NJDEP Stakeholder Meeting #1
Infiltration BMP Manual Update

June 23, 2017

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Impetus

- Infiltration basins are designed and constructed much larger than if they were assumed to function
- Ignoring infiltration is a significant obstacle to mainstreaming Green Infrastructure
- NJ citizens pay for this in terms of dollars, land disturbance/cover and environmental impact

Background

- NJAC 7:8 is actually silent as to infiltration counting
- The NJDEP put guidance in Chapter 5 and other chapters of the Best Management Practices manual to not count infiltration for > WQ storm
- Since then Appendix E adopted, joint infiltration basin study completed and infiltration basin BMP chapter updated

Objective

Establish an appropriate technical framework to normalize how infiltration is counted

Guidance on Drafting a Standard

- "To accomplish the goal of maintaining predevelopment runoff characteristics, there must be a reasonable standard that is easily recognized, reproducible, and applied without opportunity for misrepresentation."

-Source: 2000 Maryland Stormwater Design Manual, Volume I, revised through May 2009.

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NJDEP Potential Issues to Address

- Soil Permeability Testing – reliance on a limited number of soil test pits and/or improper implementation of testing protocols may not provide accurate soil permeability information
  - Appendix E fully addresses
  - Should be clarified or expanded to clearly permit a type of falling head test (similar to NY or MD)
  - Design/modeling requirements conservative

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NJDEP Potential Issues to Address

- Construction Methods - soil compaction during construction may decrease soil permeability and infiltration rates – Addressed in this presentation
- Maintenance – improper maintenance that decreases soil permeability, such as insufficient removal of accumulated sediment and overgrown vegetation may decrease actual infiltration rates – Addressed in this presentation

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NJDEP Potential Issues to Address

- Groundwater Mounding – a reduction in permeability rate may occur when groundwater mounding is present – Addressed in this presentation
- Soil Temperature – soil permeability may decrease when the ground is partially or fully frozen and impact the infiltration rate.
  - Course sand insulates subsoil and resistant to freezing
  - What is return period of ice storm/frozen ground with major design storm rain event?
  - Several conservative design factors applied

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Base

1. NJDEP Chapter 5 of NJ Stormwater BMP Manual (February 2004)
2. NJDEP Chapter 9.5 and other chapters of NJ Stormwater BMP Manual (February 2016)
3. NJDEP Appendix E of NJ Stormwater BMP Manual (September 2009)

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Current Standards

- Use lowest field tested rate from list of approved tests
- Apply a factor of safety = 2 to field infiltration rate (Ksat)
- Minimum subsoil design infiltration rate = 0.5 in/hr
  (1 in/hr field tested)
- Maximum design infiltration rate for rock = 0.5 in/hr
- Maximum design infiltration rate = 10 in/hr
- Minimum distance to SHWT = 2 feet

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Current Standards

- Analyze maximum extent of transient groundwater mound if potential adverse impacts can not be ruled out by inspection
- Maximum design drain time = 72 hours
- Maximum infiltration only (without gravity surface outfall) depth = 2 feet

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Modeling (Routing) Parameters

- Exfiltration* <u>rate</u>
- Exfiltration* <u>area</u>

*Basin modeling software designation, but means infiltration

Modeling Rate Options

- Constant flow rate (cfs)
- Constant velocity (in/hr)
- Conductivity (Darcy's Law : V=Ks*I)

  V = Infiltration rate (velocity)

  Ks = Saturated hydraulic conductivity

  I = Hydraulic gradient (head differential/thickness)

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Modeling Area Options

- Surface area (downward only – Horizontal leg of slope triangle)
- Wetted area (all exposed areas regardless of slope)
- Horizontal area (for pipes and arches since water surface not accurate representation of infiltration surface)

