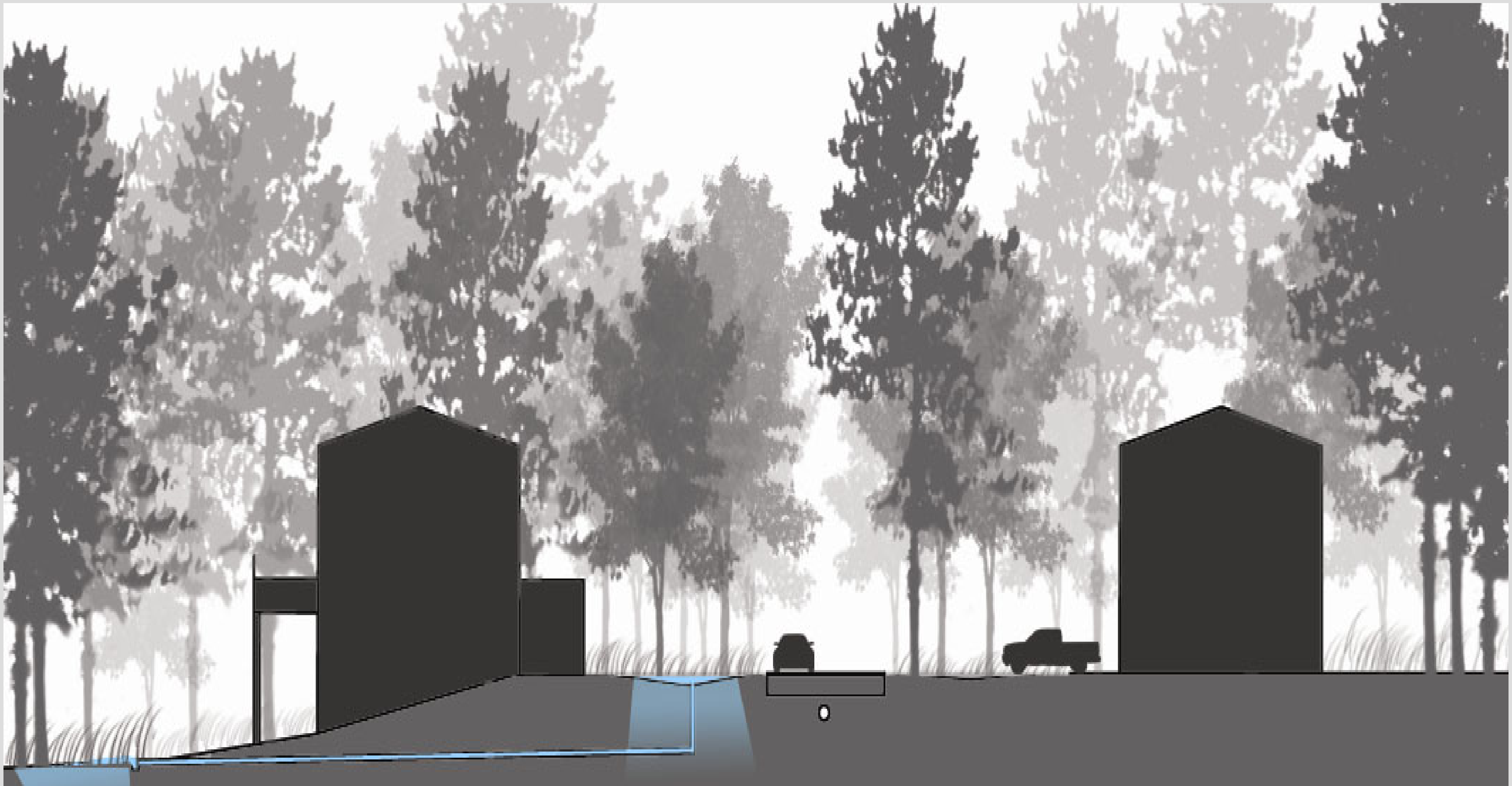
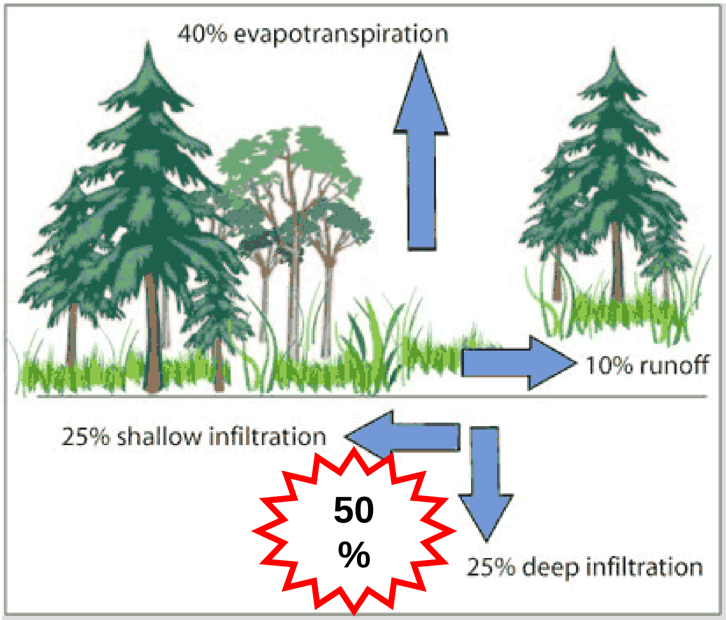
Impacts of Stormwater Infiltration on the Groundwater System

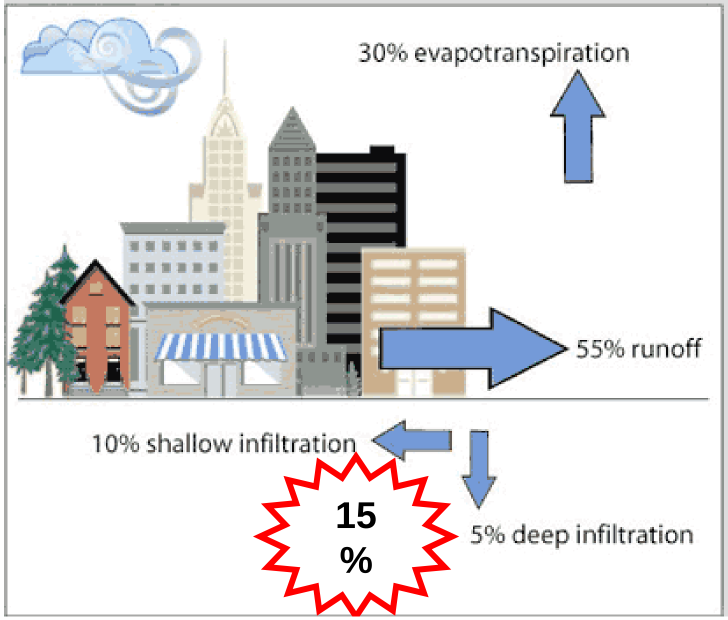


Carl K. Almer I Water Resources Engineer I Emmons & Olivier Resources, Inc.
Gregory LeFevre, MS, EIT I Graduate Student, Environmental Engineering I U of M

water I ecology I community

What is the issue?





