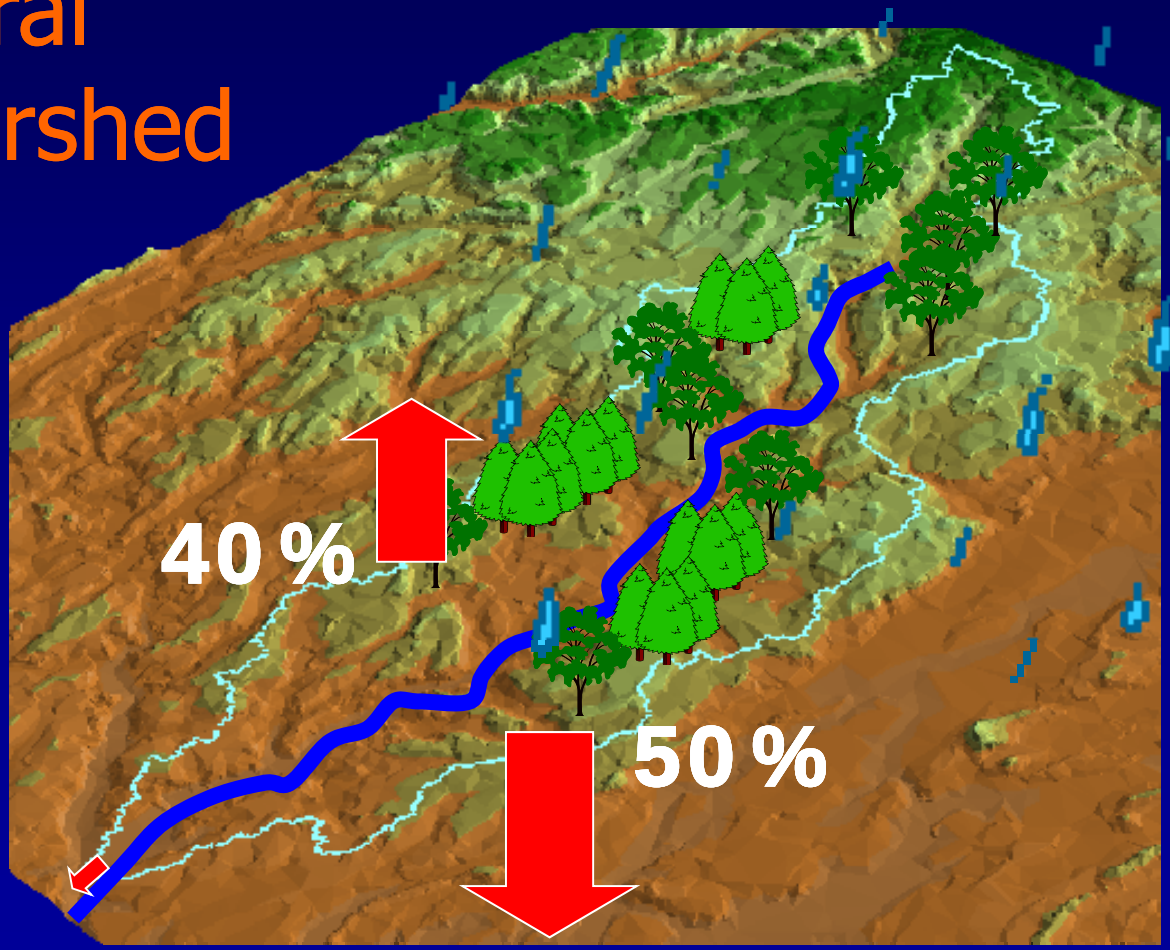
Management of stormwater runoff through infiltration

Bruce Wilson and
Mike Trojan

Minnesota Pollution
Control Agency
St. Paul, MN

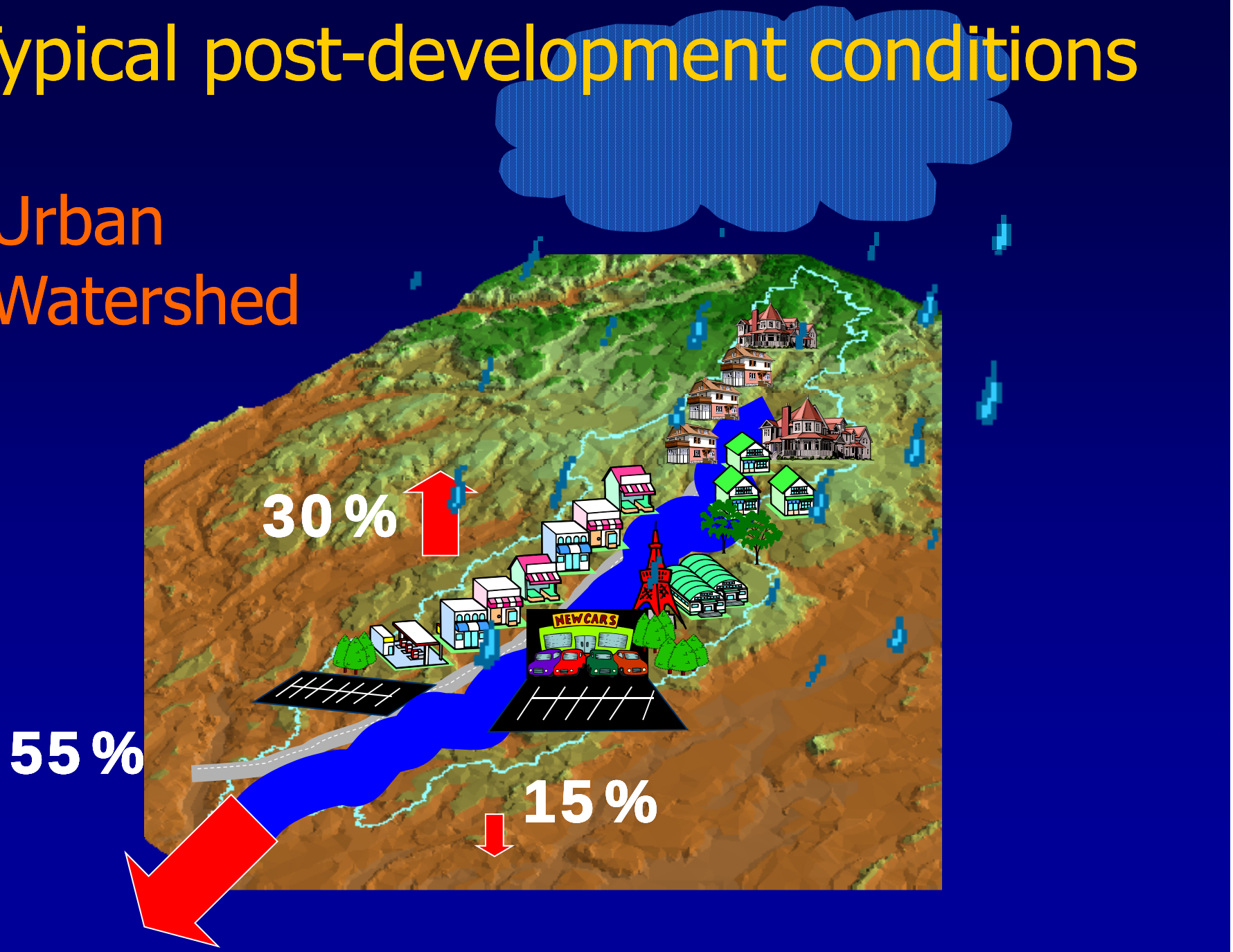
Typical pre-development conditions:

