Groundwater Impacts of Stormwater Infiltration: Considerations for Low Impact Development

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Presentation Overview

- Groundwater modeling applications to green, or low impact development design

- Philadelphia’s “Green Streets” Program
  - Hydraulic influences – groundwater mounding and potential for basement flooding
    - 12th Street Infiltration Trench System

- Washington State Infiltration Trench
  - Water quality – infiltration trench upgradient of community public supply wells

- Future Considerations
Philadelphia “Green Streets” Project

- Site-scale and regional models developed

- DYNFLOW (www.dynsystem.com)
  - Fully 3D, finite element groundwater flow model
  - Used on over 300 projects worldwide
  - Vetted by the International Groundwater Modeling Center
  - GIS compatible
Site Specific Applications

- Initial evaluations considered “box model” with fixed hydraulic conductivities

- Simplified approach
  - Single K
  - Fixed gradient
Site-Scale Model Results

Precipitation

- $K_v = 1 \text{ ft/d}$
- $K_h = 5 \text{ ft/d}$
- $K_h = 10 \text{ ft/d}$
- $K_h = 20 \text{ ft/d}$
- $K_h = 50 \text{ ft/d}$
Site-Scale Model Results

- Mounding from the trenches is a localized impact
- Appears to be some local permanent groundwater mounding due to the frequency of storms in Philadelphia
- However, box models not representative of actual hydrogeologic conditions...
Model Stratigraphy and Hydrogeologic Framework

- Includes both Coastal Plain & Piedmont physiographic provinces
- Divided by Fall Line
- Two very different hydrogeologic environments
- Stratigraphy from cross-sections in USGS reports
Cross-Section through Coastal Plain

- Layers of permeable aquifer units
- Overlays bedrock
Cross-Section through Piedmont

- Sand layer overlaying bedrock
- Transmissivity is limited

Cross-Section Location
**General flow consistent with published maps**
12th Street Infiltration Design
Incorporate Regional Model

- Create sub-regional model utilizing regional model stratigraphy and boundary conditions
Stratigraphic Framework
Simulate trenches using finite elements
Create Model Input – Recharge File

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**Green Infrastructure Input Data**

| Required Trench Volume (ft³) | 632.5 |
| Impermeable area served (ft²) | 7590 |
| Vertical Hydraulic Conductivity (ft/d) | 1 |

| Infiltration Area (ft²) | 534.507 |
| Trench Depth (ft) | 3.5 |
| Infiltration Amount (ft³/time step) | 5.568 |
| Porosity | 0.4 |

**Trench System 1**

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<th>Actual Date &amp; Time (hours)</th>
<th>Input: Rainfall during time step (inches)</th>
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<th>Potential Volume in trench (ft³)</th>
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<th>Model Input: Actual Infiltration Amount (ft³/time step)</th>
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Hydraulic Impacts

- Site specific
Cross-Section through Piedmont

- Sand layer overlaying bedrock
- Transmissivity is limited
- Mounding may be more problematic
Hydraulic Impacts

- Site specific

- Need more detailed information on stratigraphic framework, groundwater head and pumpage throughout Philadelphia

- Model results indicate that mounding not a major issue, in general, but need to be careful how basins are designed as mounding overlap may be an issue locally
Storm Water Infiltration – Groundwater Quality Considerations

- Case Study – Washington State
- Infiltration trench used for stormwater capture
- Sand and gravel aquifer ($K_h = 200 – 500 \frac{f}{d}$)
- Inflow rates as high as 10 CFS
- Water supply well 600 feet away
- Concerns about downgradient water quality impacts
  - Particularly pathogens
- Groundwater modeling to evaluate mounding and travel time to supply well
Site Conditions

- MW-2: 30 Feet From Trench
- MW-5: 120 Feet From Trench

Infiltration Trench

Water Table Before and After Infiltration
Model Simulation Results - Mounding

Model Grid

Simulated Head Rise After 7 Days
Model Simulation Results - Transport

- Travel time to closest supply well 1-2 months
- Supply well pumps infrequently
Water Quality Impacts

Infiltration Trench

Monitoring Well (30’ from Trench)
Future Goals

◆ Parties agreed to:
  ◦ Reduce trench inflows
  ◦ Maintain sufficient unsaturated zone thickness
  ◦ Monitor groundwater quality

◆ Goals
  ◦ Control of pathogens
  ◦ Sustainable groundwater resource
How the Groundwater Model Helped

- Gain better understanding of the trench/aquifer relationship
- Characterize the vulnerability of receptors
- Guide the design of an effective monitoring program
Future Considerations

- Implementation of stormwater BMP will continue to grow over the coming decades

- Care must be taken on a site-by-site basis to ensure that groundwater sustainability is considered

- Groundwater investigations may be vital to the successful implementation of such a project
  - Geologic borings
  - Long term water level monitoring
Thank You

Questions?

Contact Info

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