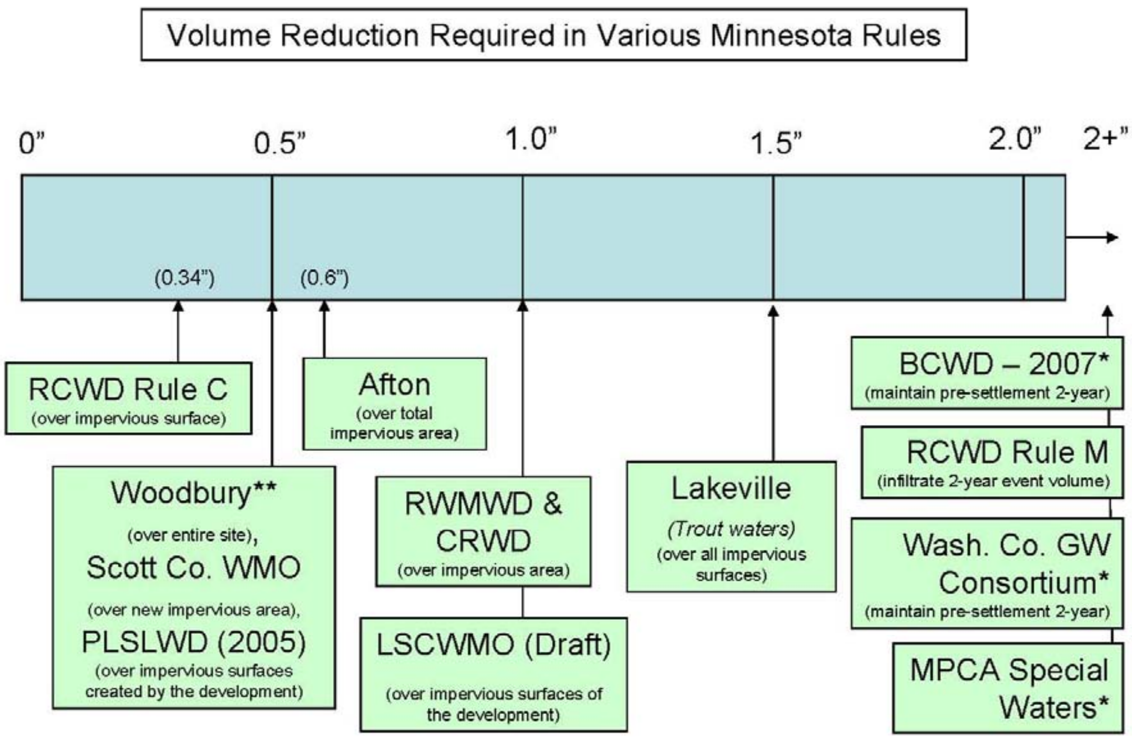
Increased use of stormwater infiltration due to:

Increased imperviousness in the landscape

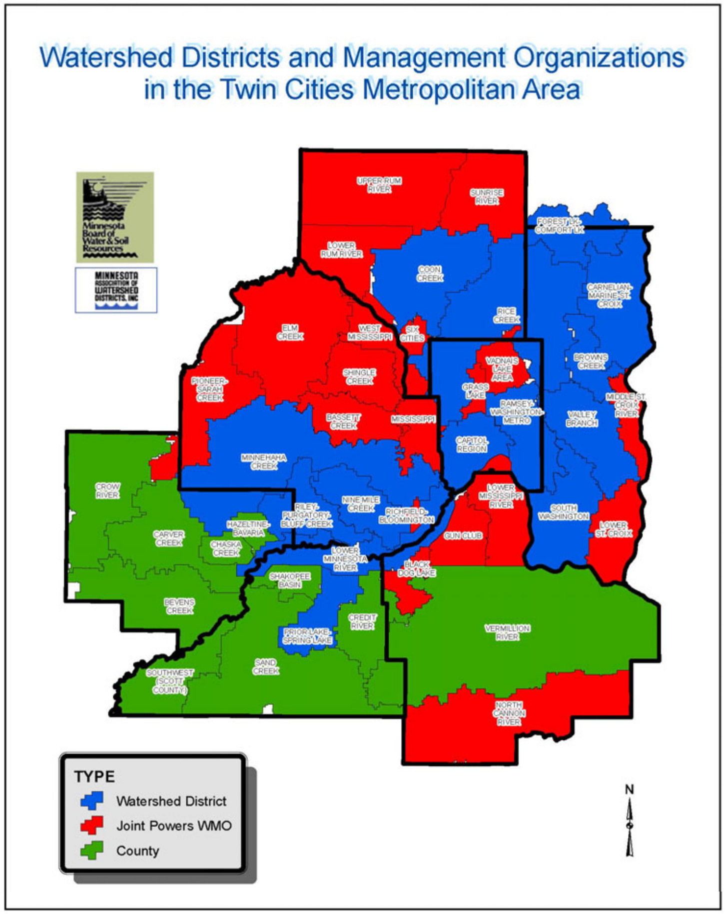
Regulatory bodies adopting volume control standards; increasing the number of infiltration practices in the landscape

Question: In the process of improving surface water quality, are we creating impacts elsewhere?