Natural Watershed



Typical post-development conditions

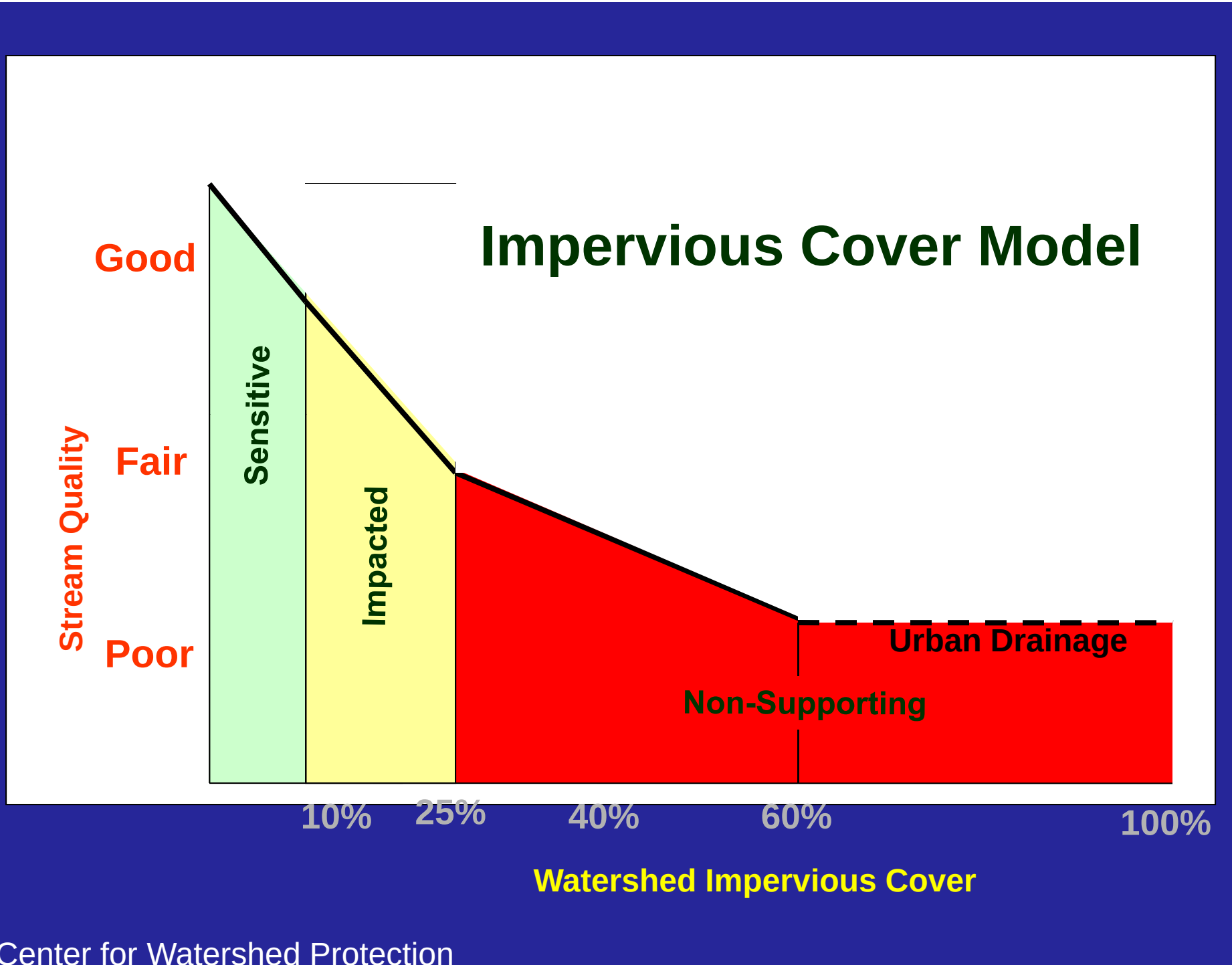
Urban Watershed



Urban Stormwater affects hydrology and water quality

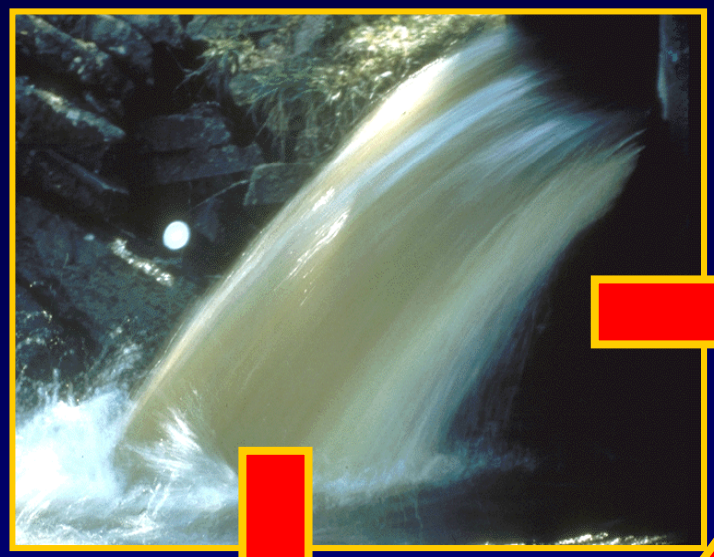
- Runoff rate & volume
- Sediment
- Nutrients
- Hydrocarbons
- Heavy Metals: Autos
- Oxygen-demanding Substances
- Bacteria
- Chloride

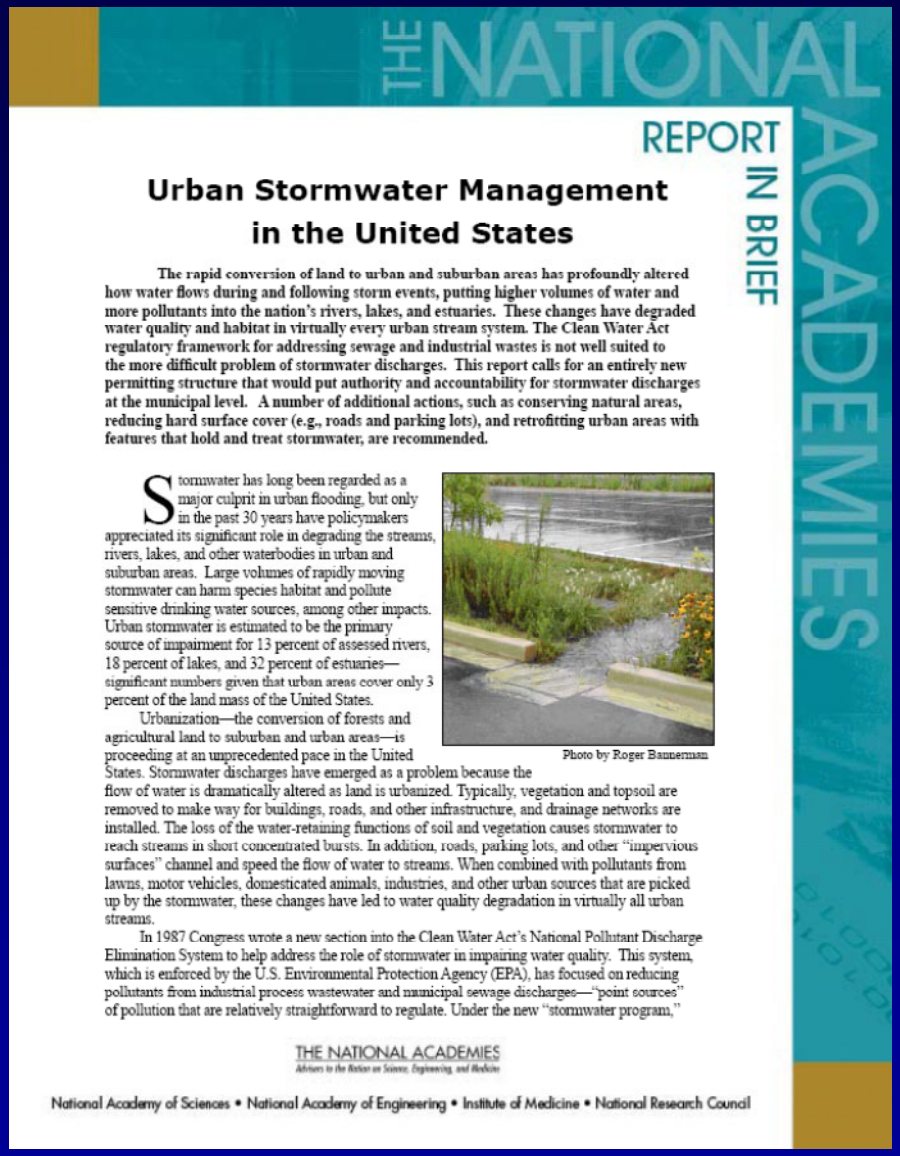
WDNR, Bannerman



Center for Watershed Protection

Traditional stormwater management





THE NATIONAL ACADEMIES

REPORT IN BRIEF

Urban Stormwater Management in the United States

The rapid conversion of land to urban and suburban areas has profoundly altered how water flows during and following storm events, putting higher volumes of water and more pollutants into the nation's rivers, lakes, and estuaries. These changes have degraded water quality and habitat in virtually every urban stream system. The Clean Water Act regulatory framework for addressing sewage and industrial wastes is not well suited to the more difficult problem of stormwater discharges. This report calls for an entirely new permitting structure that would put authority and accountability for stormwater discharges at the municipal level. A number of additional actions, such as conserving natural areas, reducing hard surface cover (e.g., roads and parking lots), and retrofitting urban areas with features that hold and treat stormwater, are recommended.

Stormwater has long been regarded as a major culprit in urban flooding, but only in the past 30 years have policymakers appreciated its significant role in degrading the streams, rivers, lakes, and other waterbodies in urban and suburban areas. Large volumes of rapidly moving stormwater can harm species habitat and pollute sensitive drinking water sources, among other impacts. Urban stormwater is estimated to be the primary source of impairment for 13 percent of assessed rivers, 18 percent of lakes, and 32 percent of estuaries—significant numbers given that urban areas cover only 3 percent of the land mass of the United States.

