Rainwater harvesting and Irrigation management

Presentation for the
VAPSS Fall Technical Meeting
Low Impact Development-Current Practice and Research Needs
Wetland Studies & Solutions Inc., Gainesville VA

David Sample, Ph.D., P.E., D.WRE
Assistant Professor
Biological Systems Engineering
Based at the Occoquan Watershed Monitoring Lab
Manassas, VA

CENTER for WATERSHED STUDIES at VIRGINIA TECH

Virginia Cooperative Extension

Biological Systems Engineering

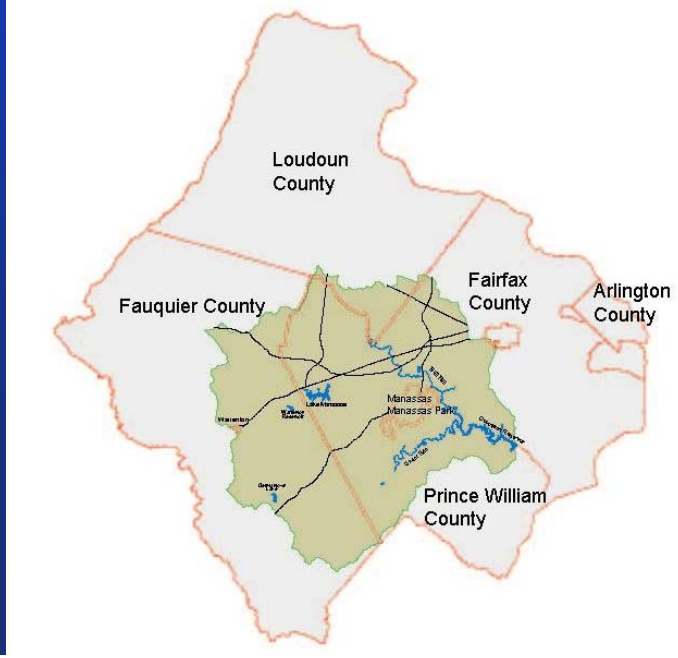
Outline

- Introduction
- The Hydrologic Cycle and Water Demand
  - Water Balance
  - Runoff and Stormwater Quality
  - Estimated Water Needs
  - Initial Screening Examples
- RHS Design for Runoff Control in Virginia
  - Function
  - Design using Cistern Spreadsheet/Runoff Reduction
- Simulation/Operation of RHS Systems
  - Schematic
  - Operational Policies
- Conclusion

- CEE-OWML has been monitoring the Occoquan watershed in NOVA for over 35 years
  - Tom Grizzard, CEE
  - Glenn Moglen, CEE
  - Adil Godrej, CEE
  - David Sample, BSE

- Campus
  - CEE Department
  - BSE Department
  - Center for Watershed Studies

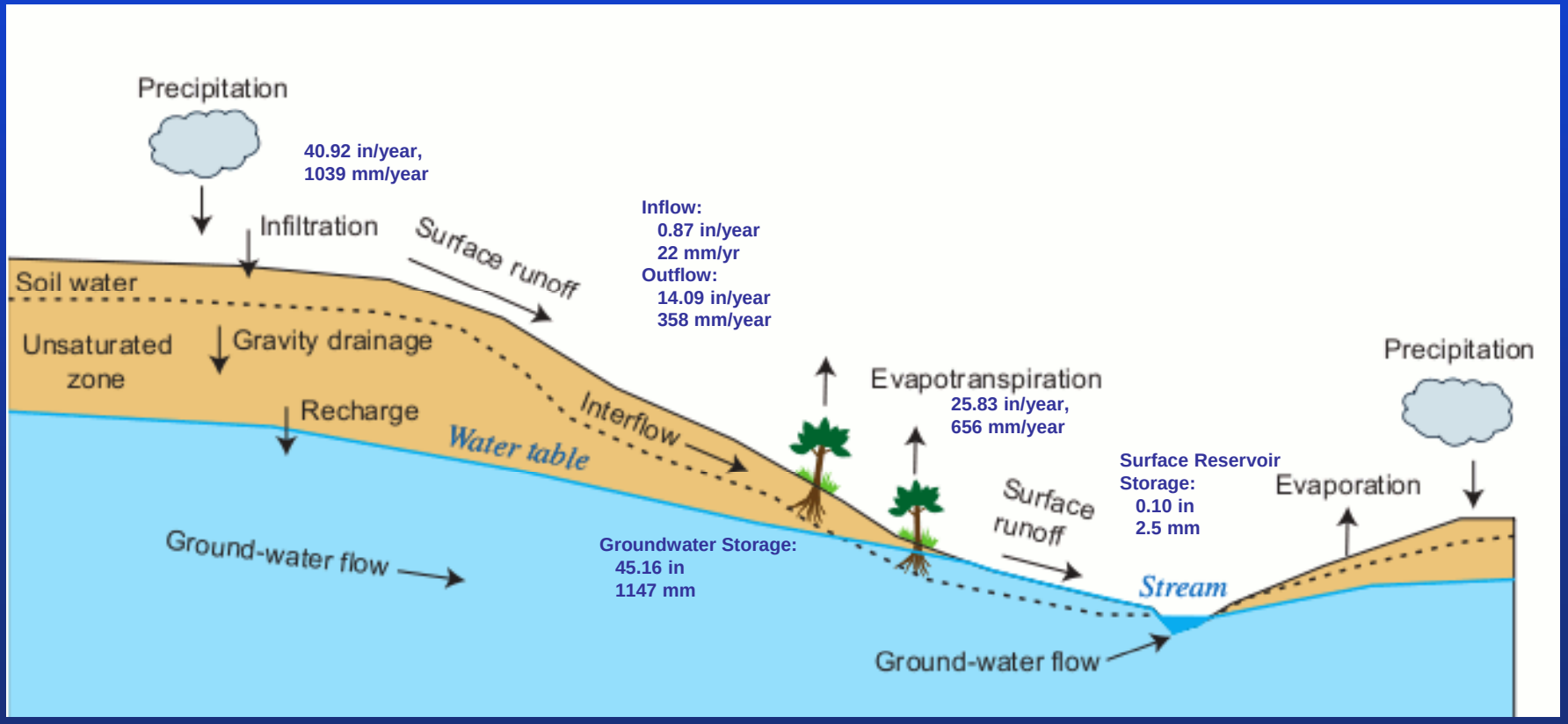
CENTER for WATERSHED STUDIES at VIRGINIA TECH



The Hydrologic Cycle and Water Demand

Hydrologic Cycle

- Precipitation
- Infiltration
- Evapotranspiration
- Runoff
- Recharge
- Soil Moisture

