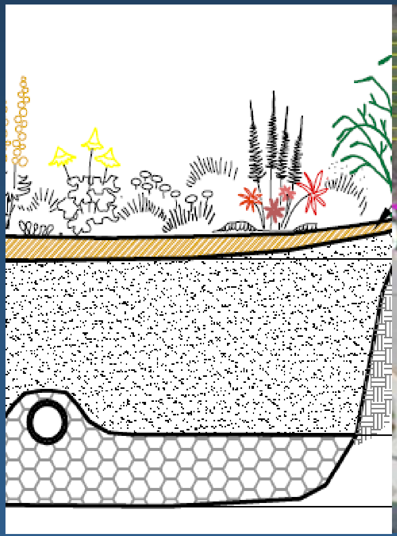
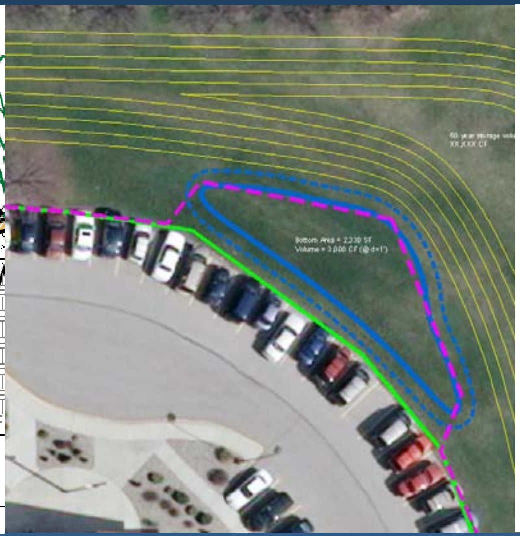
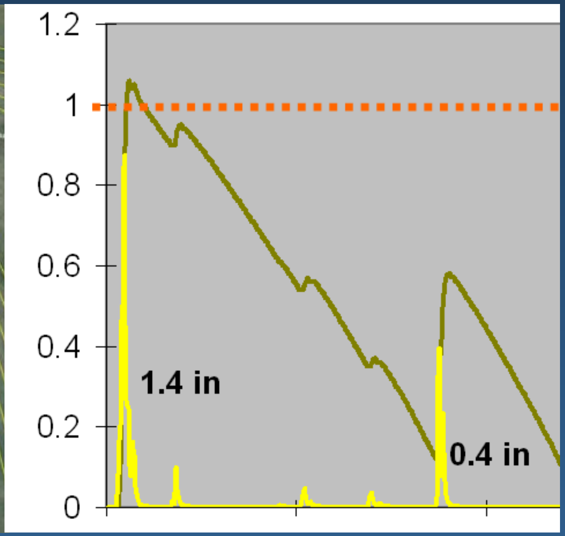
LID Modeling Using SWMM







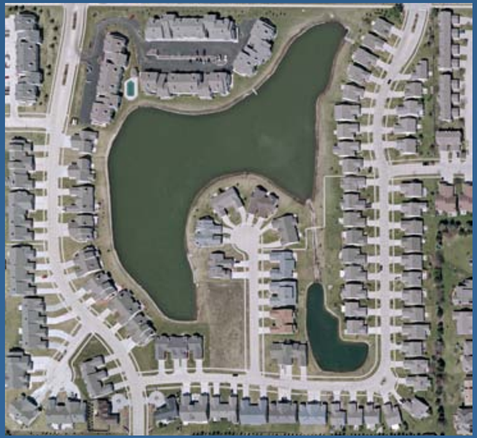
Presented by:
Gregory P. Kacvinsky, P.E.
Foth Infrastructure & Environment
IAFSM: September 29, 2009