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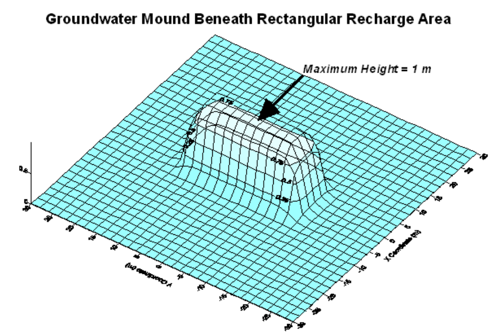
Groundwater Mounding Reality

- Infiltration does NOT stop if groundwater mounds
- GW Mound is dynamic, not static as is infiltration rate
- Visualize pouring a glass of water into a “slice of sand”
- Shape water forms in the sand depends on volume and rate of water, volume of unsaturated soil, permeability rate, depth to water table
- When flow stops, pressure stops and gravity takes over collapsing the mound into the groundwater table

Modeling Groundwater Mound:



- USGS Hantush Excel Spreadsheet
  - Simplified version of actual site conditions
  - Only Horizontal flow, no vertical component
  - Based on a fixed duration of steady infiltration rate – i.e. finite volume
  - Limited to simple and symmetric basin geometries
  - Max of transient height and extent from the center based on duration and infiltration rate all else equal
  - Image from www.AQTESOLV.com by HydroSOLVE, Inc. graphically showing result similar to spreadsheet

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Modeling Groundwater Mound:

- What is SEEP/W 2D finite element analysis to produce animation based on?
  - More robust numerical method
  - Models transient or steady state flows
  - i.e. can model a variable depth and duration from a routed basin hydrograph
  - Can model transition from initial to steady state condition with continuous flow over time (infinite volume)
  - Based on varying flow rate over time – Models inflow hydrograph
  - Includes both horizontal and vertical flow (with vertical anisotropy)
  - Animations are transient, based an assumed but realistic soils and inflow hydrograph, includes both horizontal and vertical flow, and accounts for unsaturated zone above SHWT.

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Groundwater Mounding Scenario

Analysis and Animation:

- Scenario – 10 acre site, 80% Imp, HSG C Soil, Tc Impv 10 min, Tc Perv 20 min, 100 year Monmouth Cty rainfall
- Assumed basin – 620 ft long x 50 ft bottom width, 6 foot working depth (to be extreme), 3:1 side slope, includes SHWT at 2 ft below infiltration surface (worst case)
- Design permeability rate of 0.5 in/hr (worst case),
- Horizontal rates: kx1 (unrealistic), kx10