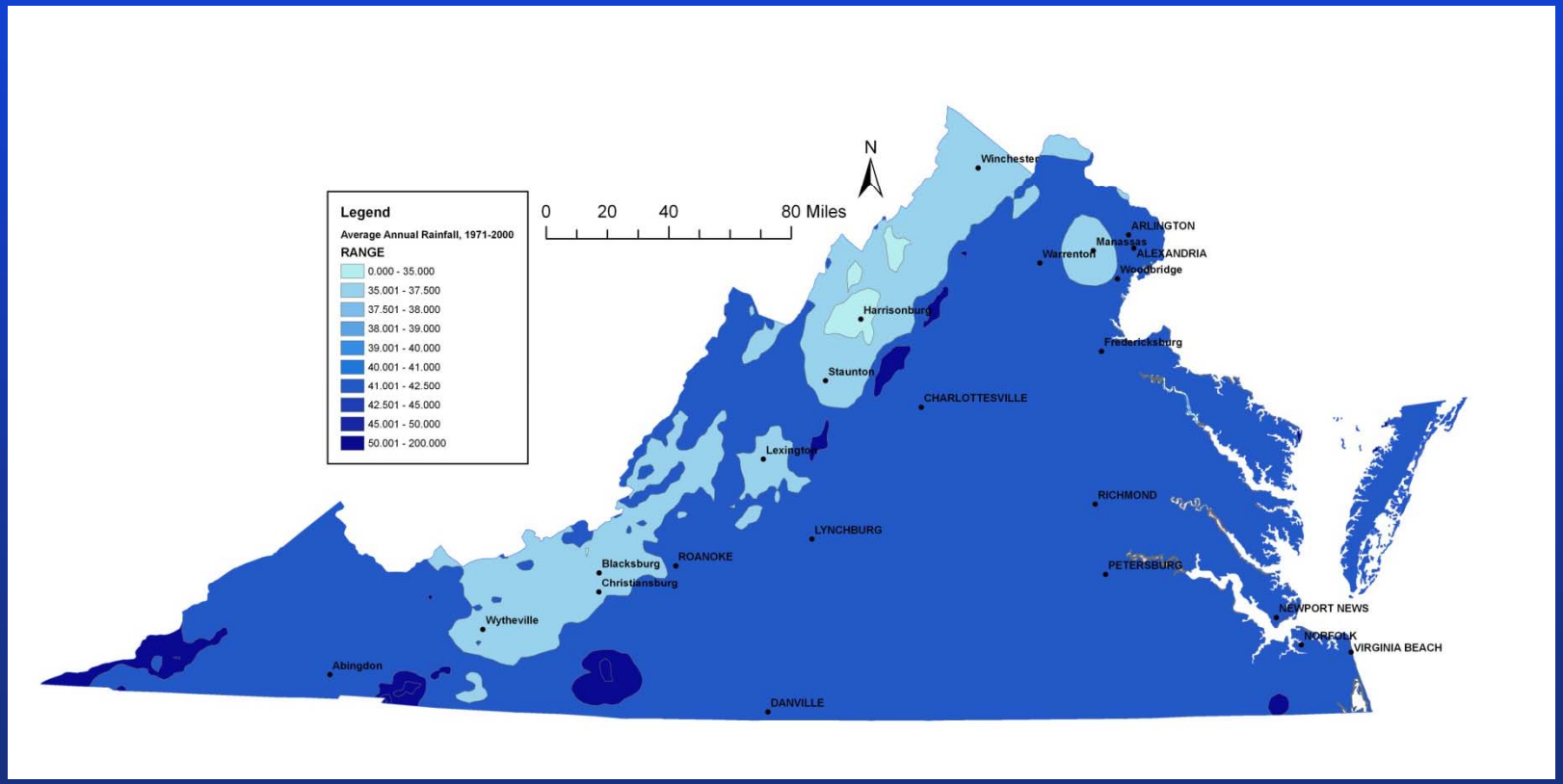


Source: VDEQ (2009) Virginia's Water Resources, http://www.vanaturally.com/vanaturally/guide/water.html

CENTER for WATERSHED STUDIES at VIRGINIA TECH

Precipitation

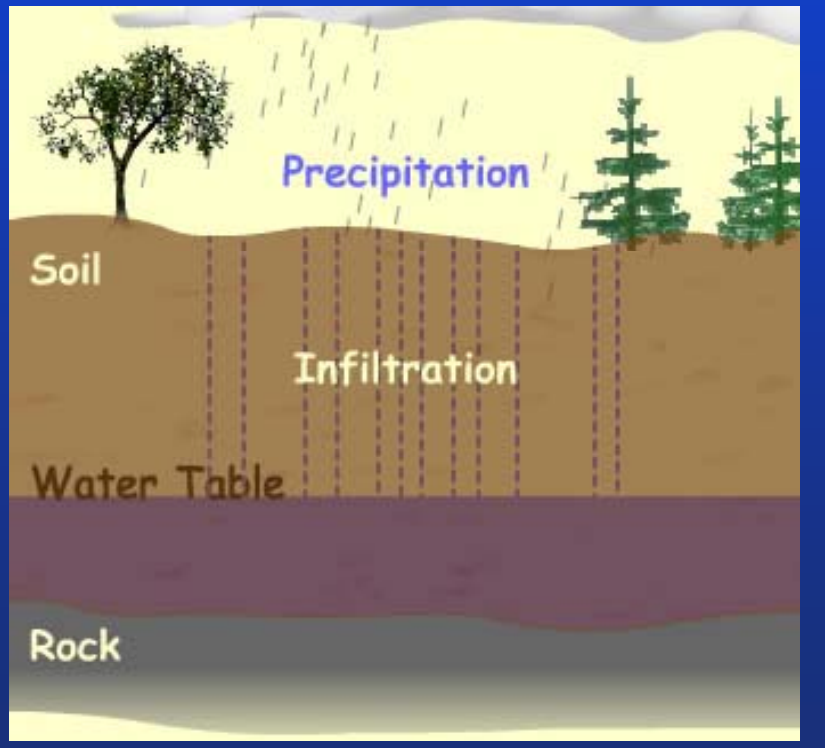
- Averages 40-42 inches/year (1016-1067 mm)



Source: National Atlas, at www.usgs.gov

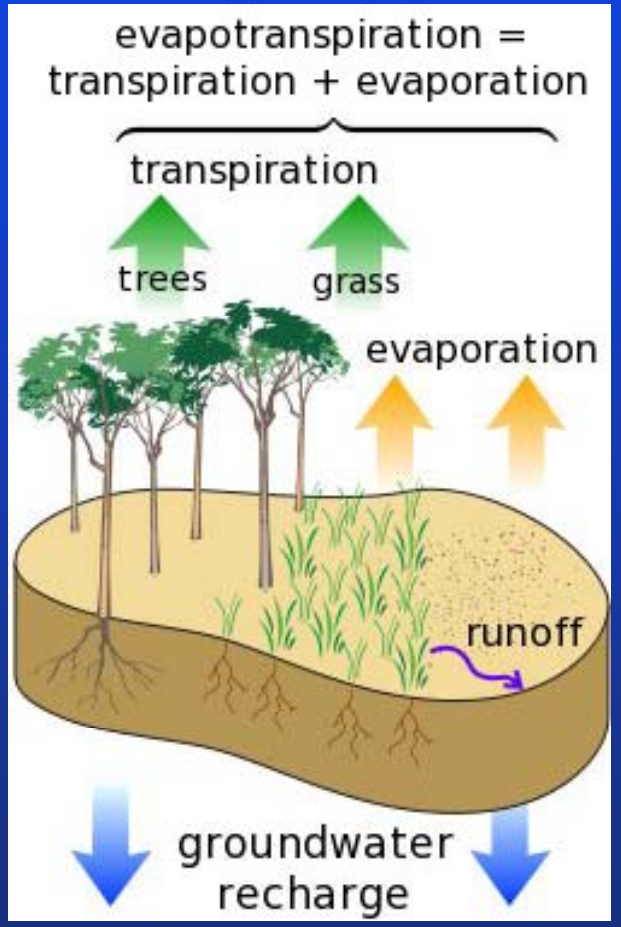
Infiltration

- Infiltration function of:
  - Soil types/porosity
  - Soils hydraulic properties
  - Soil moisture content
  - Vegetation



