Pollution of Drinking Water Aquifers due to Infiltration

UNIVERSITY OF MINNESOTA
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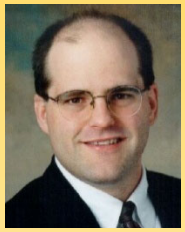
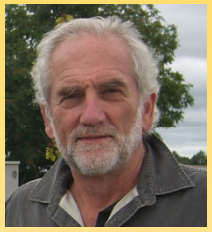




1. Impact of urbanization on runoff.
2. Why stormwater infiltration?
3. Are there groundwater quality impacts of infiltration?
4. What are we doing to investigate the potential impacts?
5. Conclusions

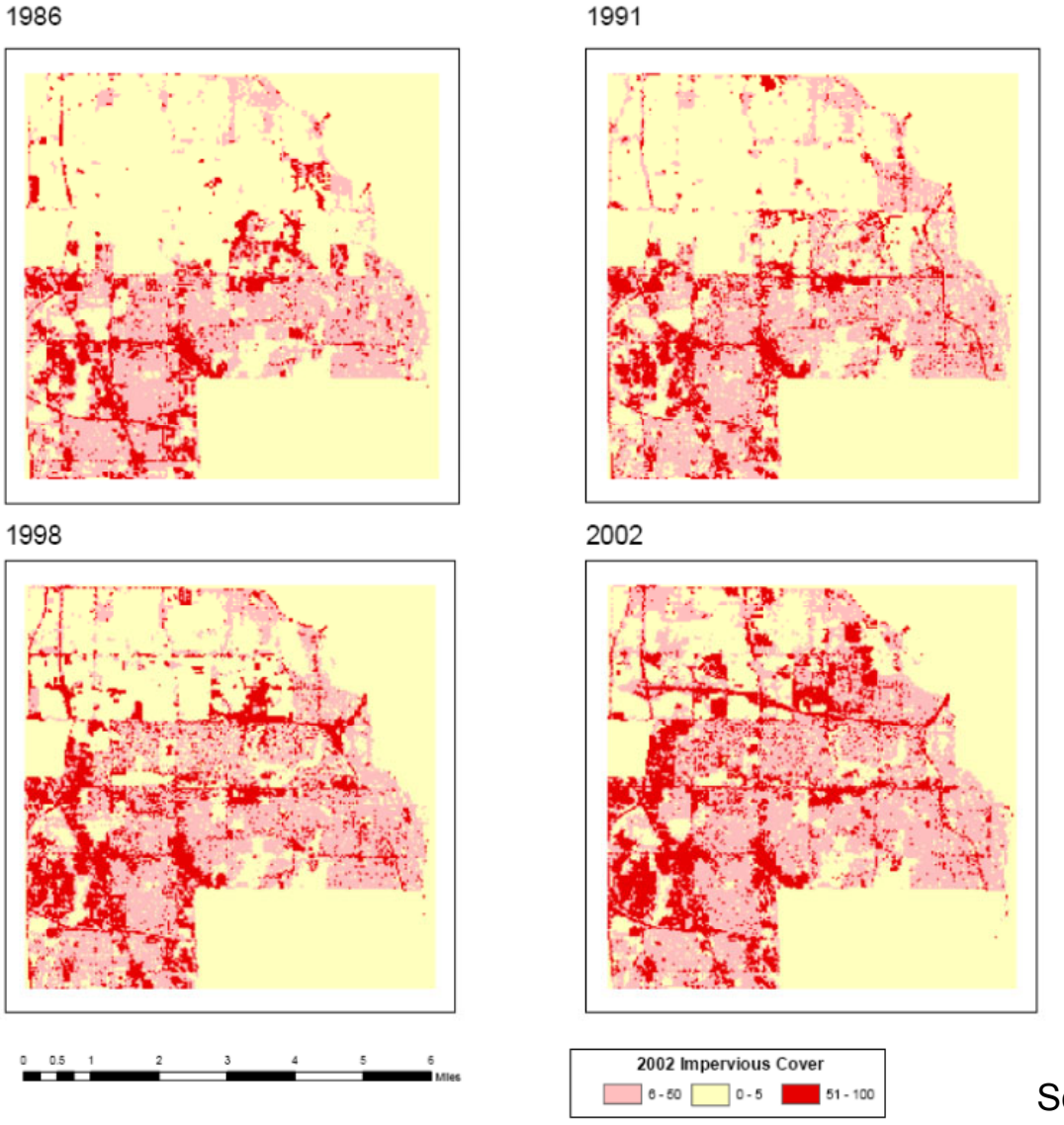
Photo: Robert Dexter

Department of Civil Engineering
Environmental · Geomechanical · Structures · Mechanics and Physics · Transportation · Water Resources

What is the impact of urbanization?

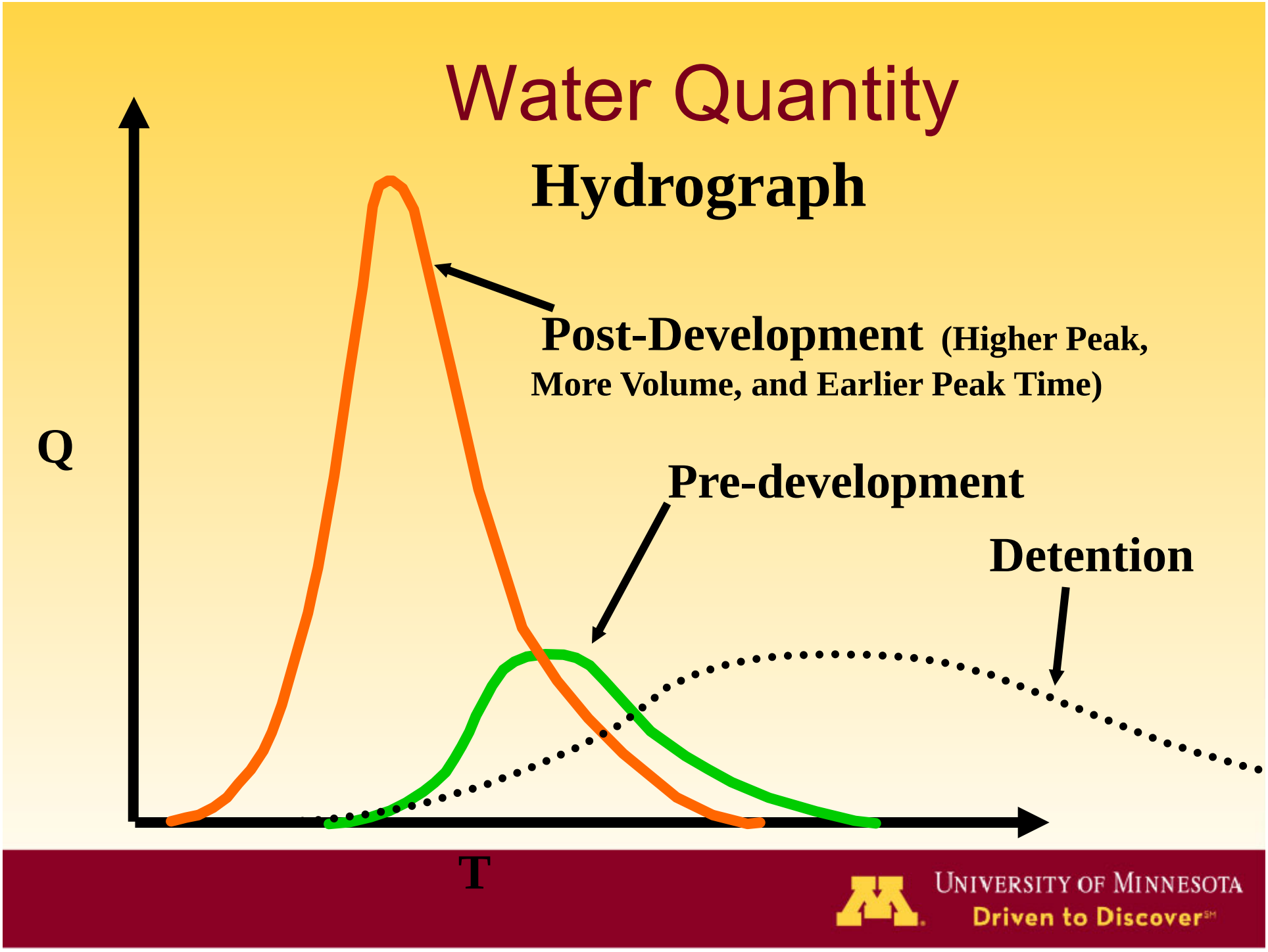
Figure 2.1 Differences in Annual Water Budget from Natural Land Cover to Urbanized Land Cover (Source: May, University of Washington)