Changing Design Criteria

Foth

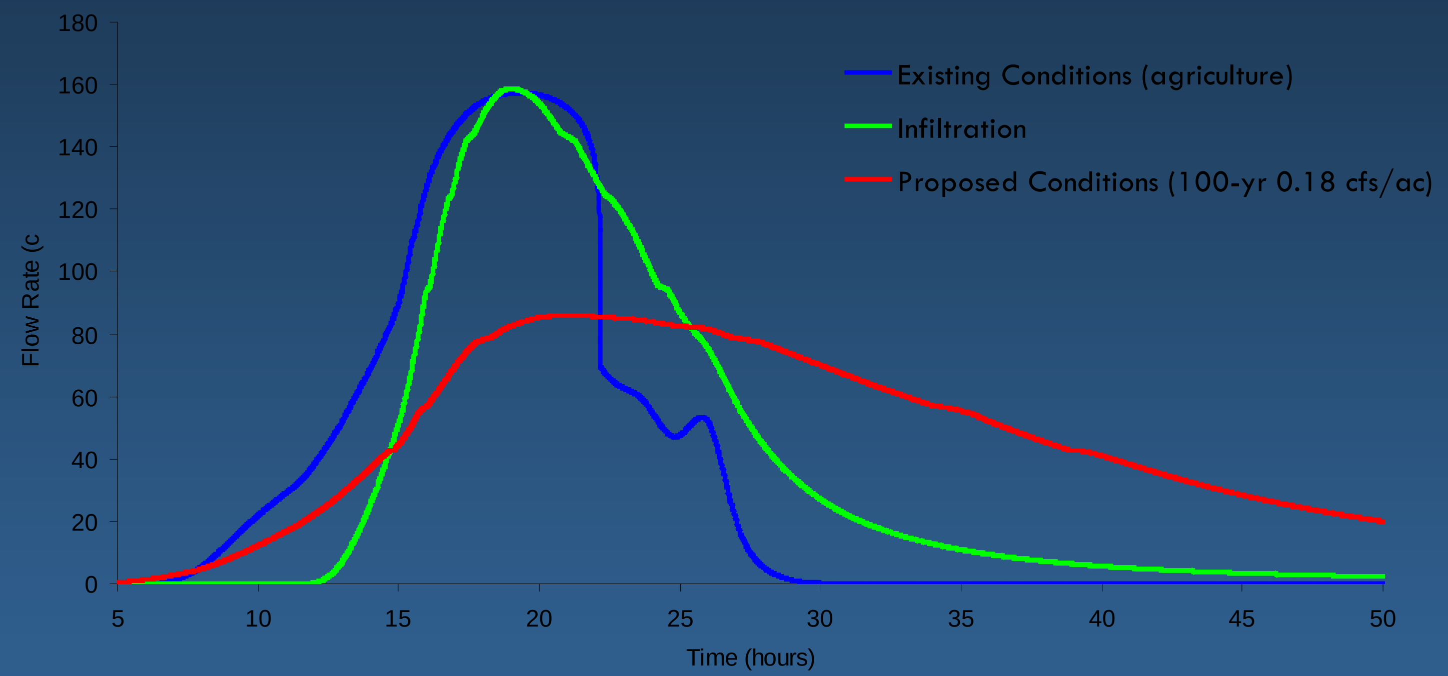
Stormwater Analysis

- Pre-LID World
  - Pre- and post- development peak runoff comparison
  - Pond volume and peak flow determination
  - Sewer sizing / channel sizing
  - Event-based analysis (i.e. 100-yr, 24-hr storm)



Foth

Stormwater Analysis

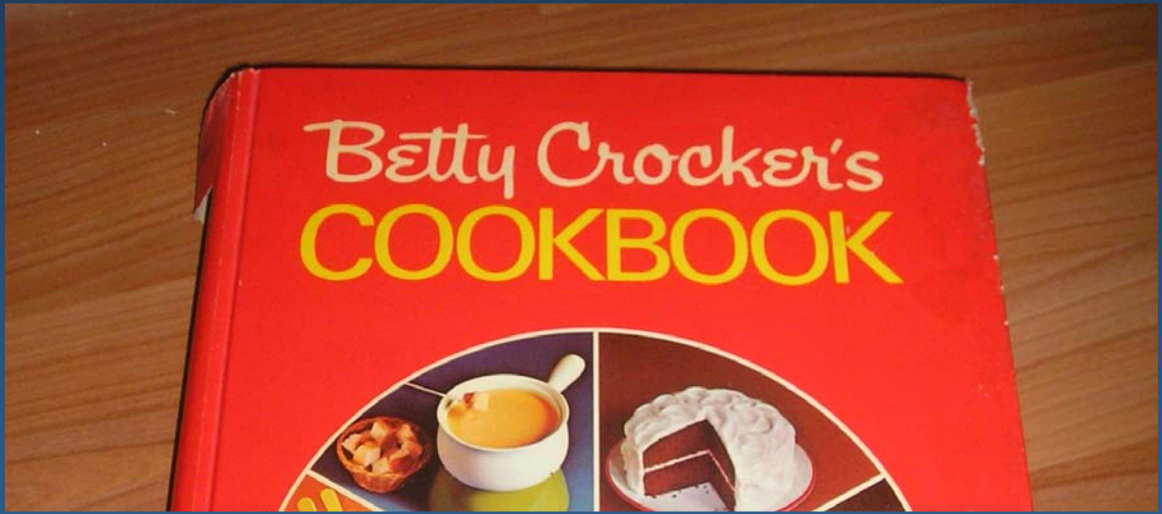


- LID World
  - Pre- and post- development runoff ***<u>VOLUME</u>***
  - Match pre-existing hydrology
  - Continuous simulation

Foth

Conventional Modeling

- TR-20
- HEC-HMS
- PondPack
- HydroCAD
- SWMM



Foth

SWMM and LID Modeling

- Storm Water Management Model (SWMM)
  - EPA-SWMM v. 5.0 (U.S. EPA)
  - XP SWMM (XP Software)
  - PC SWMM (Computational Hydraulics International)
  - Info SWMM (MWH Soft)
  - InfoWorks (Wallingford)
- RECARGA

SWMM and LID Modeling

- EPA SWMM v. 5.0.16 (updated July 2009)
  - A modeling platform that can perform all needed LID modeling needs:
    - Rainfall / runoff calculation
    - Infiltration within storage areas
    - Sewer flow calculations (gravity and pressure)
    - Detention pond / flood control
    - Pumps
    - Event-based *and* continuous simulation