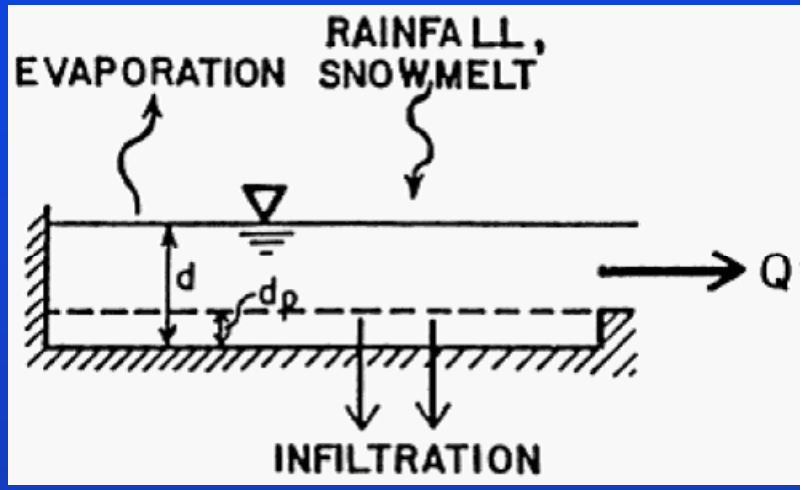
Evapotranspiration

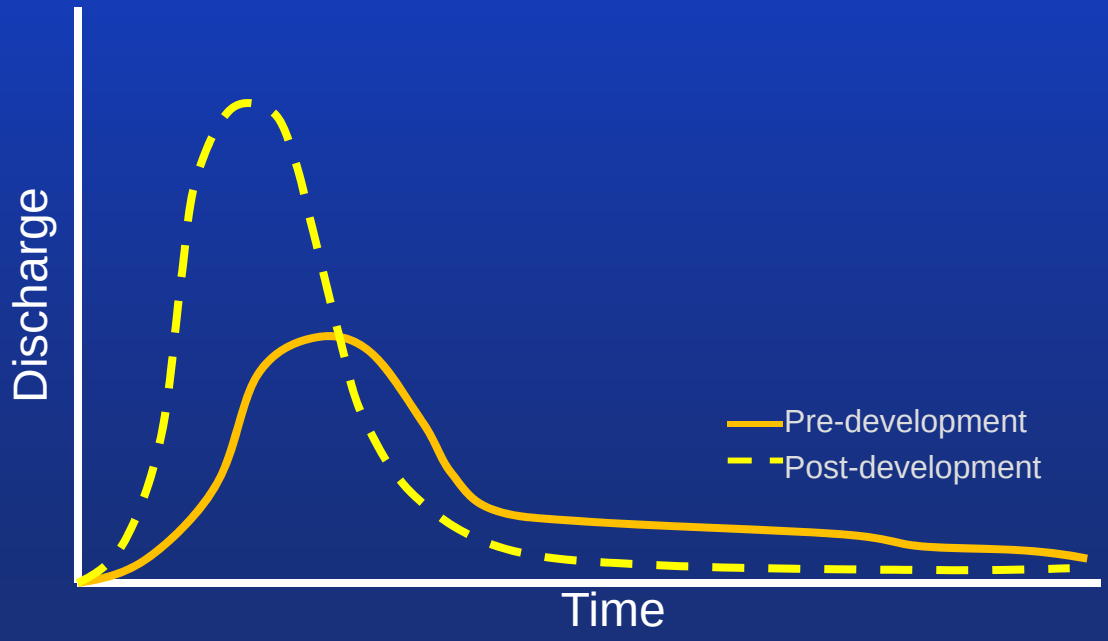
- Temperature Based Methods
  - Bowen
  - Thornthwaite
- More Accurate Method- Modified Penman-Monteith (Allen 1998)
- Function of Radiation, vapor pressure, wind speed, air temperature



Runoff

- Depends upon:
  - Rainfall intensity
  - Antecedent moisture
  - Density of vegetation (interception, ET)
  - Imperviousness
  - Slope



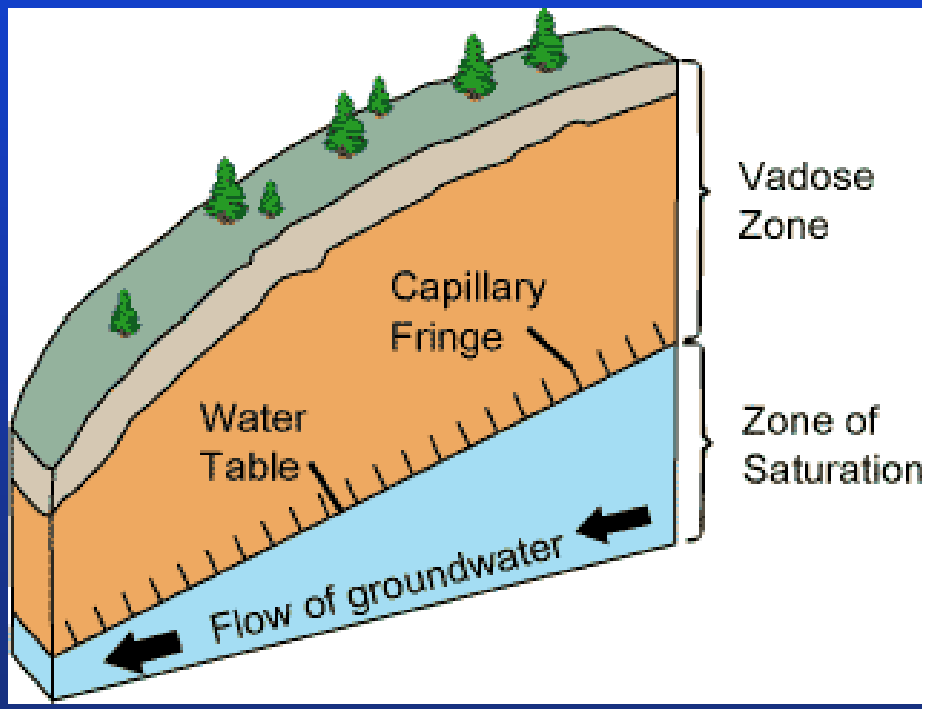


CENTER for WATERSHED STUDIES at VIRGINIA TECH

Sources: Tess Wynn, "Low Impact Development", 2009, Biological Systems Engineering, Virginia Tech

Recharge

- Recharge-Saturated Zone
- Process is extremely slow-faster in coastal areas
- Often calculated as a calibration parameter

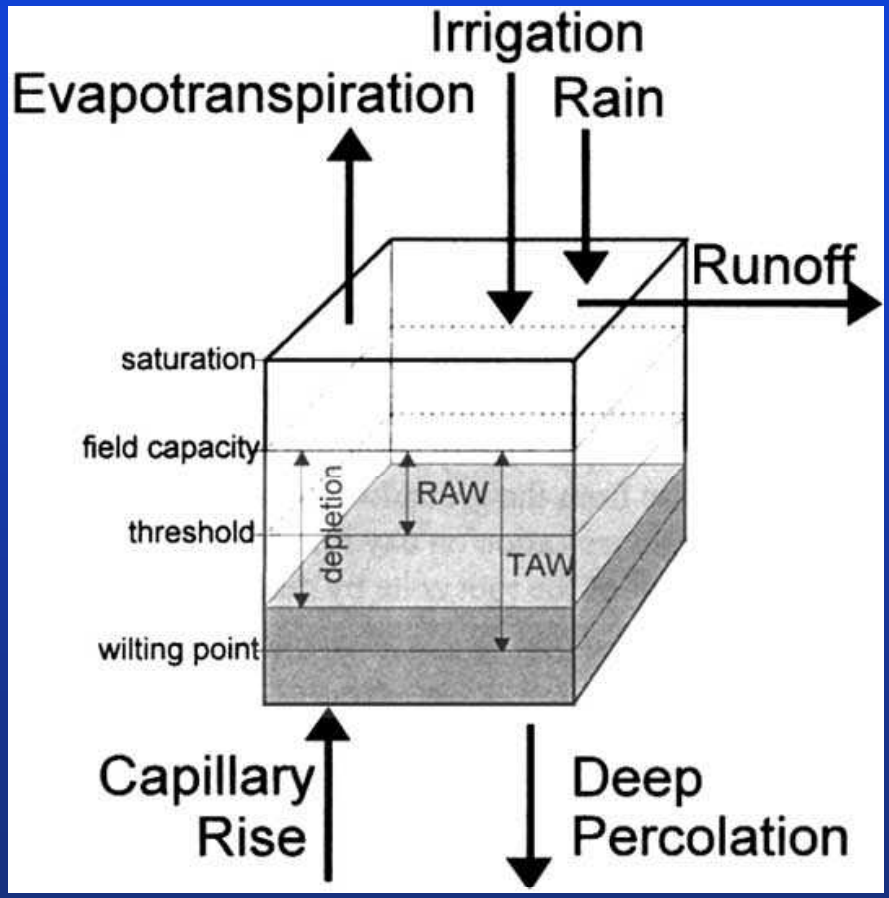


Source: USGS - GROUND WATER ATLAS of the UNITED STATES: Delaware, Maryland, New Jersey,
North Carolina, Pennsylvania, Virginia, West Virginia, HA 730-L