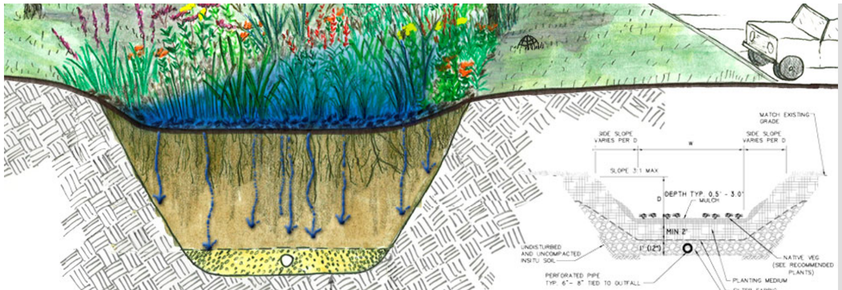
More & More Infiltration Required…

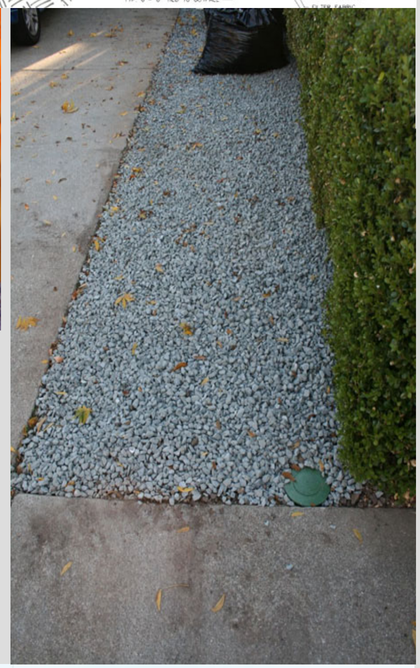


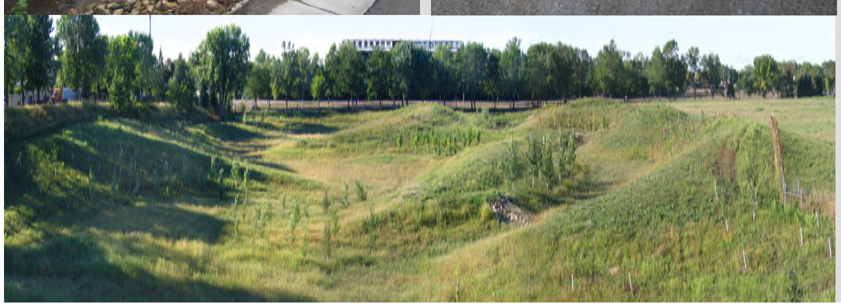
*Requires control of pre- vs, post-development volume difference over project area for this event; **Standard is ½" over entire site



Stormwater Infiltration BMPs







Definition

Natural or constructed depressions located in permeable soils that capture, store and infiltrate the volume of stormwater runoff associated with a particular design event.

Types of Stormwater Infiltration BMPs

Raingardens / Bioretention

Infiltration Trenches

Dry Wells / French Drains

Infiltration Galleys

Infiltration Basins

Pervious Pavements

Others…

Raingardens / Bioretention

Description

Bioretention is a shallow terrestrial-based water quality and water quantity control process.

Bioretention raingardens employ a simplistic, site integrated design that provides opportunity for runoff infiltration, filtration, storage and water uptake by vegetation in a shallow depression.

Raingardens are typically sized to for drainage areas less than 1-acre.

Infiltration Trenches

Description

An infiltration trench is a shallow excavated trench, typically 3 to 12 feet deep, that is backfilled with a coarse stone aggregate allowing for the temporary storage of runoff in the void space of the material.

Trenches are commonly used for drainage areas less than 5 acres in size and often utilized in combination with an overlying raingarden.

Dry Wells / French Drains

Description

A dry well or french drain is a smaller variation of an infiltration trench. It is a subsurface storage facility (a structural chamber or an excavated pit backfilled with a coarse stone aggregate).

Due to their size, dry wells are typically designed to handle stormwater runoff from smaller drainage areas, less than one acre in size (e.g. roof tops).

Infiltration Galleys

Description

Several underground infiltration systems, including pre-manufactured pipes, vaults, and modular structures, have been developed as alternatives to infiltration basins and trenches for space-limited sites and stormwater retrofit applications.

Infiltration Galleys are commonly used for drainage areas ranging from 1 to 10 acres in size.

Infiltration Basins

Description

An infiltration basin is a natural or constructed impoundment that captures, temporarily stores and infiltrates over several days. In the case of a constructed basin, the impoundment is created by excavation or embankment.

Infiltration basins are commonly used for drainage areas of 5 to 50 acres. Typical depths range from 2 to 12 feet, including bounce in the basin.