City of Brooklyn Park
Impervious Coverage based on Satellite Remote Sensing



Source: Bruce Wilson, MPCA

Water Quantity



Water Quality

- Maestre and Pitt (2005) investigated the results of 3757 NPDES runoff records from municipalities
- Median Dissolved Values /National Drinking Water Std

– Zinc	51 µg/L	None
– Copper	8 µg/L	1,300 µg/L
– Cadmium	0.5 µg/L	5 µg/L
– Chromium	2 µg/L	100 µg/L
– Lead	3 µg/L	0 µg/L
– Nitrates	0.6 mg/L	10 mg/L
– Ammonia	0.4 mg/L	None
– Oil and grease	4 mg/L	None

Water Quality

- And Chlorides
  - Difficult to treat
  - Novotny and Stefan say that 2/3 of the road salt stays in the Twin Cities basin

  - TMDLs for Chloride in the Shingle Creek Watershed- GW-surface water influence?

Vermont Transportation Department

Why Stormwater Infiltration?

- Reduce volume of runoff.
- Improved water quality in streams and lakes.
- May transfer the pollution problem to the groundwater

Infiltration practices of interest

- Rain gardens (bio-infiltration practices)

Photo: Brooke Asleson

Infiltration practices of interest

- Infiltration basins and trenches

Photo

Infiltration practices of interest

- Swales (Roadside drainage ditches)

Infiltration practices of interest

- Pervious pavement

Minnesota Stormwater Manual

Infiltration practices of interest

- Underground infiltration vaults

Minnesota Stormwater Manual

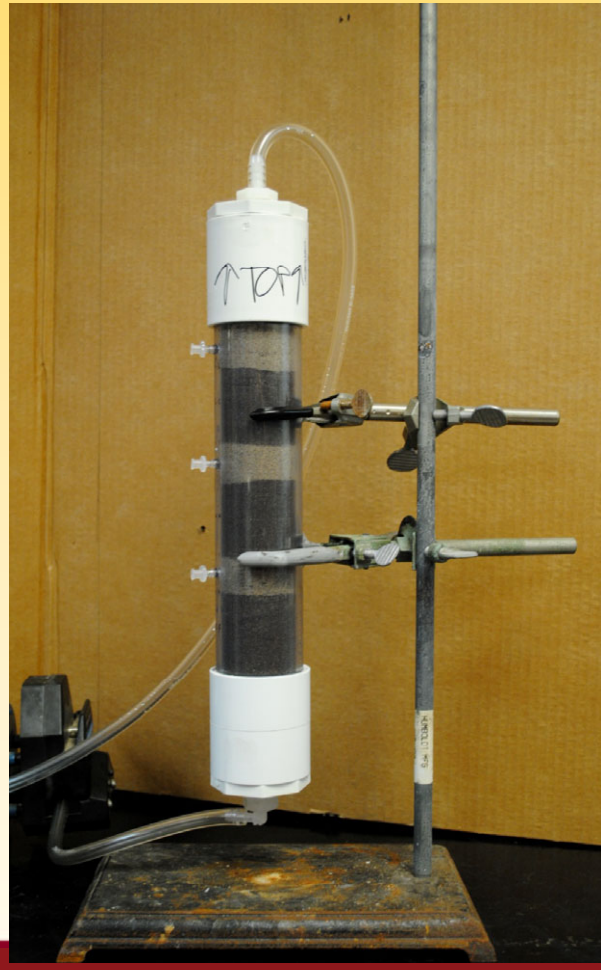
What are we doing to investigate the potential impacts?