CENTER for WATERSHED STUDIES at VIRGINIA TECH

Soil Moisture Storage

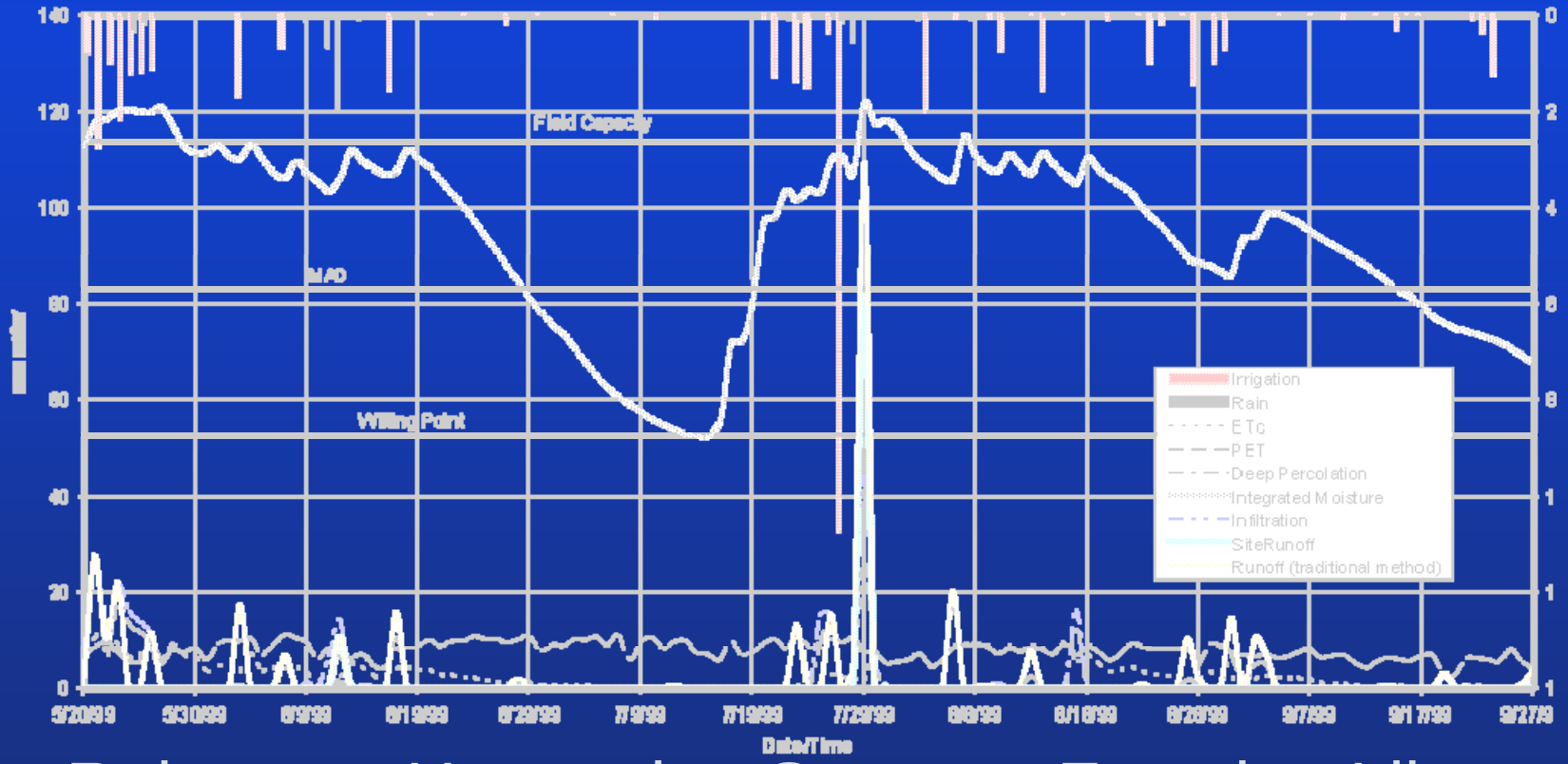
- "Leaky Reservoir"
- Field Capacity
- Wilting Point
- Readily Available Water (RAW)
- Total Available Water (TAW)



Source: Allen, R.G., Pereira, L.S., Raes, D., and Smith, M. (1998) Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements. United Nations Food and Agricultural Organization (FAO), Irrigation and Drainage Paper 56, Rome, Italy.

Water Budget

$$\Delta S = P - R + I - ET - D$$

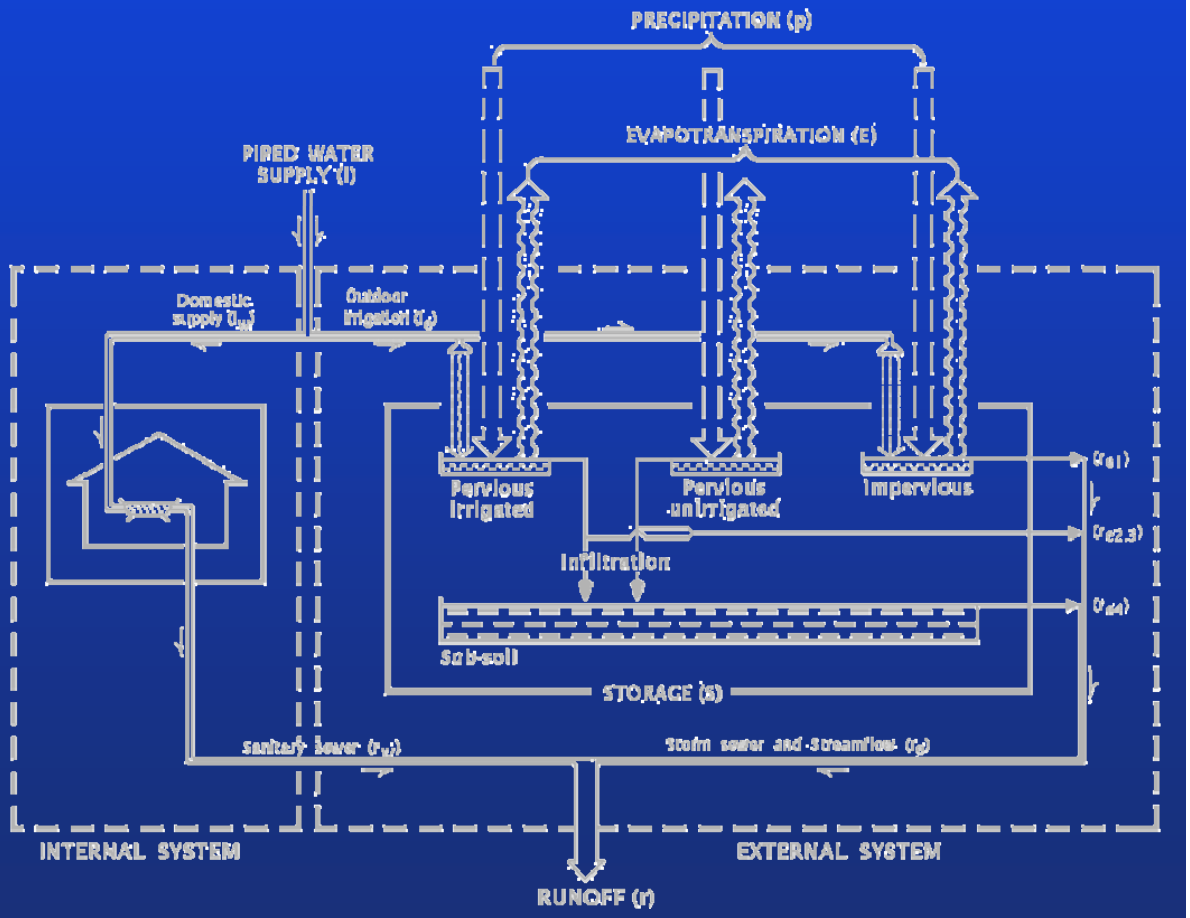


Rainwater Harvesting Systems Function Like Soil Storage

CENTER for WATERSHED STUDIES at VIRGINIA TECH

Estimating Demand/Water Needs

- Indoor Use
  - Potable Use
  - Nonpotable Use
    - Toilet flushing
    - Clothes washing
- Outdoor use
  - Active Irrigation
  - Passive Irrigation