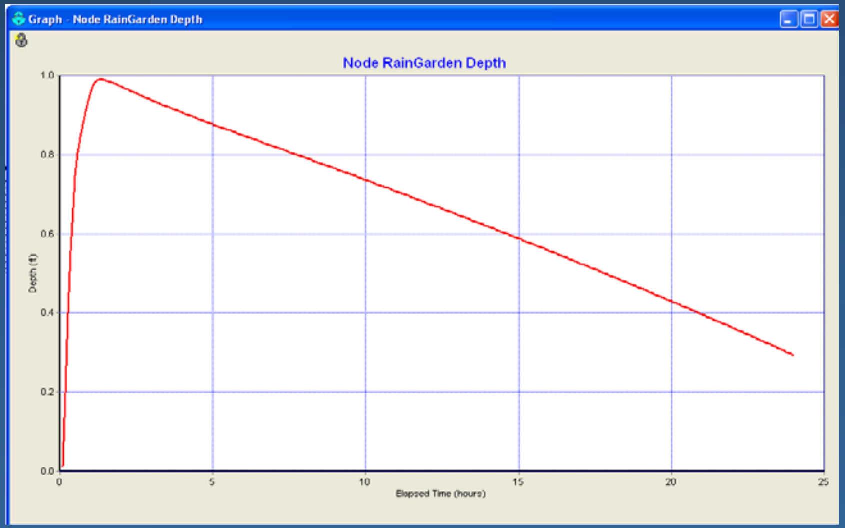
Foth

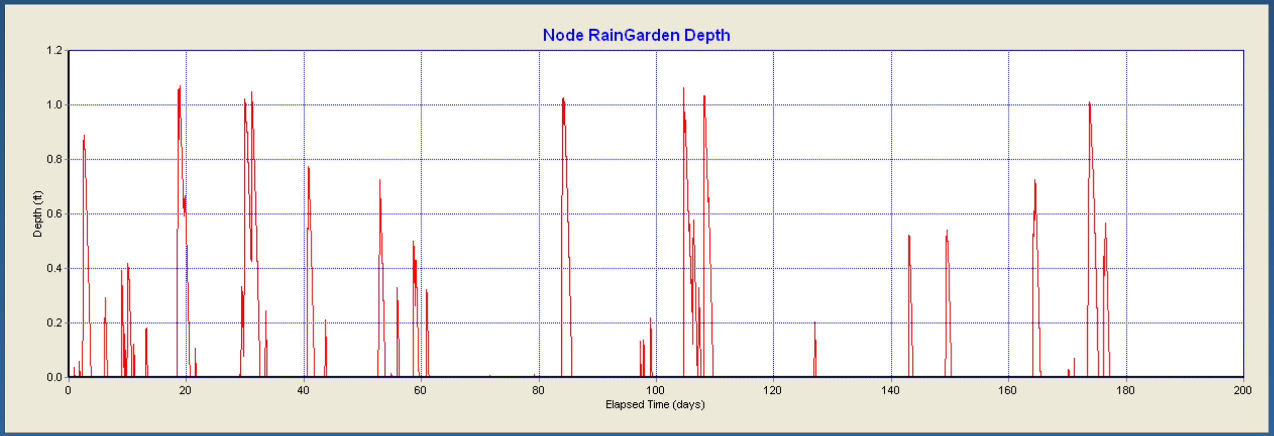
What do we need model to show?

- Emerging requirements:
  - Retention/infiltration for frequent (i.e. “water quality”) events
    - 1-year / 2-year / 1-inch / etc.
    - Water Quality Volume
  - Infiltration matching existing conditions
    - 90% of pre-development infiltration (Wisconsin)
    - Infiltrate XX% of post-developed runoff
    - 80% reduction in TSS

What do we need model to show?

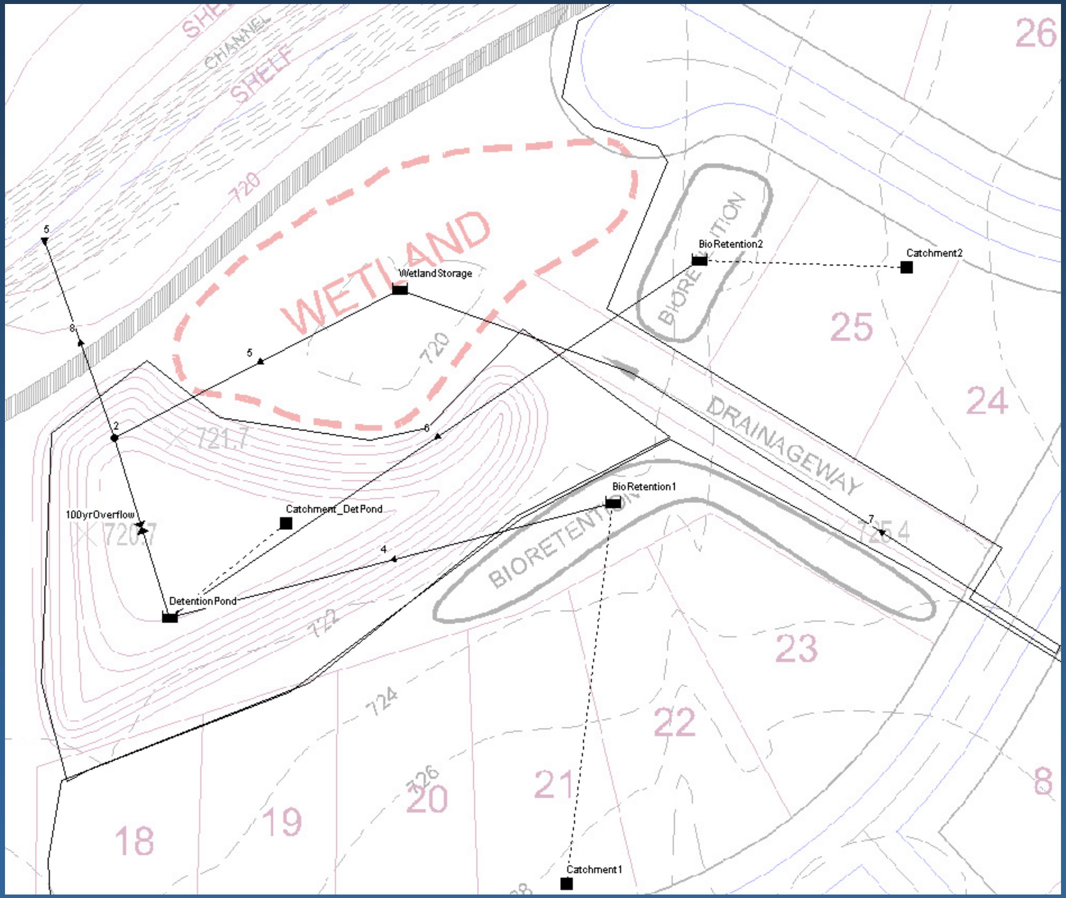
- Emerging requirements:
  - Requires event-based and continuous modeling