Photo by Roger Bannerman

Urbanization—the conversion of forests and agricultural land to suburban and urban areas—is proceeding at an unprecedented pace in the United States. Stormwater discharges have emerged as a problem because the flow of water is dramatically altered as land is urbanized. Typically, vegetation and topsoil are removed to make way for buildings, roads, and other infrastructure, and drainage networks are installed. The loss of the water-retaining functions of soil and vegetation causes stormwater to reach streams in short concentrated bursts. In addition, roads, parking lots, and other "impervious surfaces" channel and speed the flow of water to streams. When combined with pollutants from lawns, motor vehicles, domesticated animals, industries, and other urban sources that are picked up by the stormwater, these changes have led to water quality degradation in virtually all urban streams.

In 1987 Congress wrote a new section into the Clean Water Act's National Pollutant Discharge Elimination System to help address the role of stormwater in impairing water quality. This system, which is enforced by the U.S. Environmental Protection Agency (EPA), has focused on reducing pollutants from industrial process wastewater and municipal sewage discharges—"point sources" of pollution that are relatively straightforward to regulate. Under the new "stormwater program,"

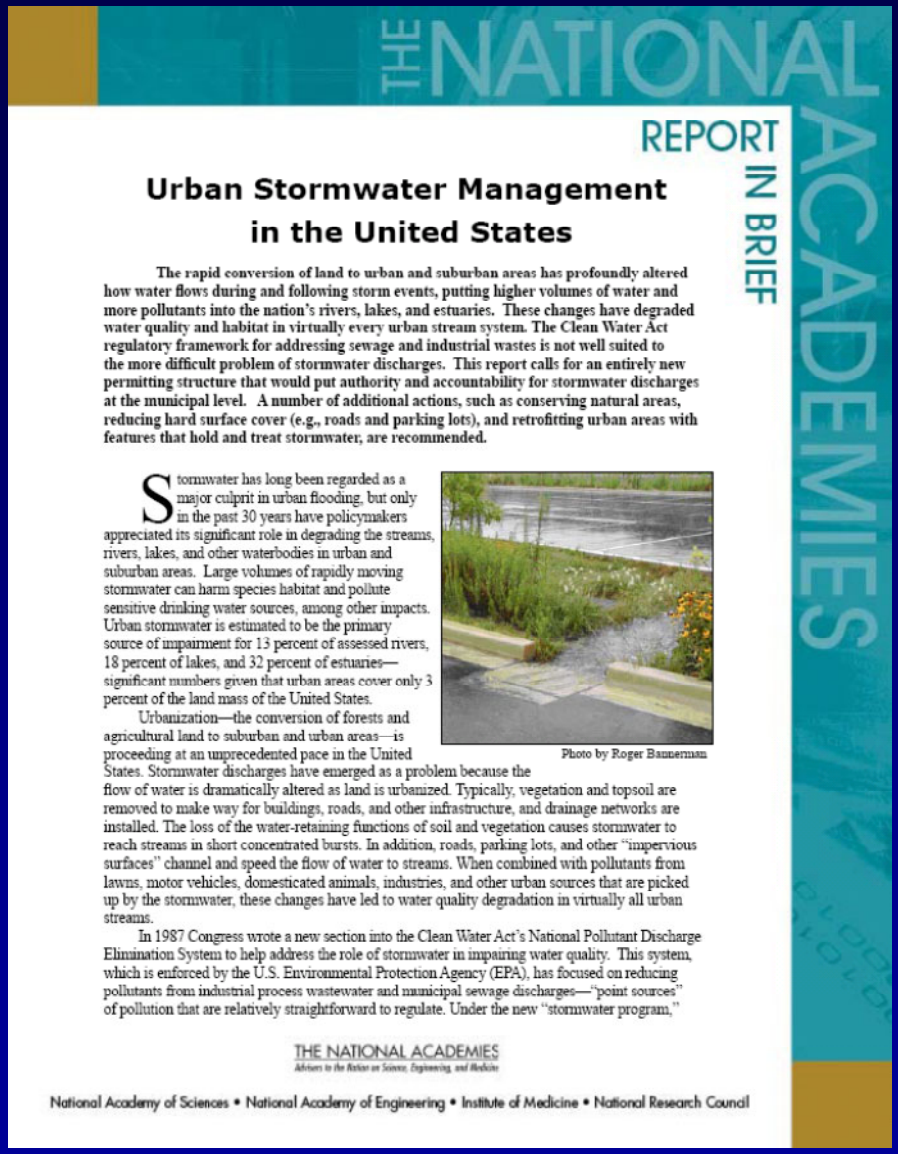
THE NATIONAL ACADEMIES

National Academy of Sciences • National Academy of Engineering • Institute of Medicine • National Research Council

National Academies 2008 report

"Past practices…have been ineffective at protecting water quality in receiving waters and only partially effective in meeting flood control requirements"

"Stormwater control measures that harvest, infiltrate, and evaportranspire stormwater are critical to reducing the volume and pollutant loading of small storms"