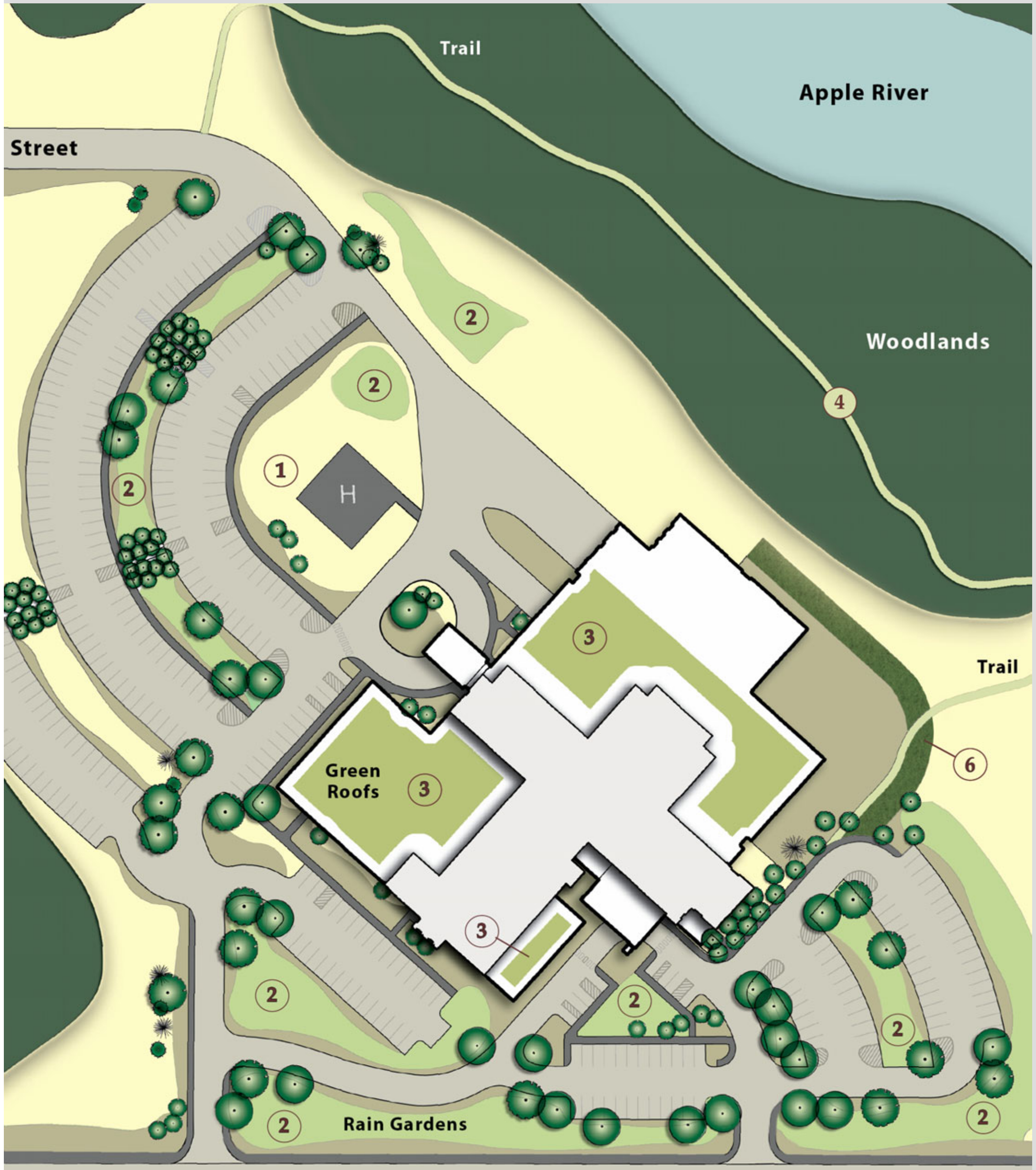
Pervious Pavements

Description

Pervious pavements reduce the amount of runoff by allowing water to pass through surfaces that would otherwise be impervious. These pavements typically incorporate a rock bed storage layer.

Water can then infiltrate into the ground, if soil permeability rates allow, or be conveyed to other BMPs or a storm water system by an under-drain.

Infiltration BMPs in Development



Benefits to the Surface Water System

Benefits:

Mimics hydrology of the site

- Reduces peak flow rates
- Decreases total flow volumes
- Increases time of concentration

Provides for groundwater recharge

- Maintains baseflow
- Recharges groundwater aquifers

Minimizes downstream impacts

- Reduces flooding
- Ameliorates thermal impacts
- Provides water quality treatment

Reduces Cost

- Minimizes Infrastructure

Impacts to the Groundwater System

Robert Pogorzelski

Potential Impacts

Potential groundwater contamination

- Spills
- Quality of stormwater runoff
- Design of infiltration practice relative to site conditions

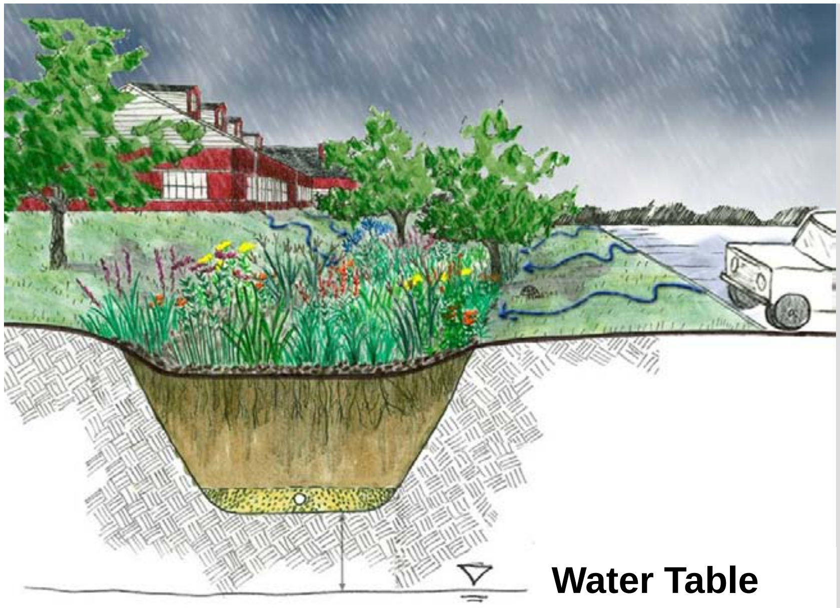
Localized increases in groundwater table

- Flooding of basements

Drinking water quality

- Nitrates (e.g. “blue baby” syndrome)
- Road salts
- Metals

Geologic Features Susceptible to Infiltration / Potential Contamination



High Water Table

Siting of an infiltration practice within or without adequate separation from the water table could result in transport of pollutants directly to the groundwater

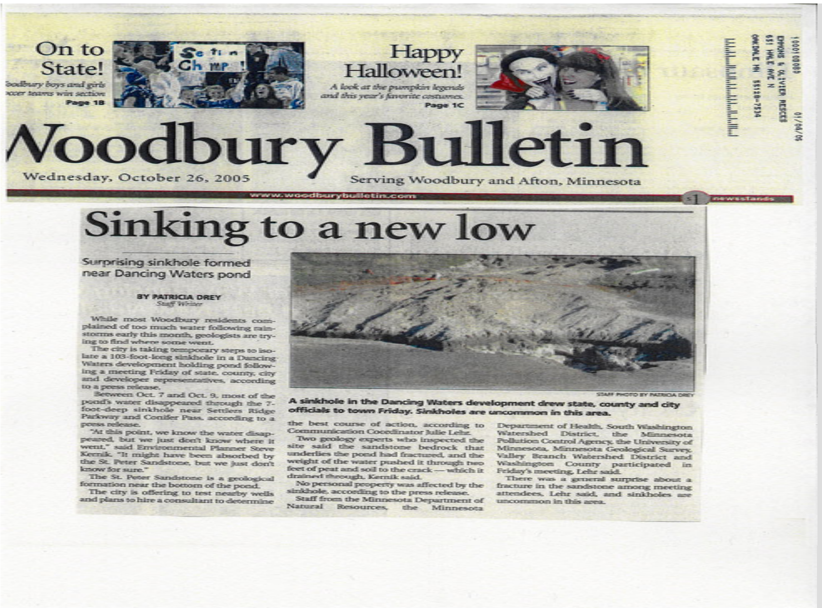
Depth to W.T. Requirement

- Provide 3 feet from bottom of infiltration practice to the seasonally high water table (MPCA)

Rationale

- Provides treatment in soil column
- Reduces likelihood of groundwater mound intersecting the bottom of practice

Geologic Features Susceptible to Infiltration / Potential Contamination



On to State!