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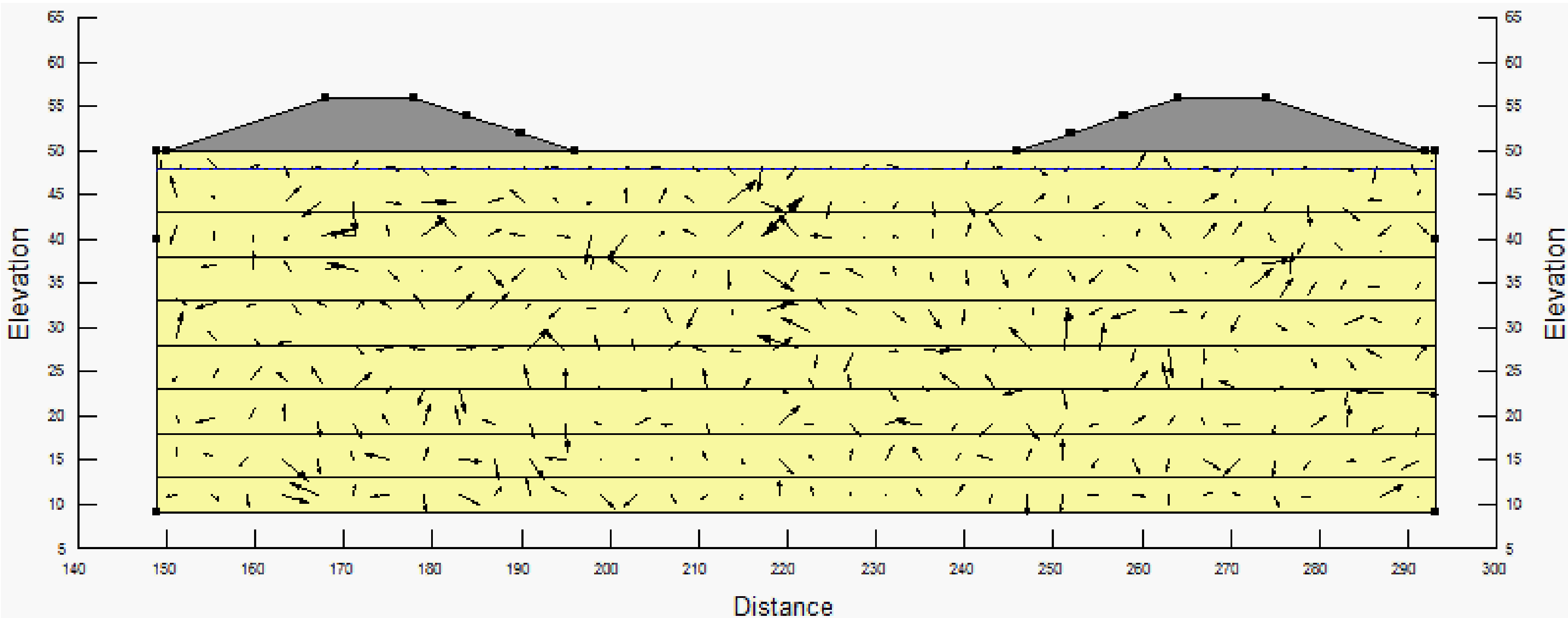
Groundwater Mounding Scenario



Groundwater Mounding Scenario

GROUNDWATER MOUNDING EVALUATION

Infiltration rate = 0.5 in/hour

Depth to SHWT (ft)	Bottom of Basin Outflow at 24 hours (in/hr)	
	K_x=1	K_x=10
2	0.25	0.57
10	0.55	1.10

Depth to SHWT (ft)	Bottom of Basin Outflow at 12.6 hours (in/hr)	
	K_x=1	K_x=10
2	0.42	1.84
10	0.85	2.69

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Groundwater Mounding Scenario

- Rates below 0.5 in/hr are based on an extreme case to force a lower rate
  - Lowest permitted permeability rate after FOS 2 applied
  - Minimum permitted depth to SHWT
  - Infiltration depth of 6 feet utilized
  - Ignores vertical anisotropy (Kx = 1)
  - Only models flow through basin bottom, not side slope

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Groundwater Scenario

- Helps to highlight sensitivities and guide regulatory framework
- GW mound lower and has less impact on actual exfiltration rates:
  - The greater the permeability rate is
  - The greater the depth to SHWT table is
  - The lower the infiltration depth is

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Base Modeling Recommendations

- Test per Appendix E
- Use lowest field tested rate (saturated)
- Apply FOS of 2
- Ignore hydraulic gradient (hydraulic gradient = 1)
- Use surface area (as opposed to wetted area to only assume vertical flow)
- Ignore horizontal flow which is typically 5-10 times vertical rate