- Surface infiltration with organic compounds in the soil
  - Rain Gardens, infiltration basins and trenches and swales

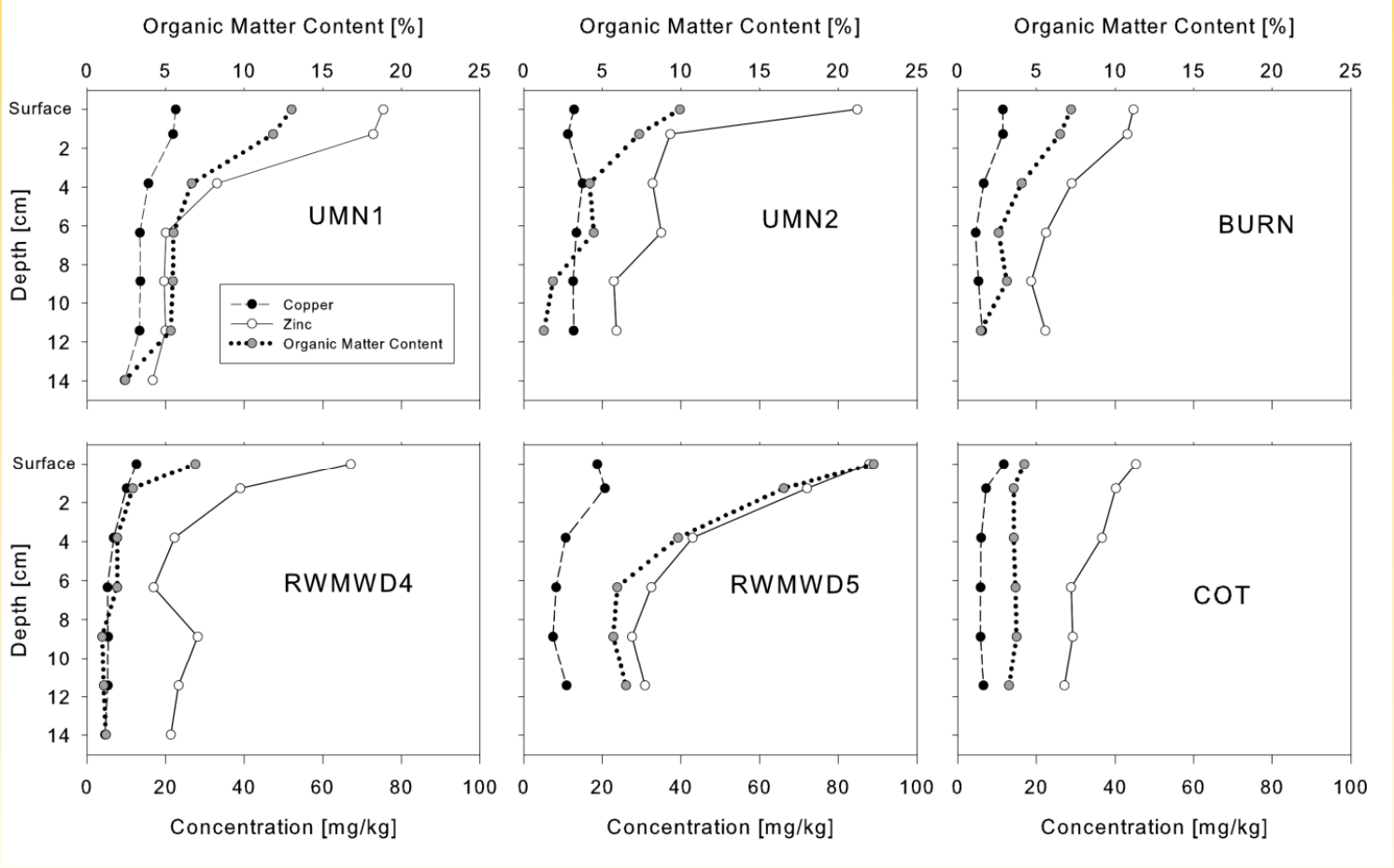
Column Studies with Rain Garden Media

Assume a rain garden made of 70/30 sand and compost by volume

- Depth of Water Treated at 6" depth
  - Cadmium: 507 m
  - Zinc: 935 m
- Time to breakthrough
  - Cadmium: 79 years
  - Zinc: 145 years