Happy Halloween!

A look at the pumpkin legends and this year's favorite costumes.

Page 1C

Woodbury Bulletin

Wednesday, October 26, 2005

Serving Woodbury and Afton, Minnesota

www.woodburybulletin.com

Sinking to a new low

Surprising sinkhole formed near Dancing Waters pond

BY PATRICIA DREY
Staff Writer

A sinkhole in the Dancing Waters development drew state, county and city officials to town Friday. Sinkholes are uncommon in this area.

STAFF PHOTO BY PATRICIA DREY

While most Woodbury residents complained of too much water following rainstorms early this month, geologists are trying to find where some went.

The city is taking temporary steps to isolate a 103-foot-long sinkhole in a Dancing Waters development holding pond following a meeting Friday of state, county, city and developer representatives, according to a press release.

Between Oct. 7 and Oct. 9, most of the pond's water disappeared through the 7-foot-deep sinkhole near Settlers Ridge Parkway and Conifer Pass, according to a press release.

"At this point, we know the water disappeared, but we just don't know where it went," said Environmental Planner Steve Kernik. "It might have been absorbed by the St. Peter Sandstone, but we just don't know for sure."

The St. Peter Sandstone is a geological formation near the bottom of the pond.

The city is offering to test nearby wells and plans to hire a consultant to determine the best course of action, according to Communication Coordinator Julie Lehr.

Two geology experts who inspected the site said the sandstone bedrock that underlies the pond had fractured, and the weight of the water pushed it through two feet of peat and soil to the crack — which it drained through, Kernik said.

No personal property was affected by the sinkhole, according to the press release.

Staff from the Minnesota Department of Natural Resources, the Minnesota Department of Health, South Washington Watershed District, the Minnesota Pollution Control Agency, the University of Minnesota, Minnesota Geological Survey, Valley Branch Watershed District and Washington County participated in Friday's meeting, Lehr said.

There was a general surprise about a fracture in the sandstone among meeting attendees, Lehr said, and sinkholes are uncommon in this area.

Karst Geology

The introduction of new and concentrated stormwater infiltration can accelerate the process and precipitate collapse in areas where natural processes may have posed no significant risk.

Contaminants present in roadway, parking lot, and landscaping runoff flow directly into the groundwater system.

Geologic Features Susceptible to Infiltration / Potential Contamination

High Permeability Soils

Contaminants present in surface water runoff are filtered and treated less in highly permeable soils and may be more readily transmitted into the groundwater system.

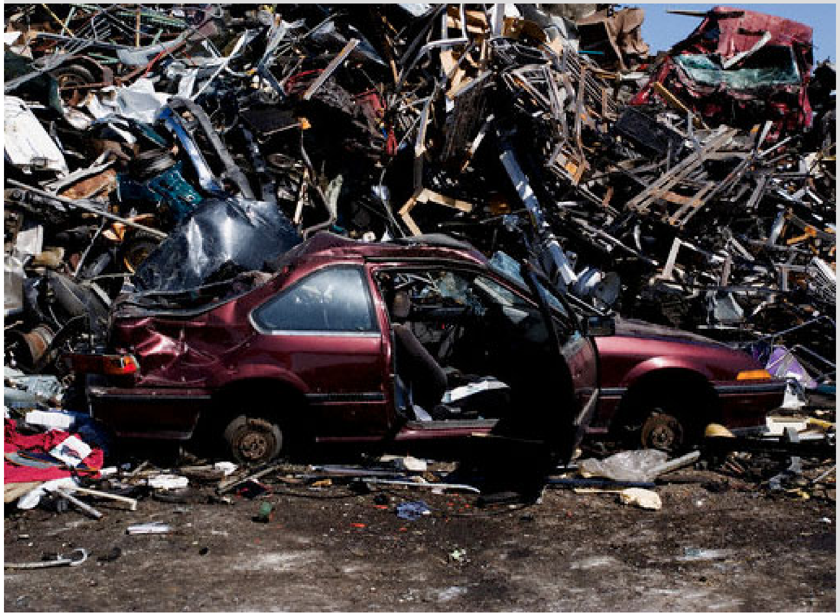
Natural Features Susceptible to Infiltration / Potential Contamination

Groundwater Dependent Natural Resources

Include plant communities and/or aquatic ecosystems that are reliant upon the chemical, hydrologic and thermal conditions sustained by groundwater, and as such are sensitive to changes in:

- Chemistry
- Temperature
- Groundwater contribution (rate and volume)

Regulatory Areas Susceptible to Infiltration / Potential Contamination



Source Water Protection & Wellhead Protection Plans

Prevent possible groundwater contamination by preventing infiltration of <u>untreated hotspot runoff</u> while recharging groundwater supplies with unpolluted stormwater to maintain flow in streams and wells during dry weather.

Infiltration of clean runoff from residential and non-residential rooftops is encouraged with acceptable pre-treatment.