Infiltration Modeling in SWMM

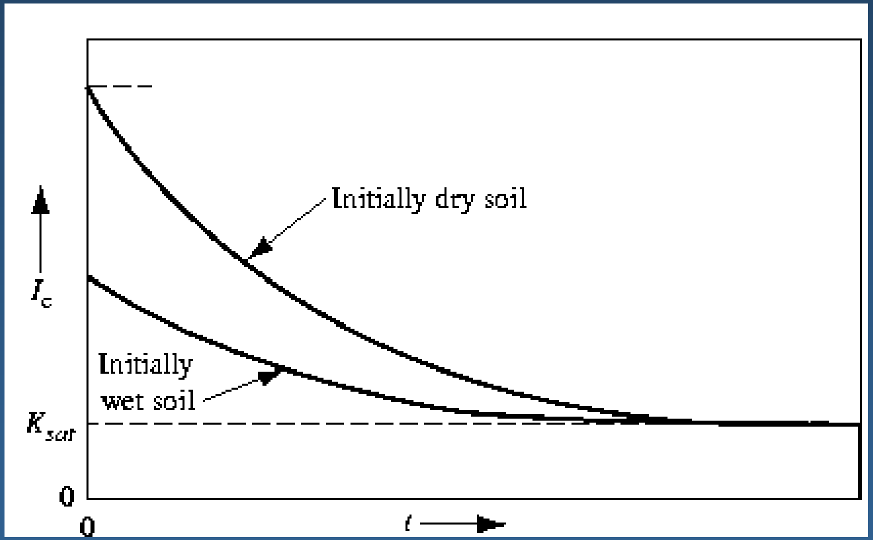
- Shares components of traditional model
  - Subcatchments
  - Detention pond
  - Pond outlet structure
- Additional components
  - Bioretention storage
  - Bioretention infiltration
  - Infiltration recovery



Foth

Infiltration Modeling

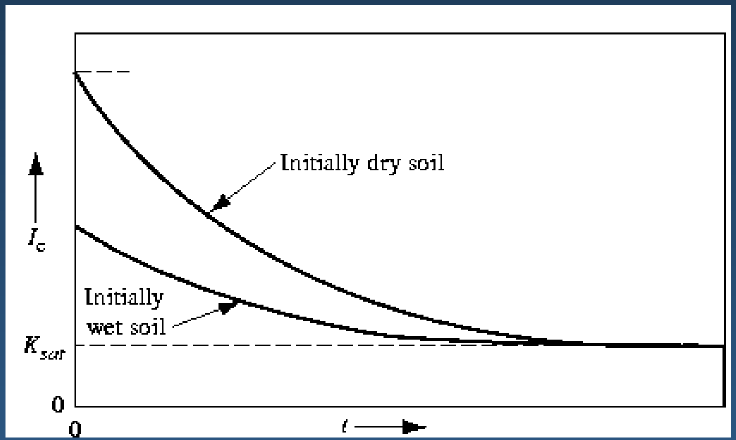
- Properly designed and constructed bioretention:
  - Unique infiltration characteristics
    - Can exceed 15-20 in/hr (initial)
    - K_{sat} can be at or below 0.5 inches per hour
- Soils achieve K_{sat} often within 10-20 minutes of onset of storm
- Vegetation maximizes infiltration

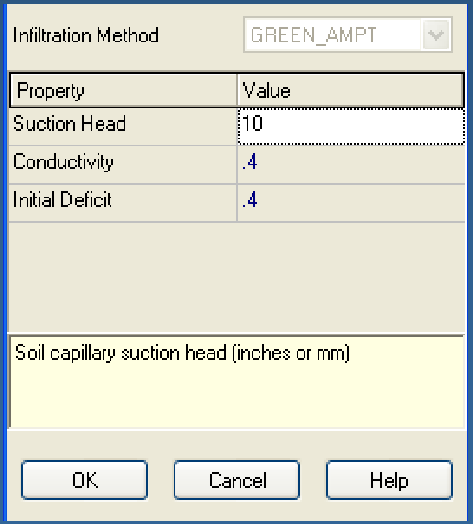


Foth

Infiltration Modeling

- Bioretention infiltration in EPA SWMM is based on Green-Ampt Equations
  - THREE VARIABLES
    - Capillary Suction Head
    - ***Conductivity***
    - Initial Deficit
  - Green-Ampt uses depth of water above soil as a factor in infiltration

