - Increase base flow in streams
- Additional challenges

Take Home Messages

- Additional challenges of infiltration
  - Can pollute Groundwater
  - Failure to Infiltrate
    - Need expertise in soil profiling
    - Different kind of excavation and grading
- Compost will help infiltrate
- Plants will help infiltrate and reduce maintenance