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Literature Review

Contamination of Soil and Groundwater Due to Stormwater Infiltration Practices

- University of Minnesota
  St. Anthony Falls Laboratory
- Peter T. Weiss, Greg LeFevre, and John S. Gulliver
- Released June 23, 2008

Available On-line:
http://proteus.pca.state.mn.us/water/stormwater/stormwater-research.html

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Heavy Metals

Sources

- Zn: motor oil, tire dust, galvanized surfaces;
- Cu: flashing, brake wear;
- Pb: paint, auto brakes, deposition;
- Cd: Deposition

Typical Stormwater Concentrations:

- Zn: highly variable (100-800 µg/L)
- Cu: ~15 to 150 µg/L
- Pb: ~6 to 75 µg/L
- Cd: very low (~2.5 to 8 µg/L)

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Nutrients

Sources:

- **Phosphorous**: excess fertilizer, decay of vegetation (leaves, grass clippings), animal wastes
- **Nitrogen**: fertilizers, animal waste, plant decay, deposition

Typical Stormwater Concentrations:

- **Phosphorous**: highly spatially and temporally variable: typical ~1 mg/L
- **Nitrogen**: typically low in urban areas (residential: 0.7 mg/L, but measured up to 13 mg/L)

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Suspended Solids

Sources:

- Construction sites, erosion, street particles, etc.

Typical Stormwater Concentrations:

- highly variable (10-10,000 mg/L), usually several hundred (national ave: 124)
- Other pollutants often bound to particles

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Petroleum Hydrocarbons

Sources:

- motor vehicle use
- asphalt sealants

Typical Stormwater Concentrations:

- variable and typically low (1-10µg/L) but also up to 100µg/L

State of the Science: Impacts of Stormwater Infiltration on Groundwater

EOR water ecology community

Road Salts

Sources:

- Road salts, water softeners

Values:

- Highly spatially variable (study in MSP region found GW wells Cl^- 4-330 mg/L and highest values closest to highways), typical values in the 100’s of mg/L

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Pathogens

Sources:

- Animal wastes, agricultural applications, sewer leaks

Values:

- Ubiquitous Distribution (95% of separate sewers), highly variable (on order of 10,000 CFU/100mL)

State of the Science: Impacts of Stormwater Infiltration on Groundwater

Pollutant Removal Mechanisms

Filtration:

- Physical capture of particles
- Effective for suspended solids, bacteria

Settling:

- Pre-treatment prior to infiltration

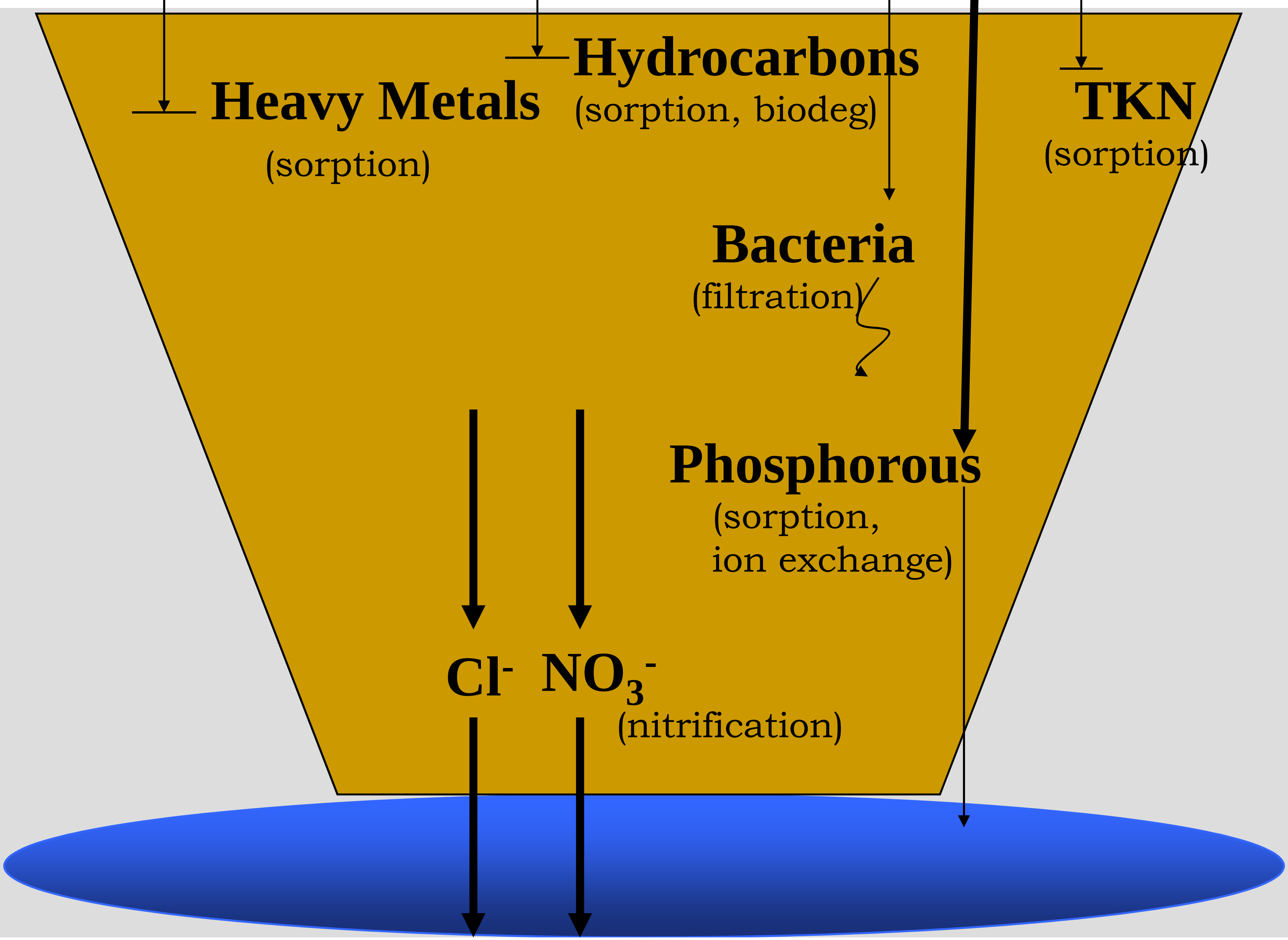
Sorption:

- Chemical binding process
- Heavy metals, Hydrocarbons, TKN bound to organic matter
- Ammonia, phosphorous ion-exchange in soil media