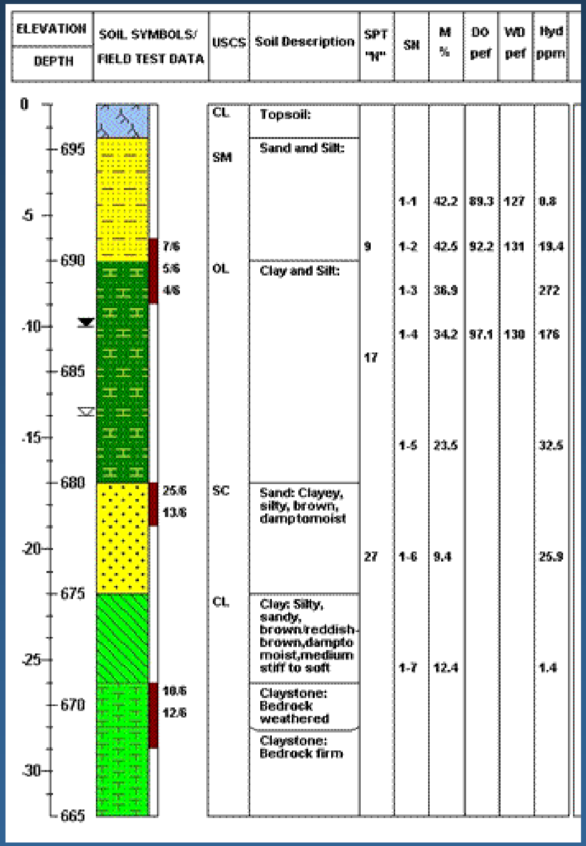




Foth

Soil Information is Critical

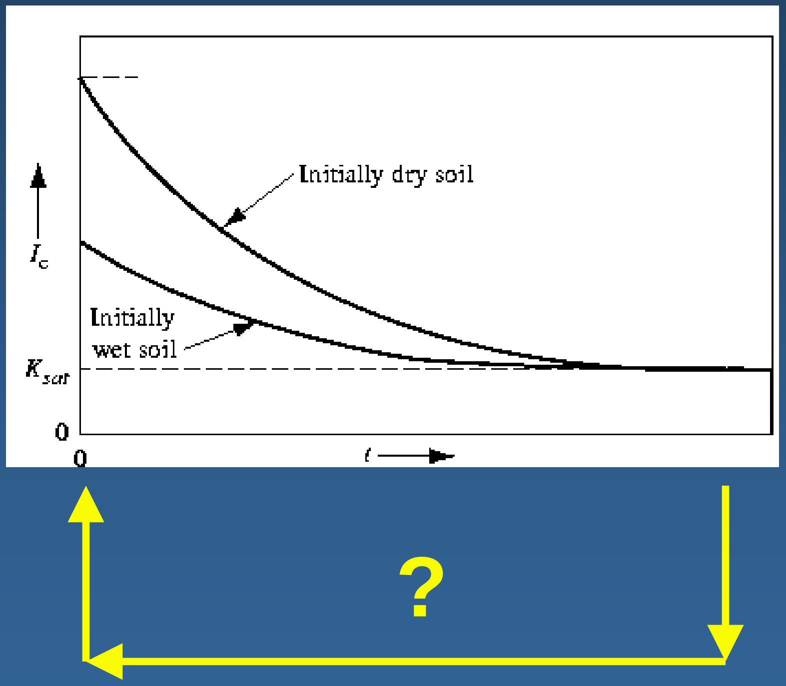
- Establish infiltration rate
  - Existing Soil Data:
    - USDA / NRCS Soils Maps
    - Soil Borings
    - Test trench/pit
  - Water table location
  - Soil type will drive model structure
    - Green-Ampt equation most dependent on K_{sat}
    - Minimum 0.3 - 0.4 inches/hour



Foth

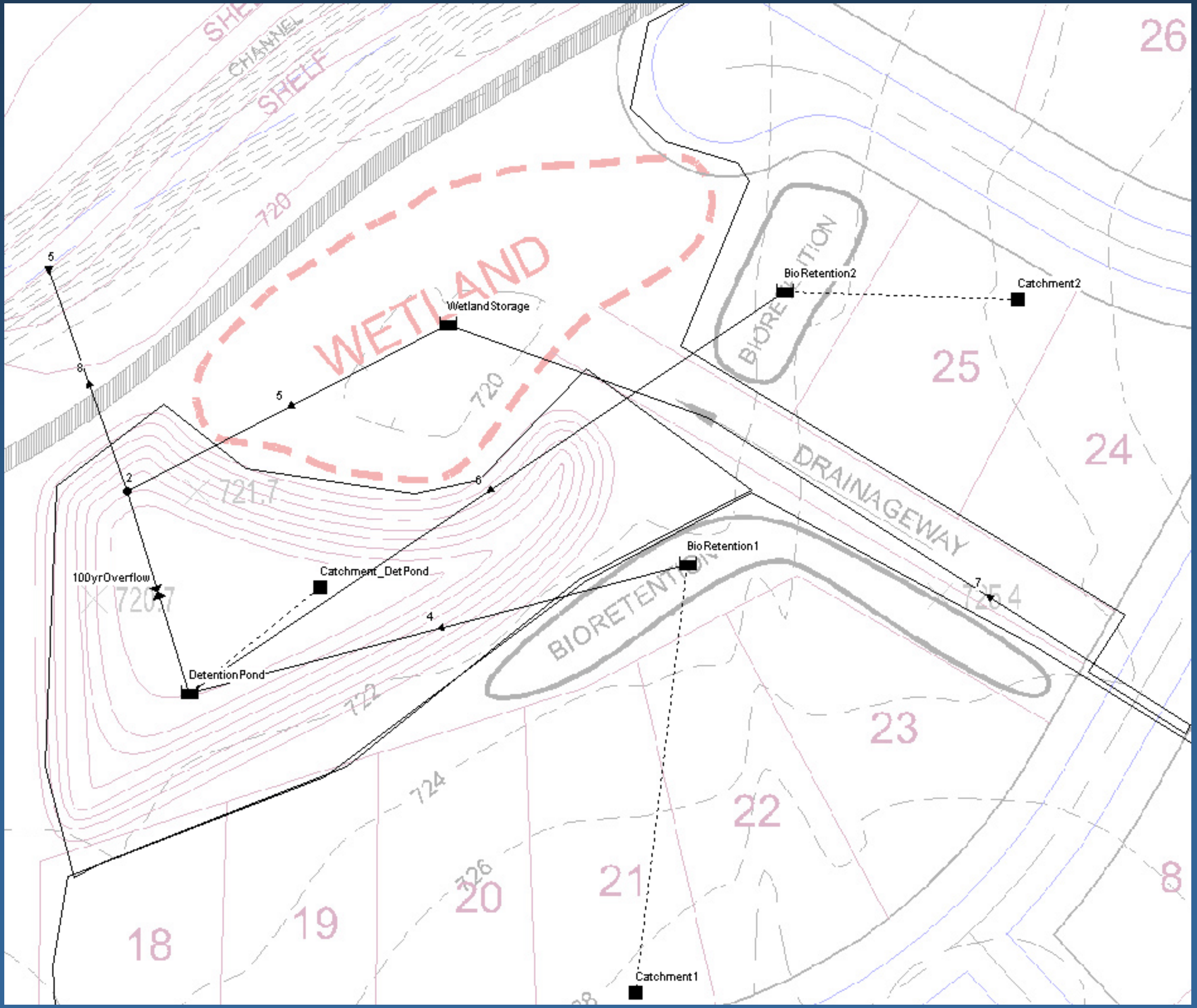
Infiltration Recovery

- Recovery of infiltration rate
  - Important for continuous models
  - SWMM default is 7 days
  - Can be modified to local conditions
    - 4-7 days is typical