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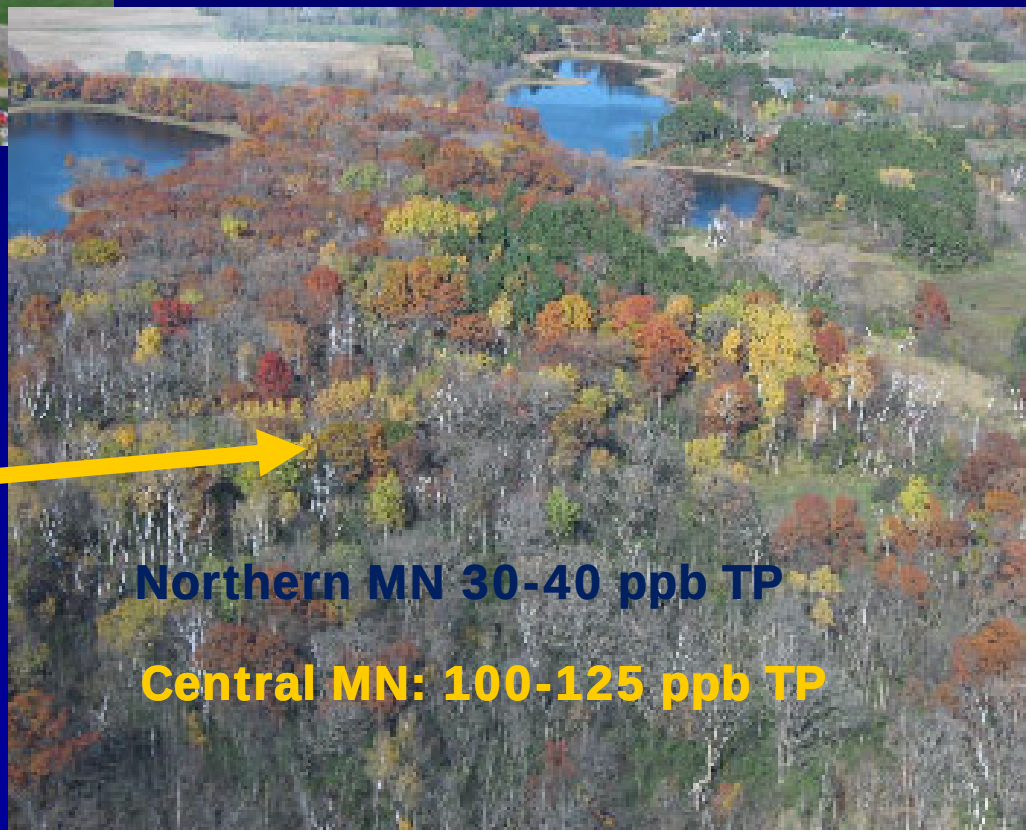
How do you make this...

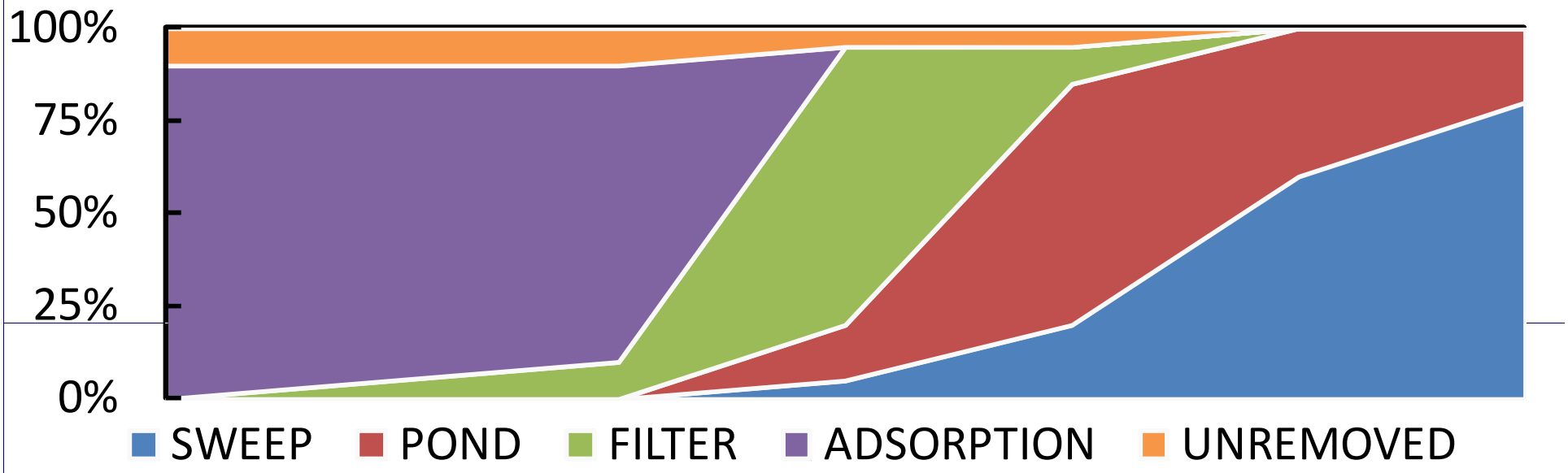
function like this?

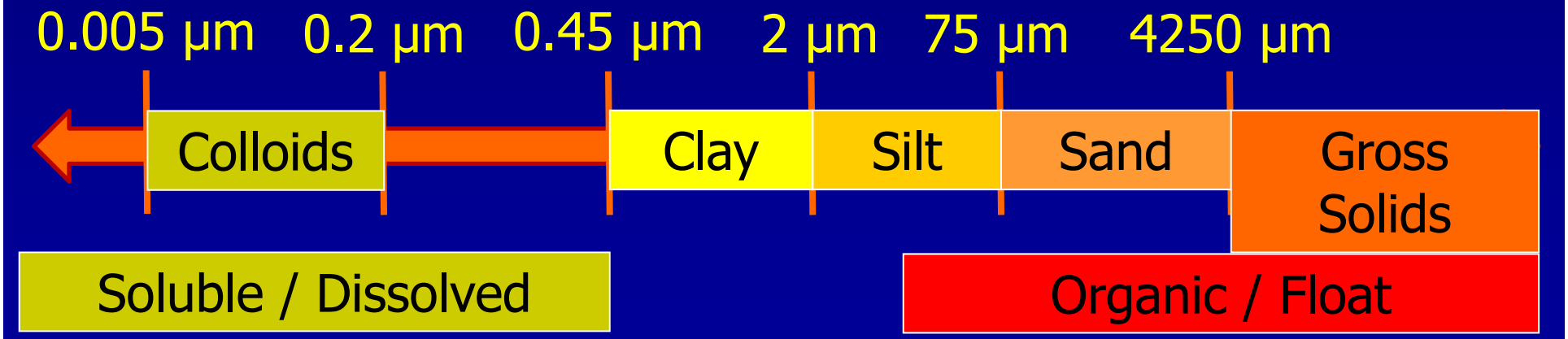


Stormwater Management

Conveyance

BMP Treatment Train





Infiltration BMPs

- Infiltration basins/trenches
- Bioretention (rain gardens)
- Permeable pavement
- Tree boxes/trenches
- Swales
- Turf management