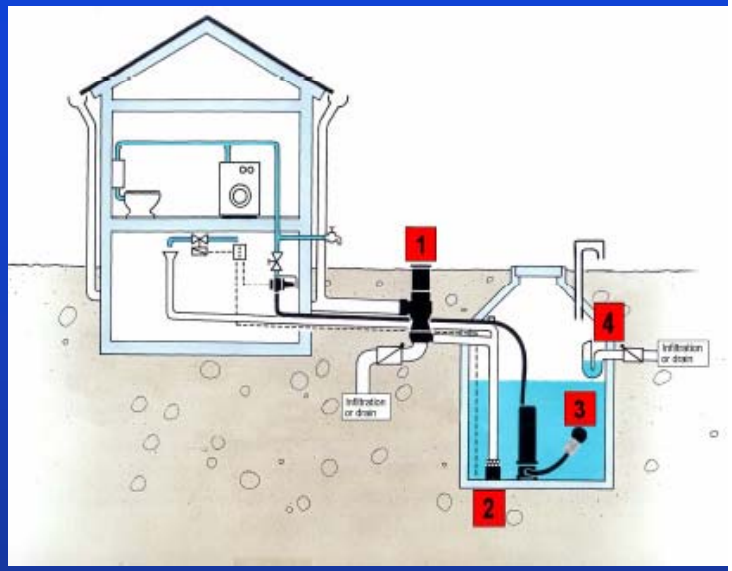


Grimmond and Oke 1986

CENTER for WATERSHED STUDIES at VIRGINIA TECH

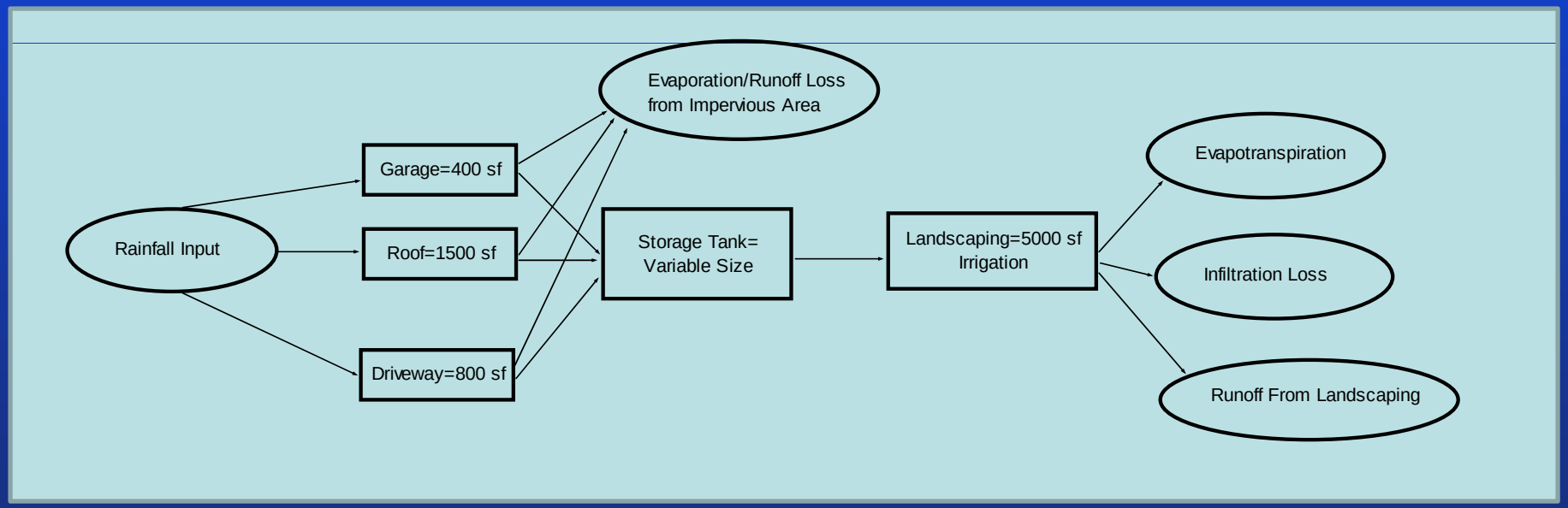
Rainwater Harvesting/Cisterns (RR)

- Captures impervious runoff
- Underground/Above
- Reuse-can be Outdoor or indoor
- Supplements water supply
- Volume benefits-maximize if managed
- Variable Removal (runoff reduction only)



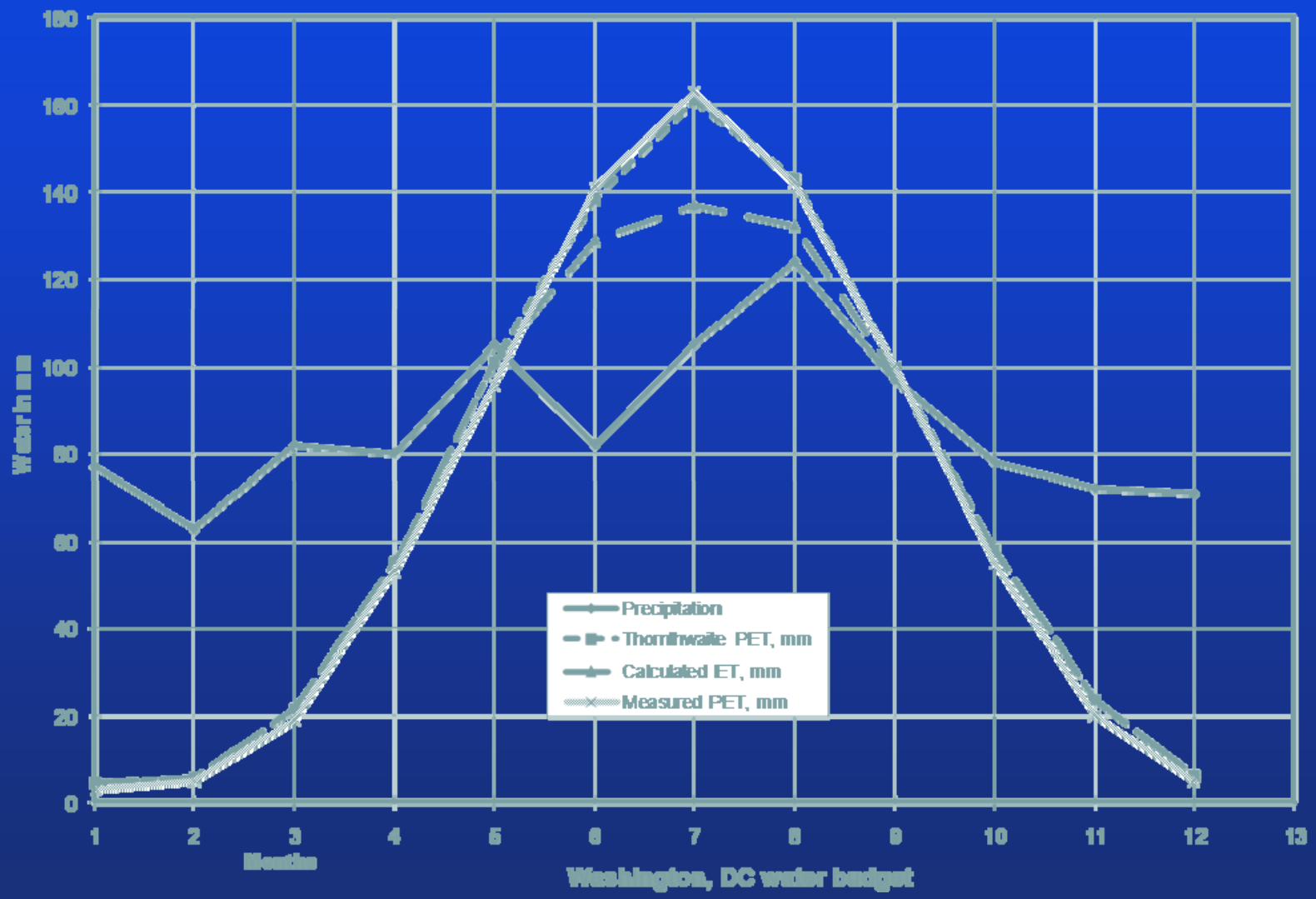
Source: Virginia Rainwater Harvest Manual, at www.CabellBrandCenter.org and WSSI/Wetland Studies and Solutions, Inc., at http://www.wetlandstudies.com.