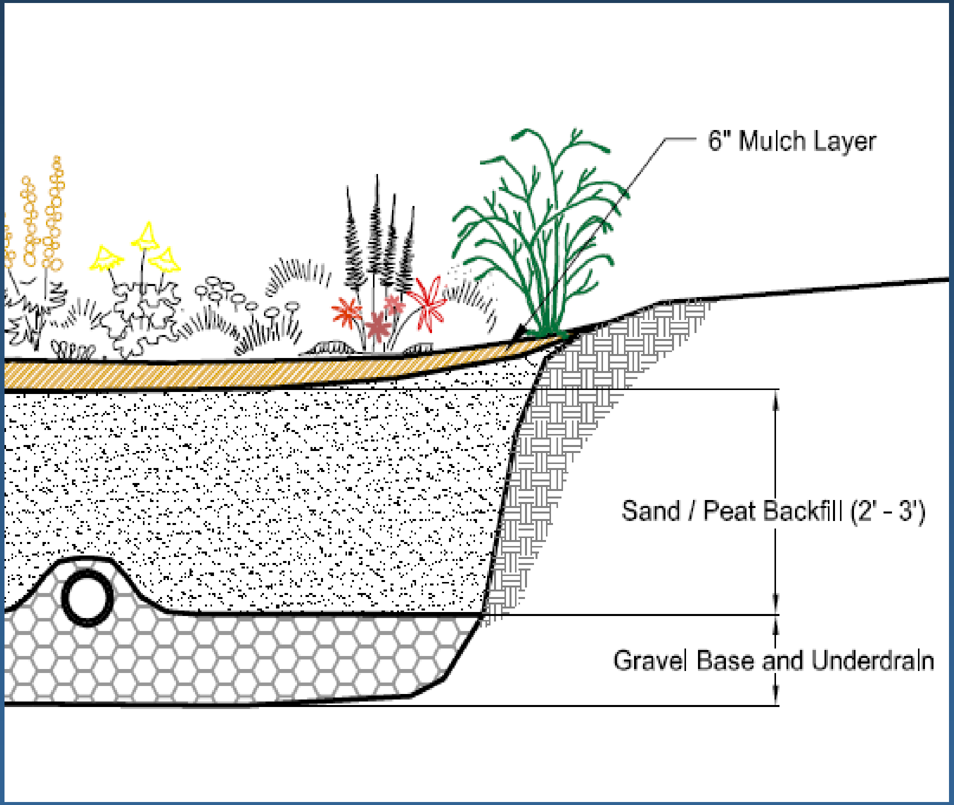
Foth

SWMM Model Schematic



Bioretention Considerations

- Model depends on design features:
  - Amended soil
  - Depth of ponding
  - Depth of cut, impact on underlying soils
  - Underdrain or no underdrain
  - Long-term impact of plant growth and root structure
    - *Studies have shown high infiltration rates, even in clayey soils*



Output Data: Event-Based

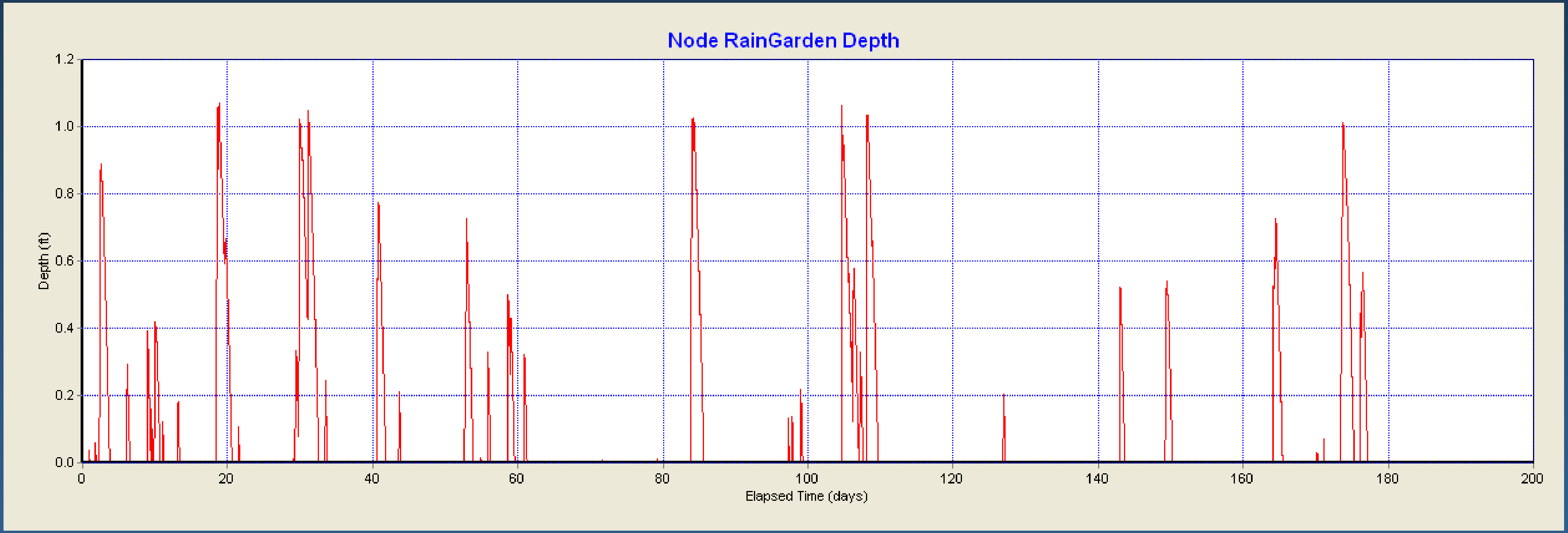
- Huff 1st Quartile
  - 1-yr, 1-hr storm
  - 1.0 inches
- Rain garden nears overflow level, but no discharge
- Rain garden volume is recaptured after 24-36 hours