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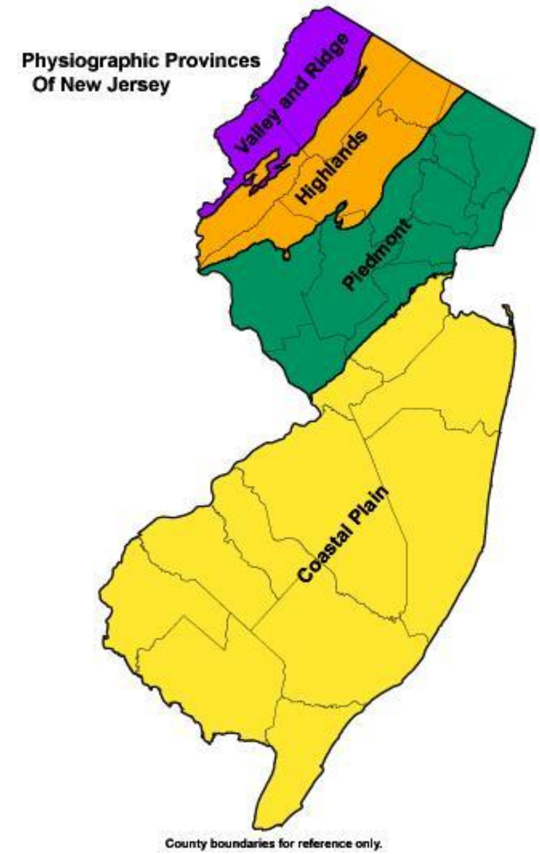
<u>IF</u> Additional Constraints Added

- Should vary by physiographic province
- Should reflect the extensive conservatism already built into the modeling
- Consider local geology (e.g. Karst)



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Additional Constraints???

- Minimum field infiltration rate (before FOS) of 2 in/hr to use for storms > WQ statewide
- Maximum design rate (after FOS) of 3 in/hr in Valley and Ridge, Highlands and Piedmont
- Maximum design rate (after FOS) of 10 in/hr in Coastal Plain
- IF basin designed to discharge 100 year storm with only infiltration, Min stormwater management system volume greater of required for 100 year with design infiltration rate (capped if applicable) or 10 year storm without infiltration

Additional Constraints???

- Maximum design infiltration depth of X feet based on infiltration rate
- Require full time construction observation and certification by PE (similar to Dam Safety Construction Inspection Program)
- Require additional soil testing/mapping in Karst

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Design Recommendations

- When appropriate, use a pre-treatment “train” to protect infiltration basins
- Use engineered bottom surfaces (coarse sand K5+)
- Side slope stabilization (sod, stone, matting, etc.)

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Construction Recommendations

- Under excavate basin during construction (at least 6”)
- Surround basin bottom with silt fence
- Haybale or stone forebays at all pipe inlets
- Lightweight equipment, work inside out to stay off subsoil horizon

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Maintenance

- Should be treated like any other stormwater management approach
- Several conservative design parameters applied
- O & M manuals are required
- MS4 Permits make municipalities responsible to enforce maintenance and draft MS4 Permits have even stronger language clearly placing ultimate responsibility and enforcement for maintenance on the municipality

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Maintenance Recommendations

Requirements for Inspection, Maintenance and Repair of Stormwater BMP's that rely on infiltration:

- Once per month (if needed): Mow side slopes, remove litter and debris, stabilize eroded banks, repair erosion at inflow structure(s);
- After every storm exceeding one (1) inch of rainfall: Ensure that infiltration BMPs drain completely within seventy-two (72) hours after the storm event. If stored water fails to infiltrate seventy-two (72) hours after the end of the storm, corrective measures shall be taken. Raking or tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces. If surficial remediation is unsuccessful, remove and replace K5 sand layer and accumulated sediment, to restore original infiltration rate;

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Maintenance (cont'd)

- Four times per year (quarterly) or two times per year if pre-treatment to reduce TSS is provided: Inspect stormwater infiltration BMPs for clogging, excessive debris and sediment accumulation within the BMP, remove sediment (if needed) when dry;
- Two times per year: Inspect for signs of damage to structures, repair eroded areas, check for signs of petroleum contamination and remediate;
- Once per year: Inspect BMPs for unwanted tree growth and remove if necessary; Disc or otherwise aerate bottom of infiltration basin to a minimum depth of six (6) inches; and
- Additional guidance for the inspection, maintenance and repair of stormwater infiltration BMPs can be found in the New Jersey BMP Manual.

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Questions…

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