Infiltration basin/trench

- Pretreatment recommended

Bioretention (rain garden)

- Organic media and vegetation enhance pollutant retardation, although organic material may release phosphorus

Permeable Pavement

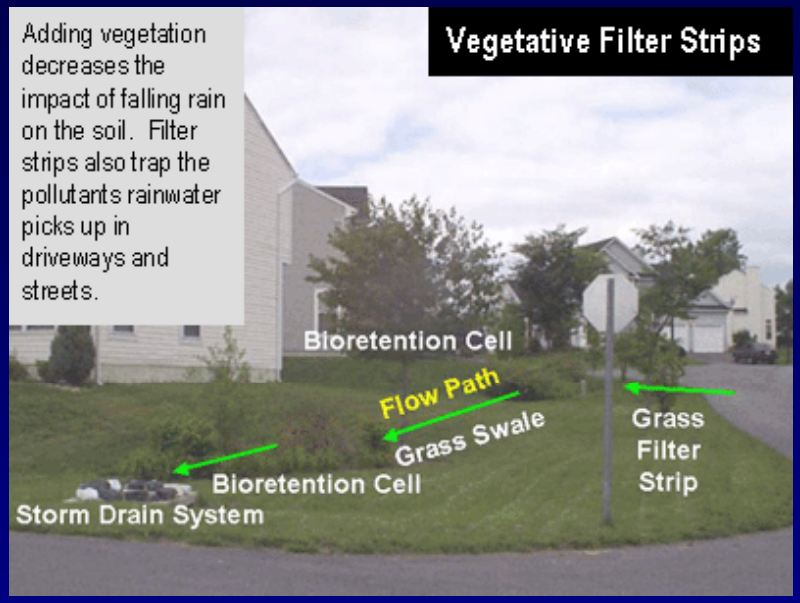
- Pretreatment required
- Regular maintenance