Foth

Output Data: 100-year Storm

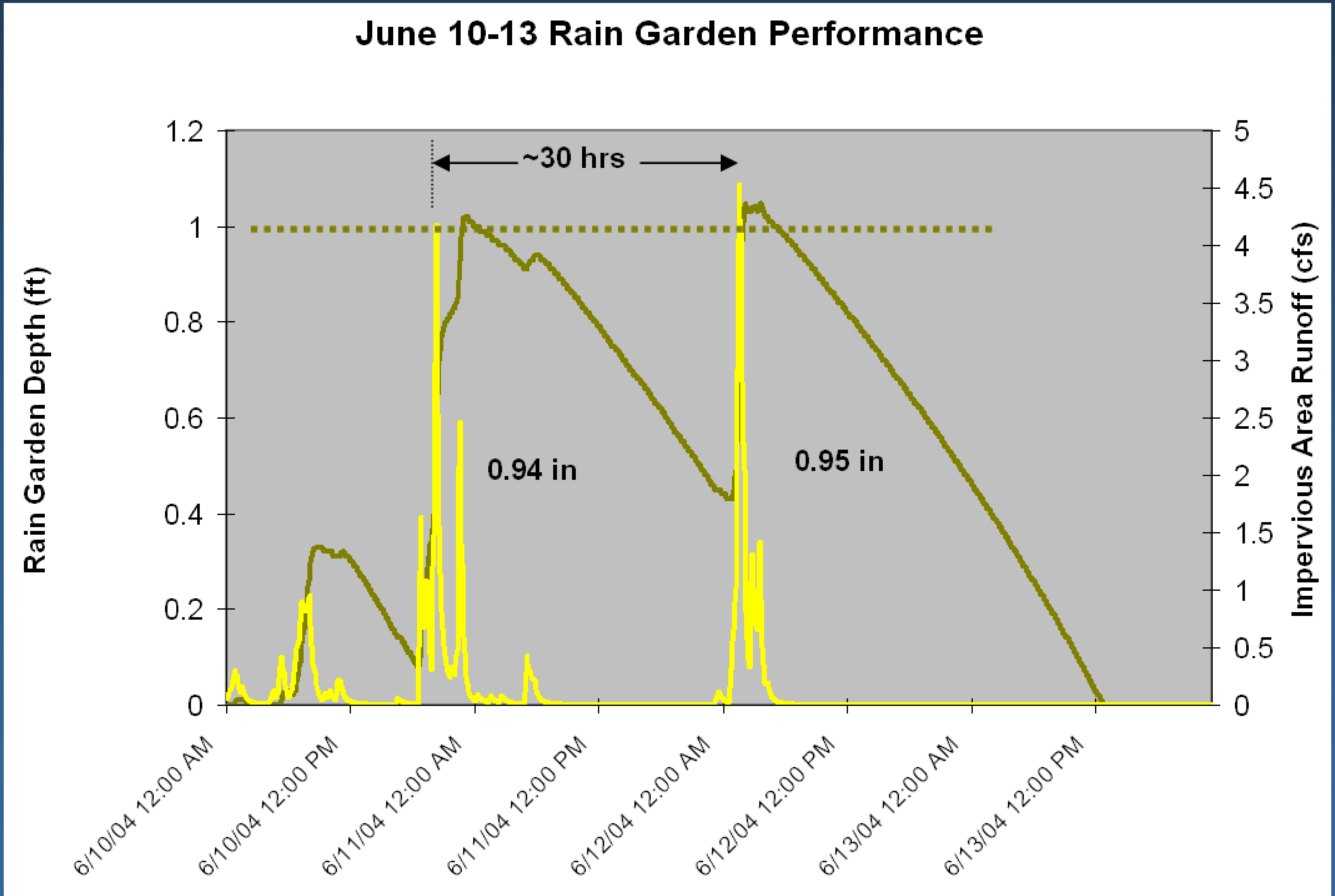
- Huff 3rd Quartile
  - 100-yr, 24-hour storm
  - 7.0 inches
- Rain garden overflows, as expected

Output Data: Continuous Simulation



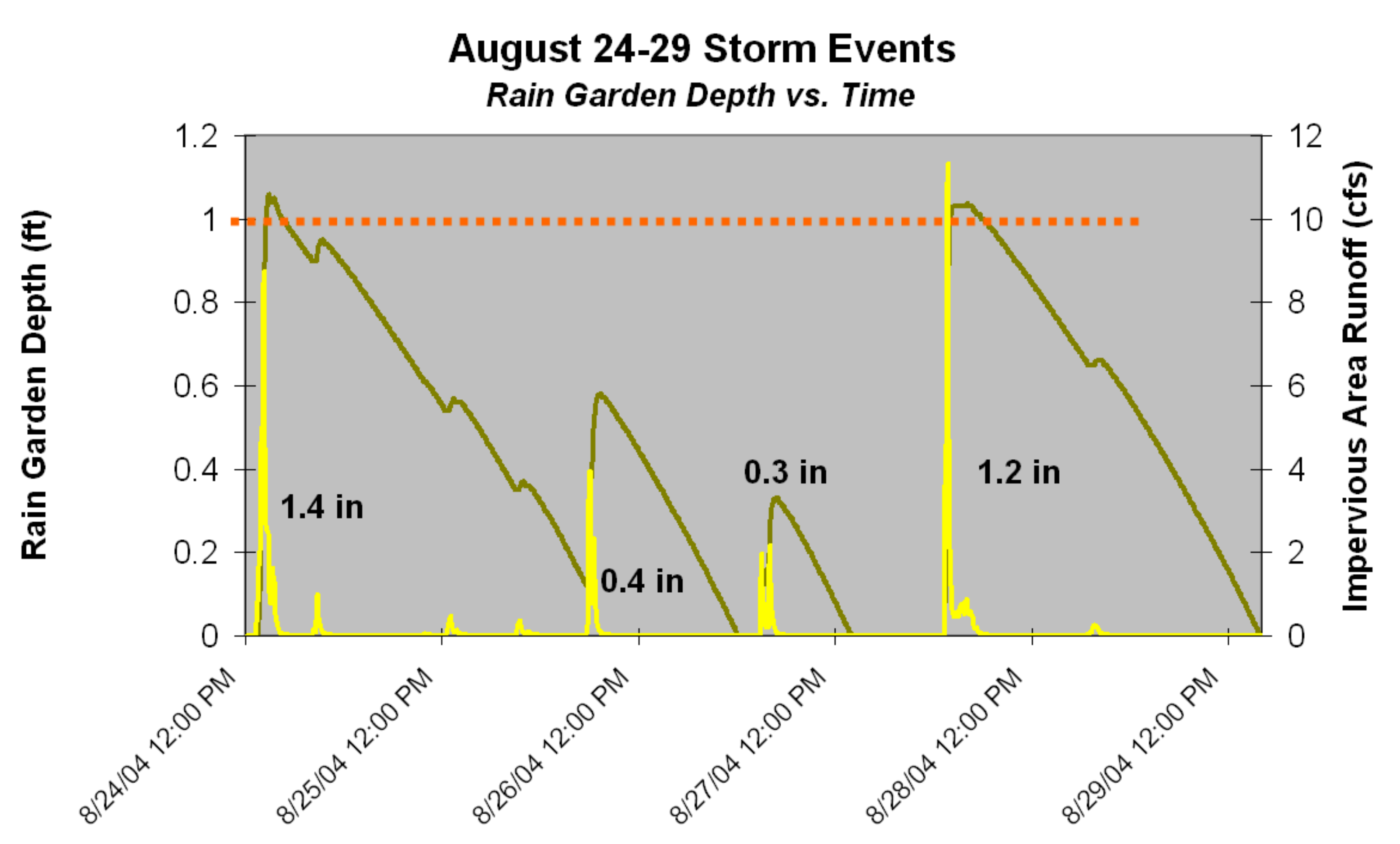
- Continuous Rainfall Data (6-8 months)
- Good test of model under real climate conditions
- ~ 30 individual rainfall events