Preliminary Screening Model



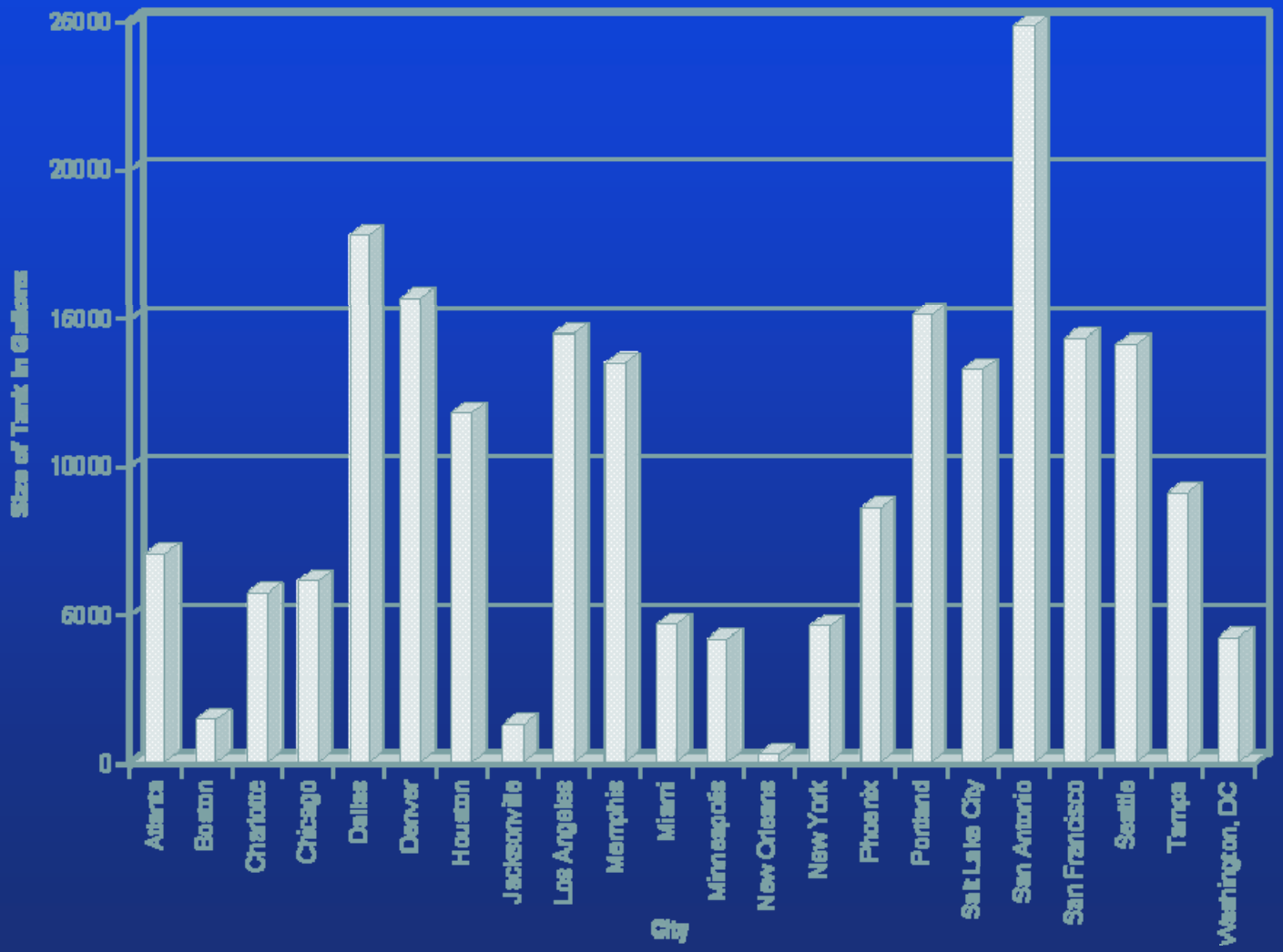
CENTER for WATERSHED STUDIES at VIRGINIA TECH

Average Monthly Water Budget



CENTER for WATERSHED STUDIES at VIRGINIA TECH

Screening Results



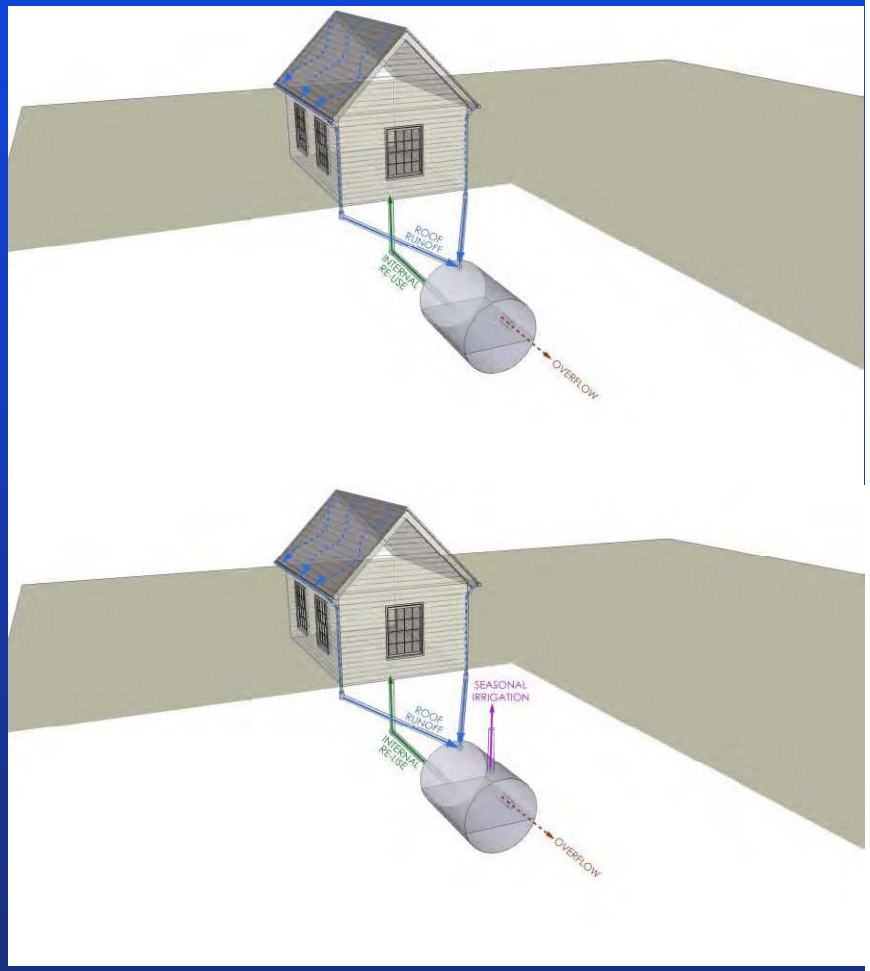
CENTER for WATERSHED STUDIES at VIRGINIA TECH

RHS Design for Runoff Control in Virginia

Configurations

1. Interior Non-Potable Demand Year-Round

2. Interior Non-potable Demand year-round, seasonal Irrigation only



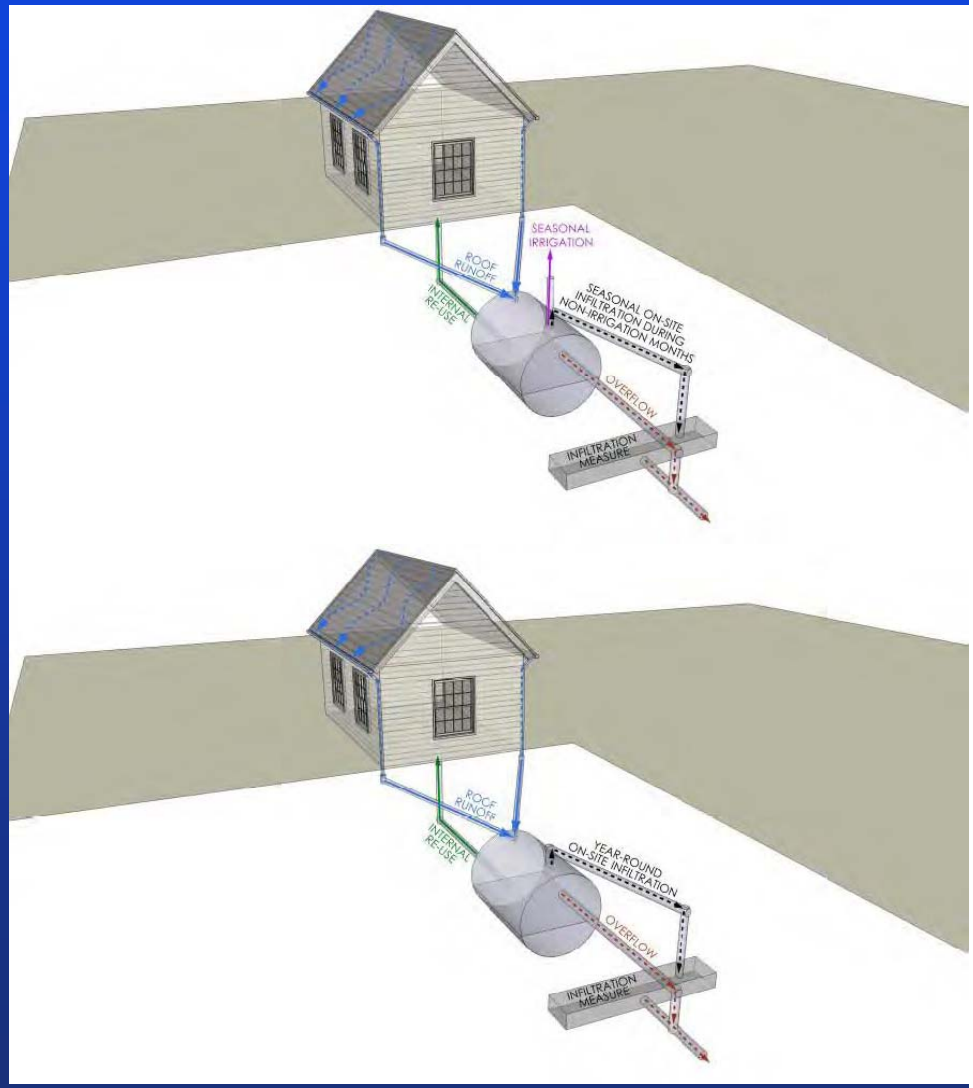
Source: VDCR (2009) Draft Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting, Version 1.2.