Tree trench/tree box

- Good in high impervious areas
- Need to get trees established

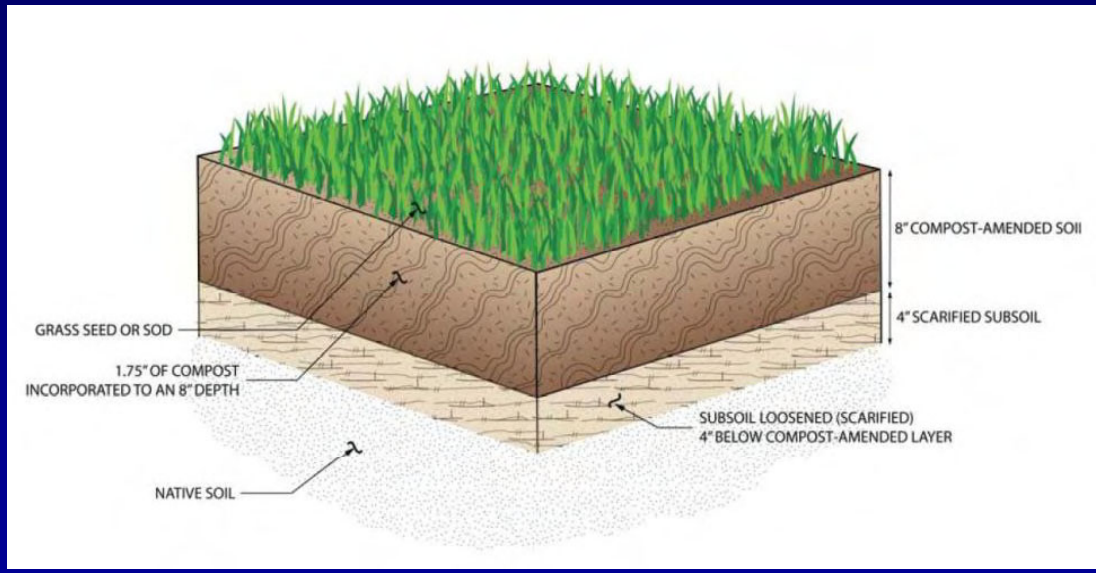
Dry swales/grass channels

- Can infiltrate water if soils are highly permeable



Turf

- Compaction issues in urban areas



Other practices that retain water can also lead to increased infiltration

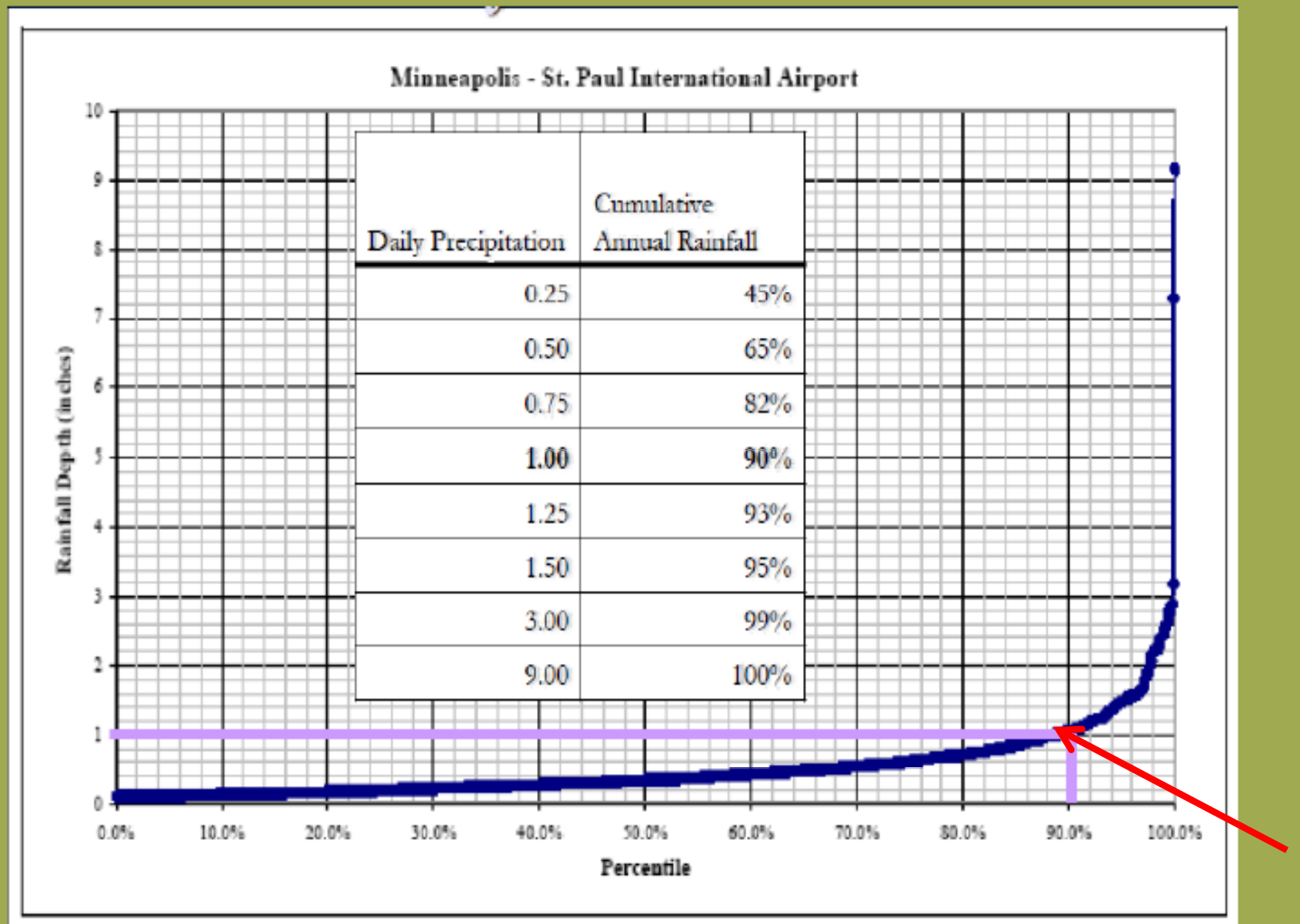
Use of stormwater infiltration practices is likely to increase

Stormwater General Permits and Incorporation of Low Impact Development Evaluation