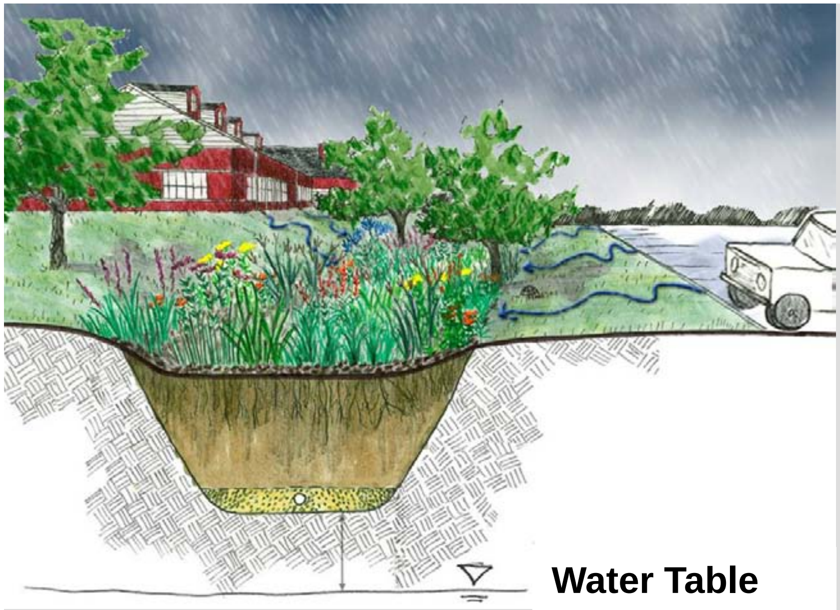
Biological

- Degradation of toxic organics(?)
- Nitrification / Denitrification

Pollutant Fate / Migration



Guidance for Siting Future Stormwater Infiltration Practices



High Water Table

Depth to W.T. Requirement

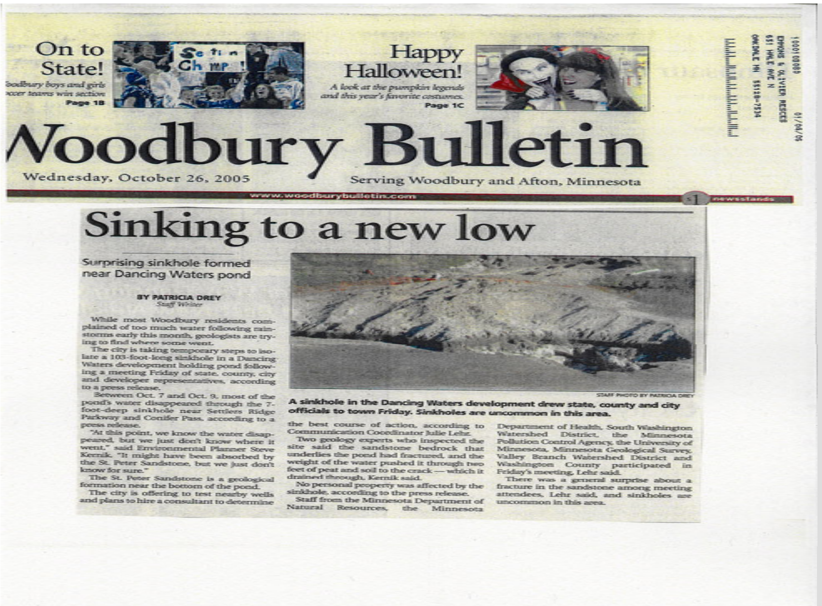
- Again, 3 feet minimum (MPCA)

- But maybe, look to our neighbors – consider increasing minimum to 5 feet from bottom of infiltration practice to the seasonally high water table (Wisconsin)

Rationale

- Greater media depth increases contact time for pollutant removal

Guidance for Siting Future Stormwater Infiltration Practices



On to State! Woodbury boys and girls soccer teams win section Page 1B

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Karst Geology

BMPs for infiltration in karst prone areas are limited:

- Infiltration practices should be dispersed (not concentrated)
- Stormwater should be conveyed to a collection and transmission system away from the karst setting (if possible)
- Minnesota Stormwater Manual contains a table (Table 7.6) that reviews the most feasible BMPs in active karst regions and the type of geotechnical investigations needed

Guidance for Siting Future Stormwater Infiltration Practices

High Permeability Soils

Pretreatment is the key, but looking to the future, additional points to consider may include:

- Soil Anisotropy to assess the potential for differential flow paths
- Soil Cation Exchange Capacity to measure the ability of the soil to remove contaminants
- Soil Thickness (or increased minimum separation from High Water Table) to establish effective filtration capacity

Guidance for Siting Future Stormwater Infiltration Practices

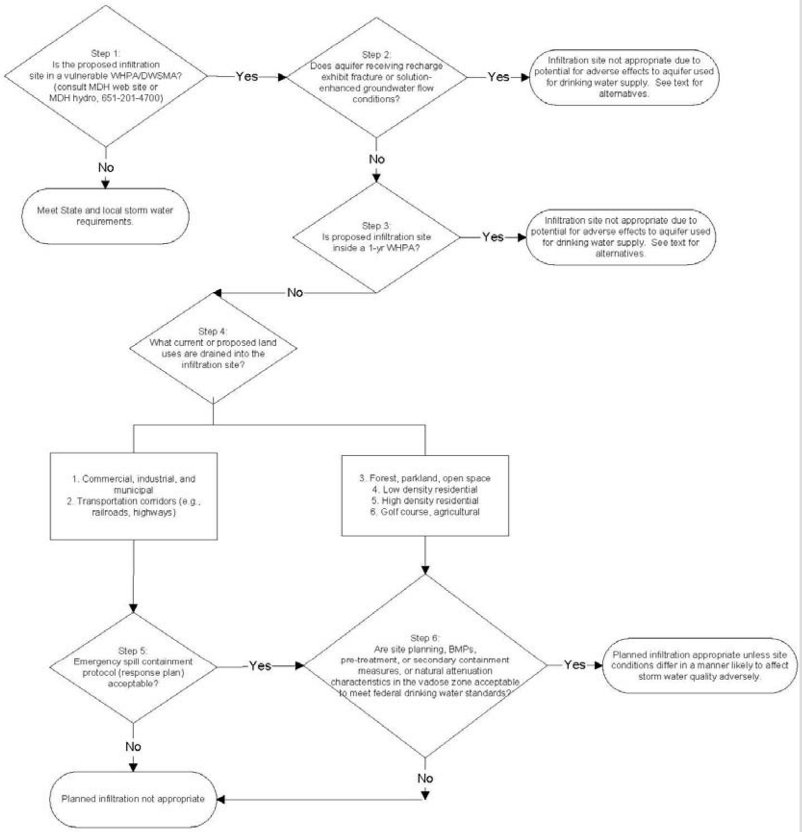
Location of Practice

Relative to groundwater dependent natural resources

- Maintain recharge (via infiltration) at a consistent rate in the contributing drainage area
- Maintain as wide of a buffer as possible around the resource
- No direct discharge of stormwater runoff (including overflow) to the resource

Guidance for Siting Future Stormwater Infiltration Practices

A Flow Chart for Evaluating Proposed Stormwater Infiltration Projects in Areas with Vulnerable Groundwater



Note: This flow chart intended for use in conjunction with MDH guidance on evaluating storm water infiltration projects in vulnerable wellhead protection areas.