CENTER for WATERSHED STUDIES at VIRGINIA TECH

More Configurations

3. Interior Non-potable Demand year-round, Seasonal Outdoor Demand, On-site Stormwater Disposal during non-irrigation months

4. Interior Non-potable Demand year-round, On-site Stormwater Disposal Year-round



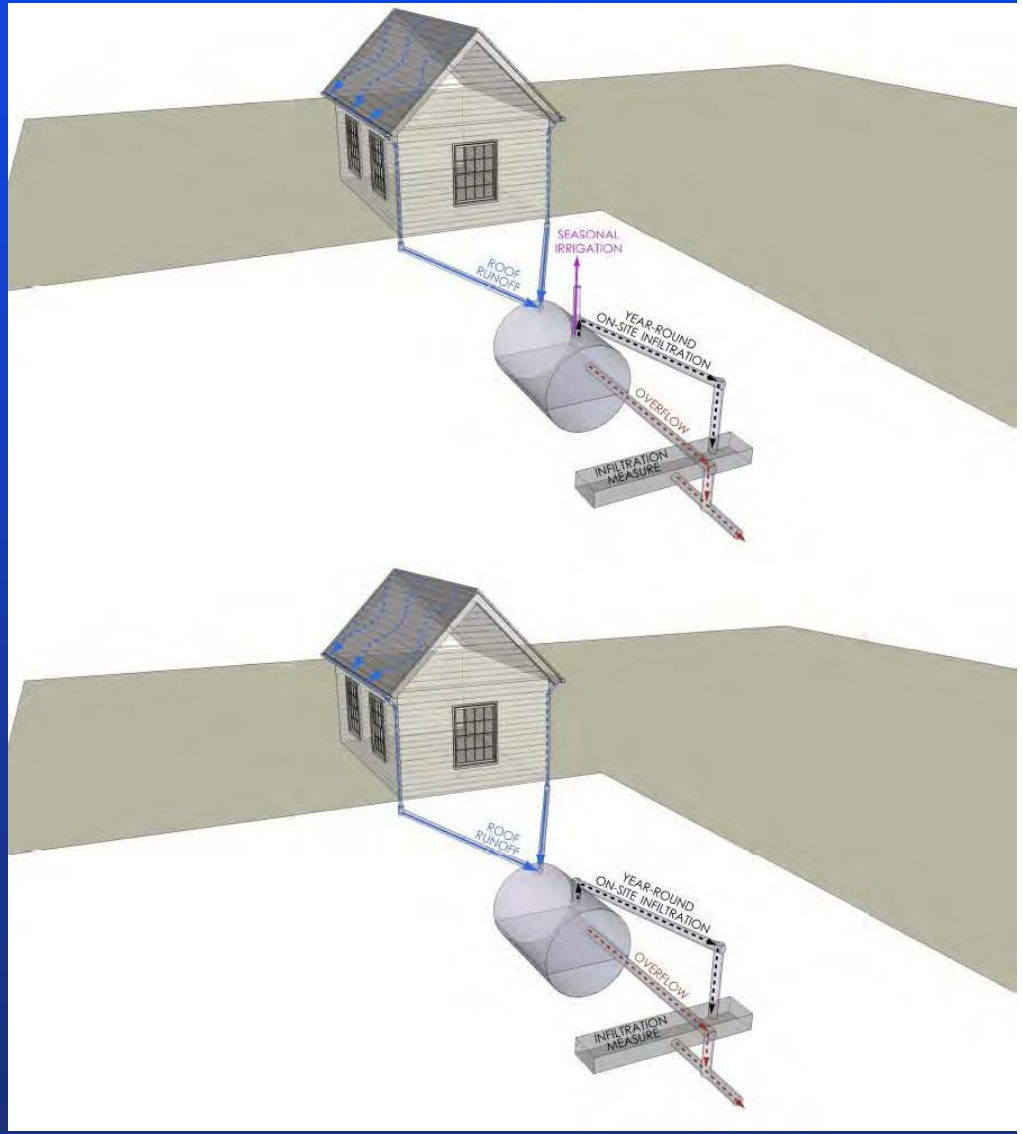
CENTER for WATERSHED STUDIES at VIRGINIA TECH

Source: VDCR (2009) Draft Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting, Version 1.2.

Even More Configuraitons

5. Year round or Seasonal Demand with Dedicated Constant Year-Round Drawdown with On-site Infiltration

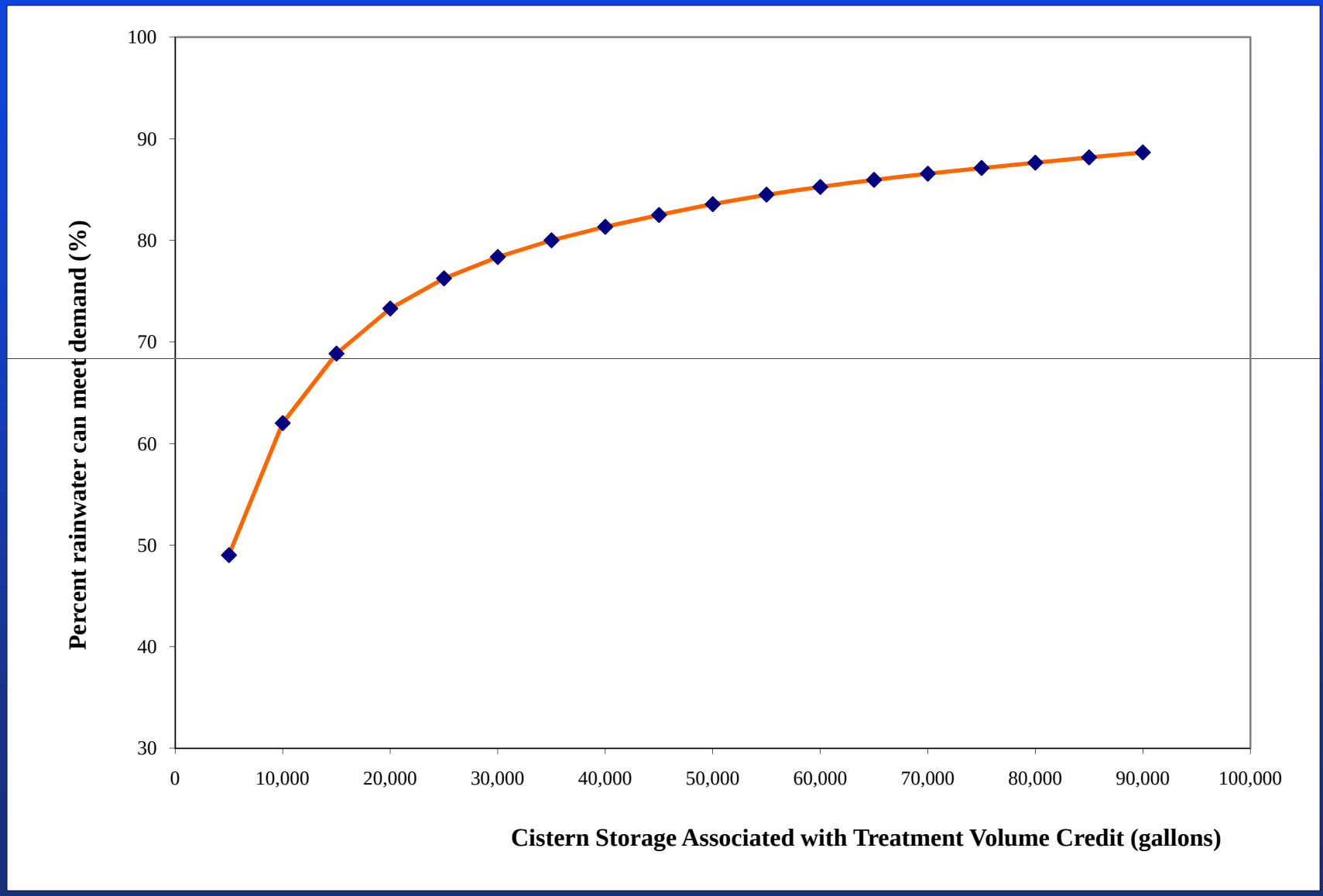
6. On-site Infiltration for Groundwater Recharge, No Re-use of Stored Water