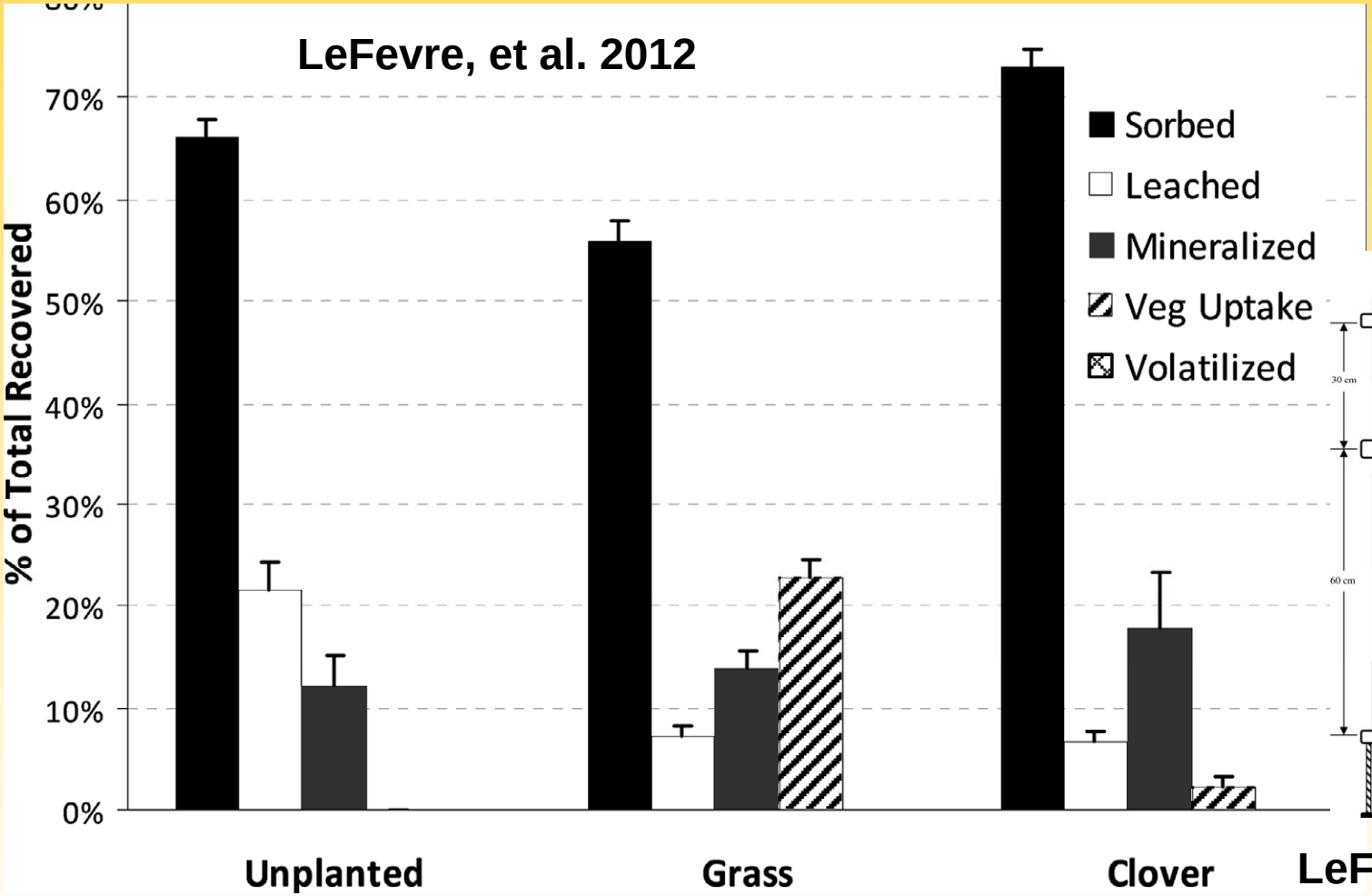
Metal Retention by Rain Gardens

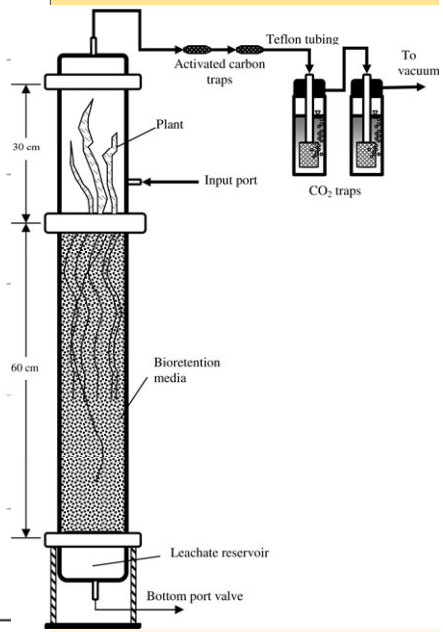


Metal Retention by Rain Gardens

Site	UMN1	UMN2	BURN	RWMWD4	RWMWD5	COT
Mean organic matter content in the top 10 cm [%]	7.4	4.6	4.1	2.2	9.9	3.7
Cd						
Mean metal concentration today [g/m^2]	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Equilibrium metal capacity [g/m^2]	6.4	6.2	6.2	5.9	6.3	6.2
Remaining capacity [%]	> 98.3	> 98.3	> 98.3	> 98.0	> 98.3	> 98.3
Zn						
Mean metal concentration today [g/m^2]	4.5	4.3	3.5	3.4	5.5	4.1
Equilibrium metal capacity [g/m^2]	30.1	28.4	28.1	26.5	30.6	27.9
Remaining capacity [%]	85.2	87.6	87.6	87.0	82.1	85.1

Column Studies
Retention of Hydrocarbons





LeFevre, et al. 2012

Organic material and surface infiltration

- Organic material in the soil has a great capacity to adsorb metals and petroleum hydrocarbons.
- Bacteria near plant roots will degrade hydrocarbons.
- Nitrates will be released by degrading organic materials
- Chlorides will pass through.

- **We need to consider chlorides and nitrates in the groundwater**

Underground Infiltration

Underground Vaults and Permeable Pavement

- Not much research
- **Need to consider all compounds of interest**
  - Nitrates
  - Chlorides
  - Metals
  - Petroleum hydrocarbons

Current Research

- Lysimeters placed below two surface infiltration facilities.
- Sumps placed below underground vault
  - Measuring metals, nitrates, chlorides and petroleum hydrocarbons

Conclusions

- Concentrations in stormwater are not high compared to drinking water standards
  - Local hot spots can occur
- Surface infiltration will likely retain metals and retain and degrade petroleum hydrocarbons
  - Nitrates and Chlorides are main concern
- Underground infiltration needs to be studied
  - All compounds need to be considered

Thank you!
Questions?