The Connecticut Department of Environmental Protection (DEP) is in the process of evaluating the incorporation of Low Impact Development principles into our Stormwater General Permits. This process incorporates:

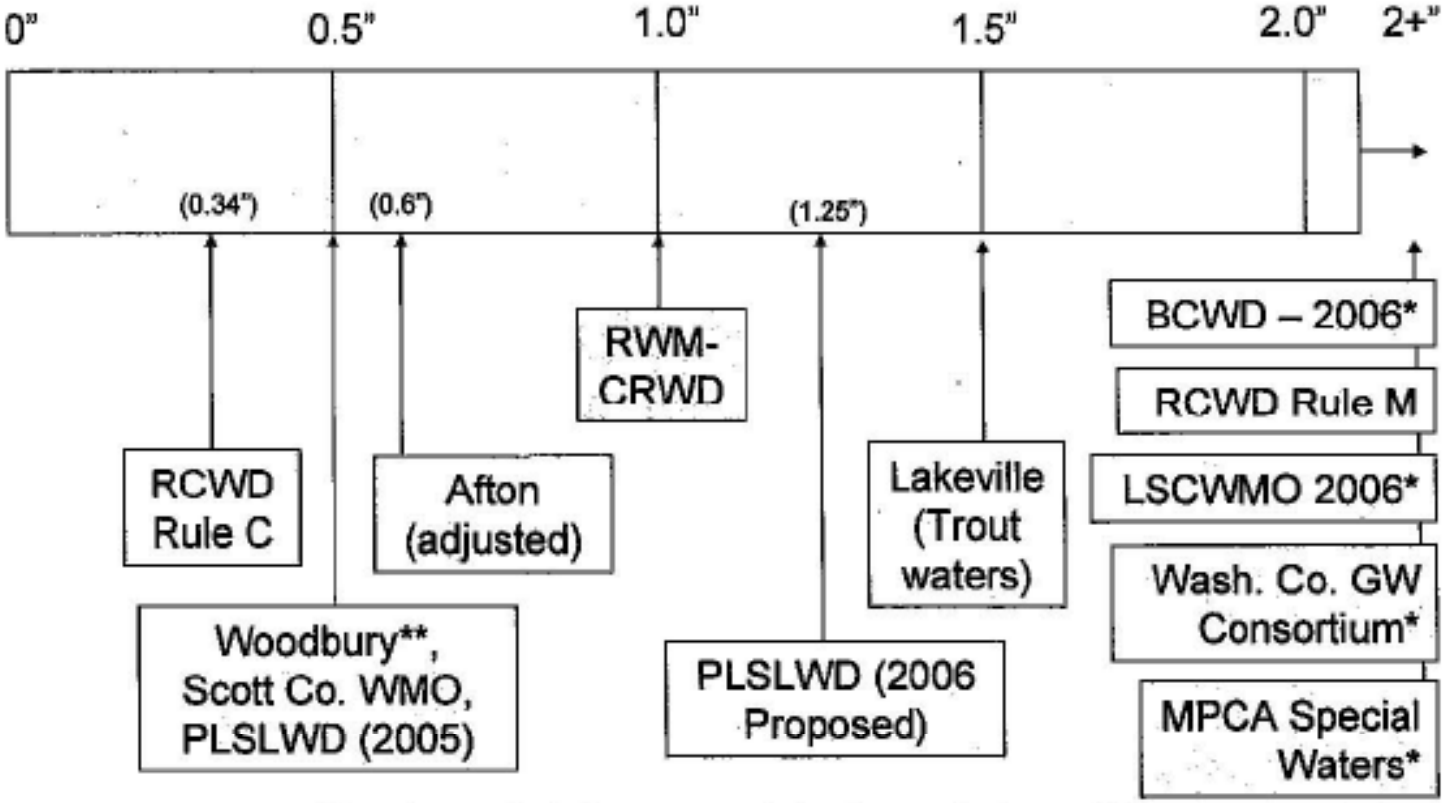
Minimal Impact Design Standards Performance Goal

"For new, nonlinear developments that create more than one acre of new impervious surface on **sites without restrictions**, stormwater runoff volumes will be controlled and the post-construction **runoff volume shall be retained on site** for 1.1 inches of runoff from impervious surfaces statewide."