Source Water Protection & Wellhead Protection Areas

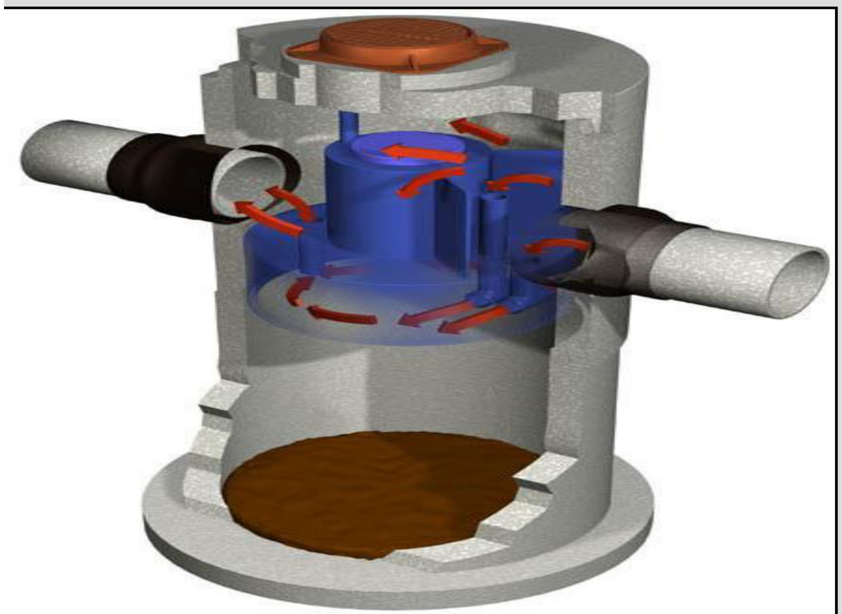
Per MN Stormwater Manual:

- No infiltration from Potential Stormwater Hotspots (PSHs), especially those with high chloride potential
- A minimum of 0.2 watershed-inches of effective pre-treatment prior to any infiltration

MDH Guidance:

- *Evaluating Proposed Stormwater Infiltration Projects in Vulnerable Wellhead Protection Areas*

Guidance for Siting Future Stormwater Infiltration Practices



Pretreatment

Stormwater Regulations

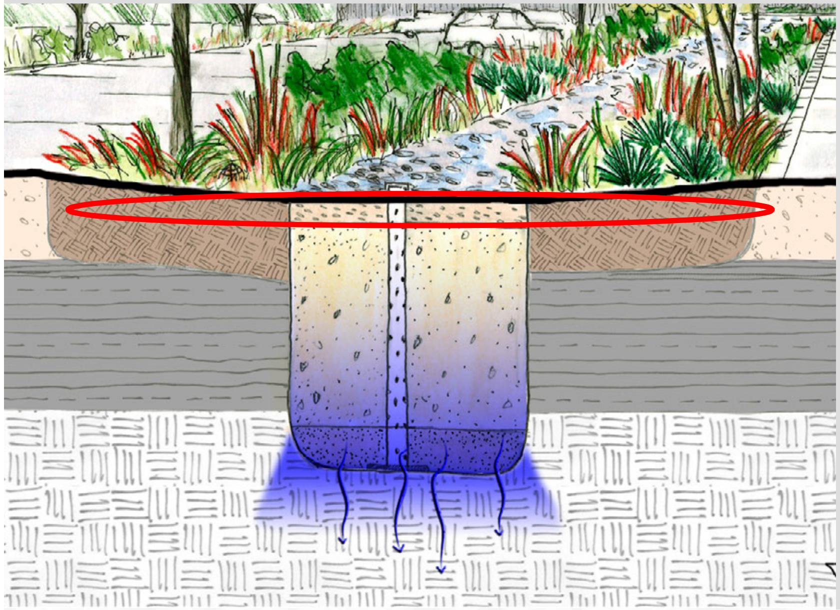
- Most regulatory bodies require, at a minimum, require some form of pretreatment such as:
  - plunge pool
  - sump pit
  - filter strip
  - sedimentation basin
  - grass channel
  - or combination of above

Pretreatment Sizing / Standards

- Sizing may be stated as a percent (25-100%) of the required infiltration volume, dependent on native soil infiltration rates (MN Stormwater Manual)

- Others Standards:
  - 50% TSS (Browns Creek WD)
  - 80% TSS (Inver Grove Heights)

Guidance for Maintaining Future Stormwater Infiltration Practices



Maintenance Considerations

Pollutant Accumulation

- Finite Sorption capacity of media
  - Heavy metal build-up
  - Phosphorous leaching
- Organic biodegradation sustainable(?)
- Estimates of media life ~20 years based upon lab tests (heavy metals)

Maintenance typically guided by clogging from TSS

- Removal & Replacement of upper media layer

Media Disposal

- No guidelines currently

Alternatives to Infiltration Practices

Alternative Volume Control Practices

Source reduction

Distributed flow paths

Evapotranspiration

- Rainwater harvesting
- Tree boxes

Green roofs / Living walls

Others…

Conclusions

The Take Home…

Infiltration *can* pose risk to groundwater.

However, much depends upon:

- Type of pollutant:
  - BMPs effective for TSS, Hydrocarbons, TP and Bacteria
  - Salts & Nitrates not effectively captured
- Siting:
  - Avoid karst geology
  - Avoid PSHs
  - Provide adequate separation from HWT

Overall, if properly designed and located infiltration BMPs provide great benefits to watershed

Thank You / Questions?

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