Output Data: Continuous Simulation



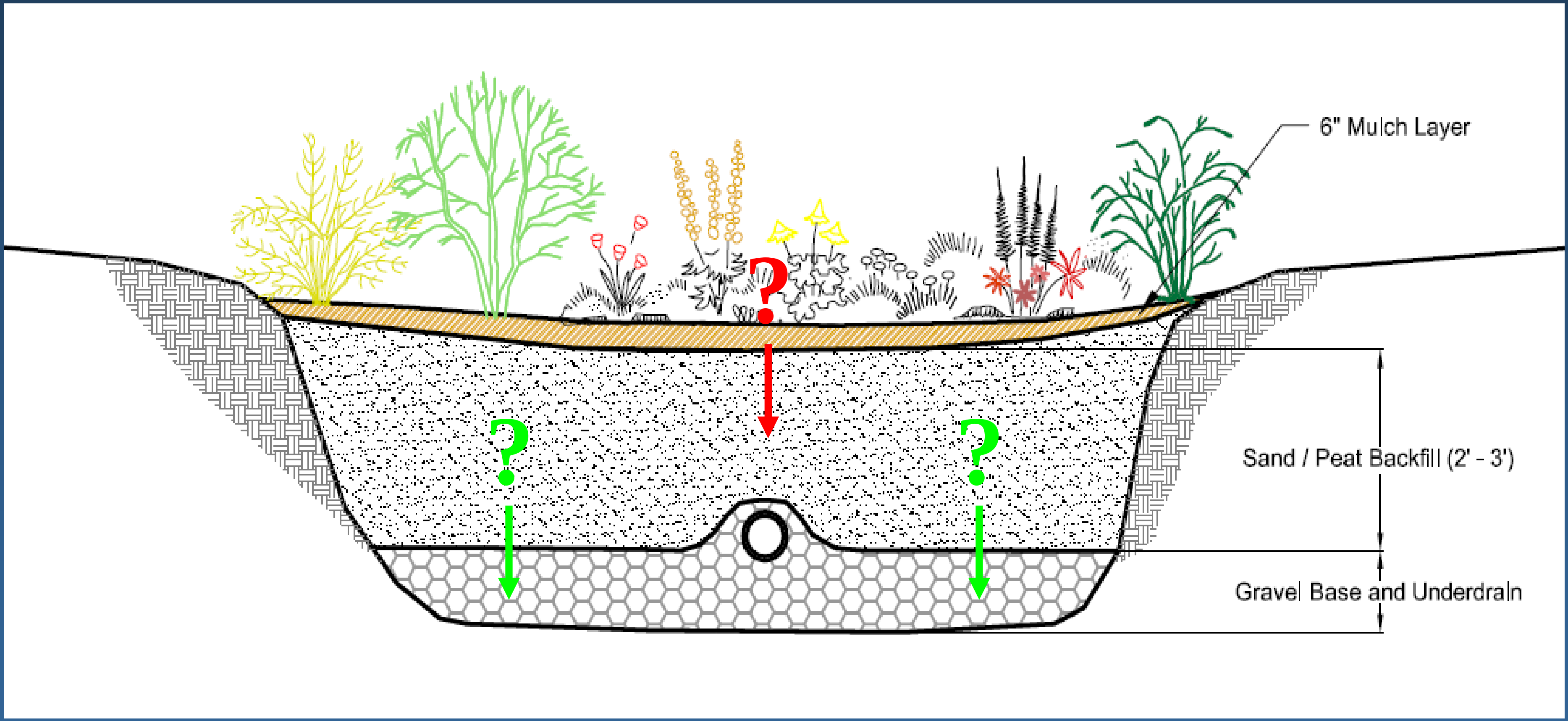
Foth

Output Data: Continuous Simulation



Foth

Underdrain Hydraulics



Foth

Wrap-up

- EPA SWMM LID Modeling
  - Simple modeling technique, easily adaptable to varying SWMM models
  - Ideal when BMPs part of integrated hydraulic system
  - Infiltration rates drive the model
  - Need adequate soil data
  - Useful for continuous simulation (CS)
  - Can be integrated with water quality modeling
    - Pollutant removal efficiencies

Foth

Wrap-up

- What Does SWMM Modeling Reveal?
  - Storage in bioretention areas is significant
    - 5% or more of storage volume for 100-yr (design) event is contained within bioretention cells
  - Bioretention cells should be able to infiltrate most stormwater runoff, even without underdrain
  - Bioretention footprint (as % of site) can range from 2% - 5%. Selected infiltration rate and local requirements will impact this number.

Foth

New Review Criteria

- Reviewers have new set of standards to consider:
  - What are appropriate ranges for infiltration variables?
  - What is appropriate depth and drawdown time?
  - How do we establish baseline (existing) infiltration hydrology?
  - How relevant is the Curve Number? Should we adapt to new methodology?