Daily Precipitation	Cumulative Annual Rainfall
0.25	45%
0.50	65%
0.75	82%
1.00	**90%**
1.25	93%
1.50	95%
3.00	99%
9.00	100%

Figure 1. Volume Reduction Required in Various Minnesota Rules



*Requires control of pre- vs, post-development volume difference over project area for this event; **Standard is ½" over entire site

Impacts on groundwater?

- Water quality – discussed by Dr. Gulliver
- Water quantity
  - Several mounding studies
  - Few field studies
  - Modeled up to 1.5 m long-term increase in WT elevation when WT is > 3 m deep (Philadelphia)[1]
  - Modeled up to 1.1 m increase after 30 years recharge (Syracuse)[2]

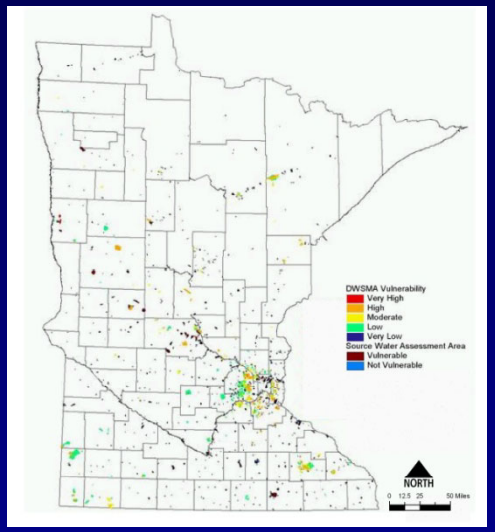
[1] Maimone et al.; Environmental Engineer, Fall 2011

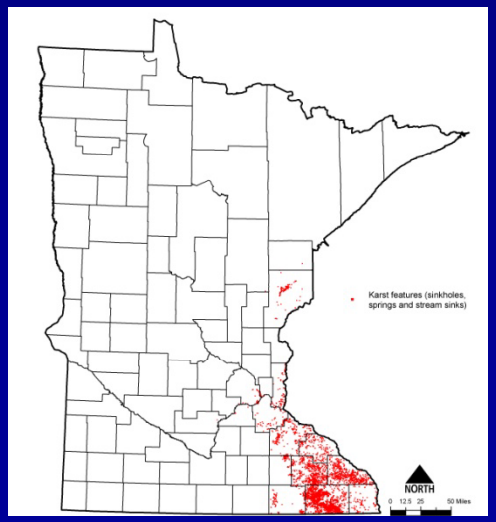
[2] Endreny and Collins; Ecological Engineering, 35 (2009), 670-677

Potential restrictions on infiltration

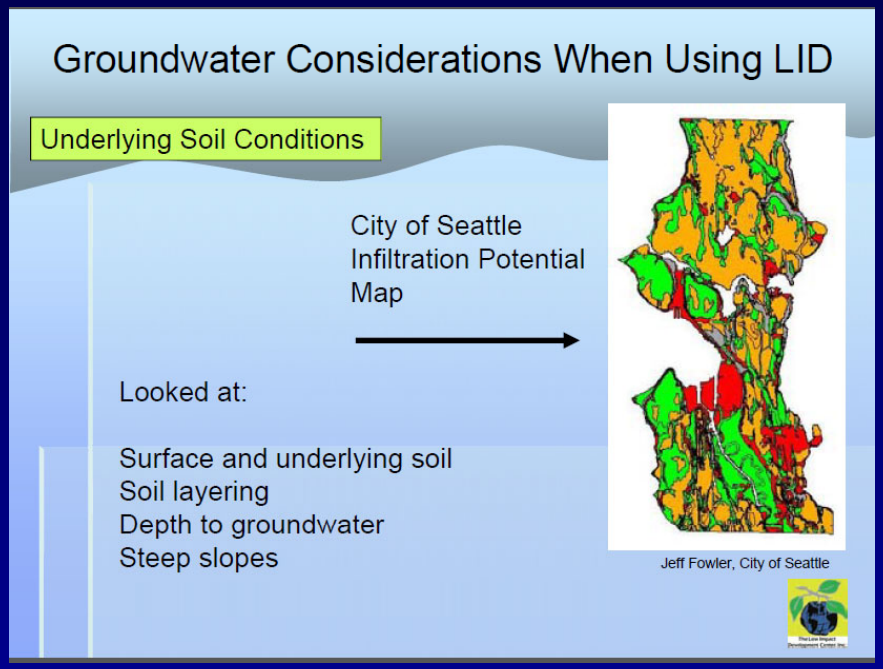
Groundwater considerations

- Source water protection areas
- Active karst topography
- Very high infiltrating soils
- Confining layers thin or absent
- Shallow groundwater
- Hotspots





What do we need?



- More data
- Guidance
- Collaboration between stormwater and groundwater professionals

Evaluating Proposed Stormwater Infiltration Projects in Vulnerable Wellhead Protection Areas

Minnesota Department of Health

Introduction

Infiltration is widely promoted because it is a practice with demonstrated long-term value in managing stormwater. As a management technique, properly designed and executed

Multifunctional, Multiple Benefits of Infiltration

- Volume control
- Groundwater recharge
- Pollutant removal

- Aesthetic value
- Civic engagement
- Vector control
- Costs?

Questions?

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