CENTER for WATERSHED STUDIES at VIRGINIA TECH

Source: VDCR (2009) Draft Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting, Version 1.2.

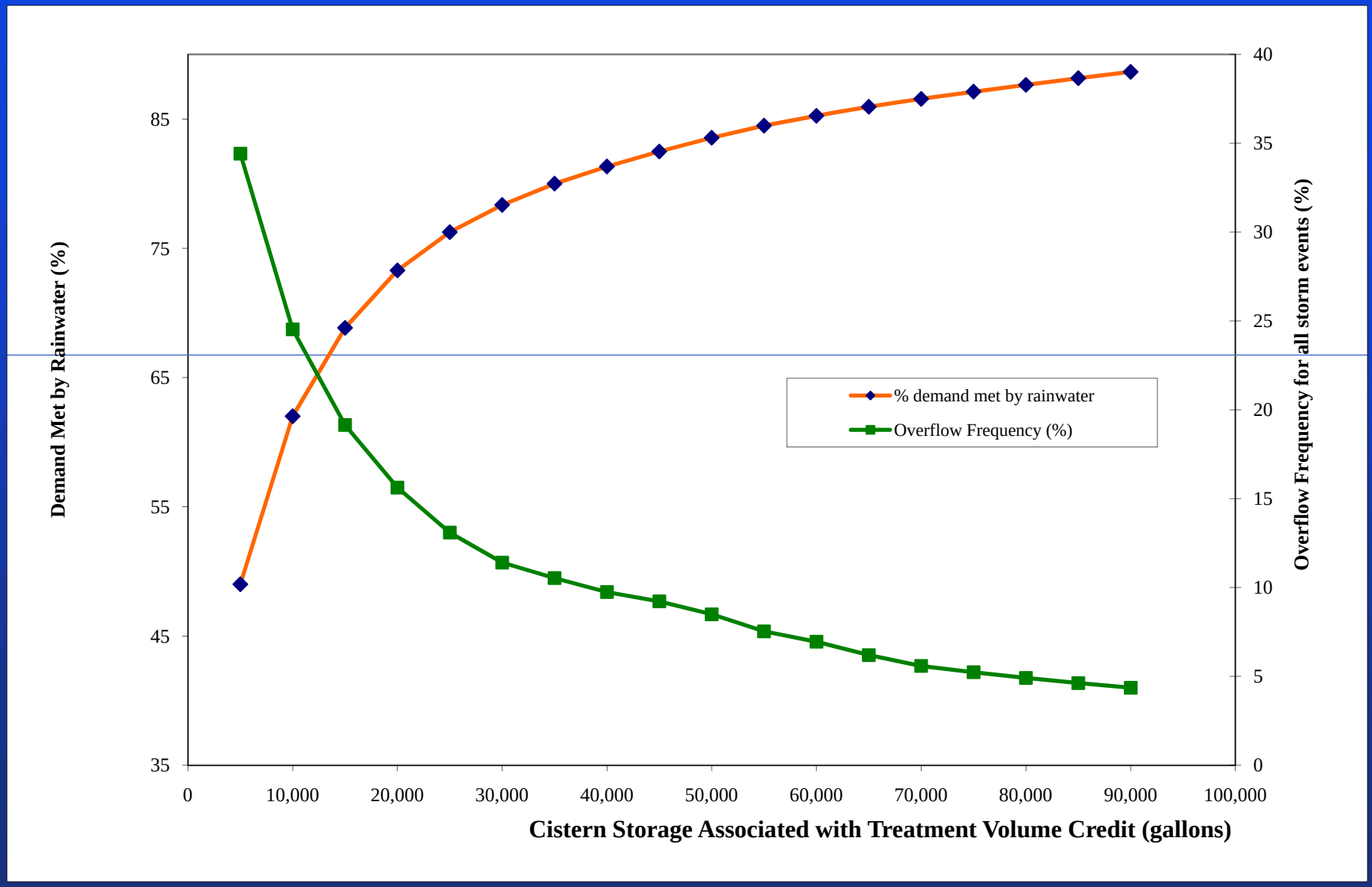
Calculate Demand Met



CENTER for WATERSHED STUDIES at VIRGINIA TECH

Source: VDCR (2009) Draft Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting, Version 1.2.

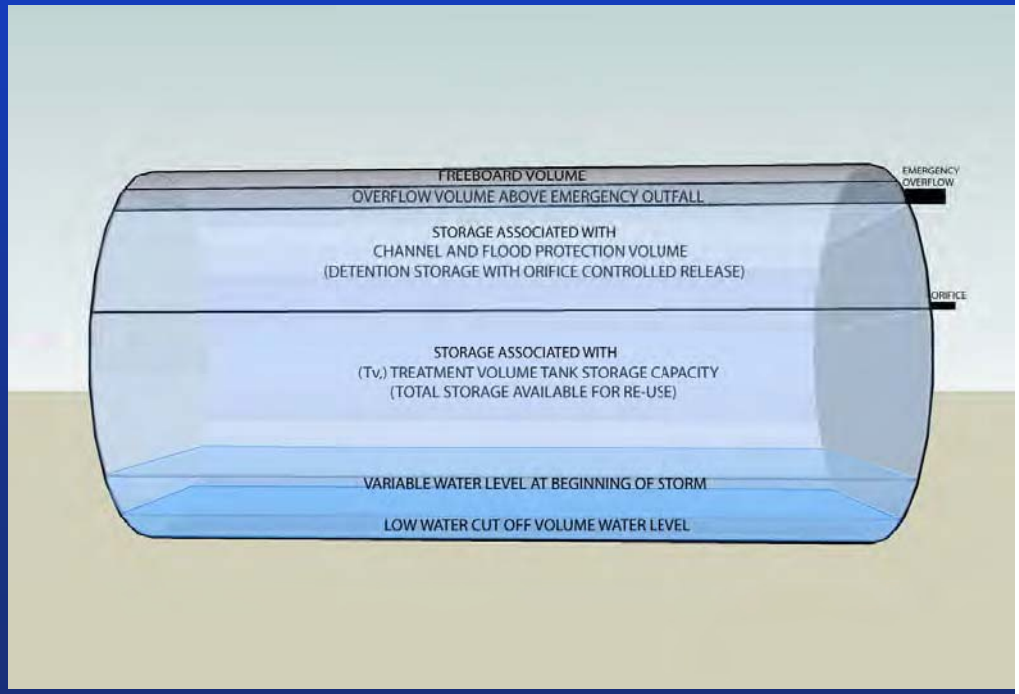
Calculate Runoff Reduction Credit



Source: VDCR (2009) Draft Virginia DCR Stormwater Design Specification No. 6, Rainwater Harvesting, Version 1.2.

Steps

- Calculate Incremental Design Volumes
- Complete Design of System
- Enter Final Volumes/Credits into Runoff Reduction Spreadsheet
  - Water Quality Volume Credit
  - Roof Area treated
- Evaluate with other BMPs to Assess WQ Status



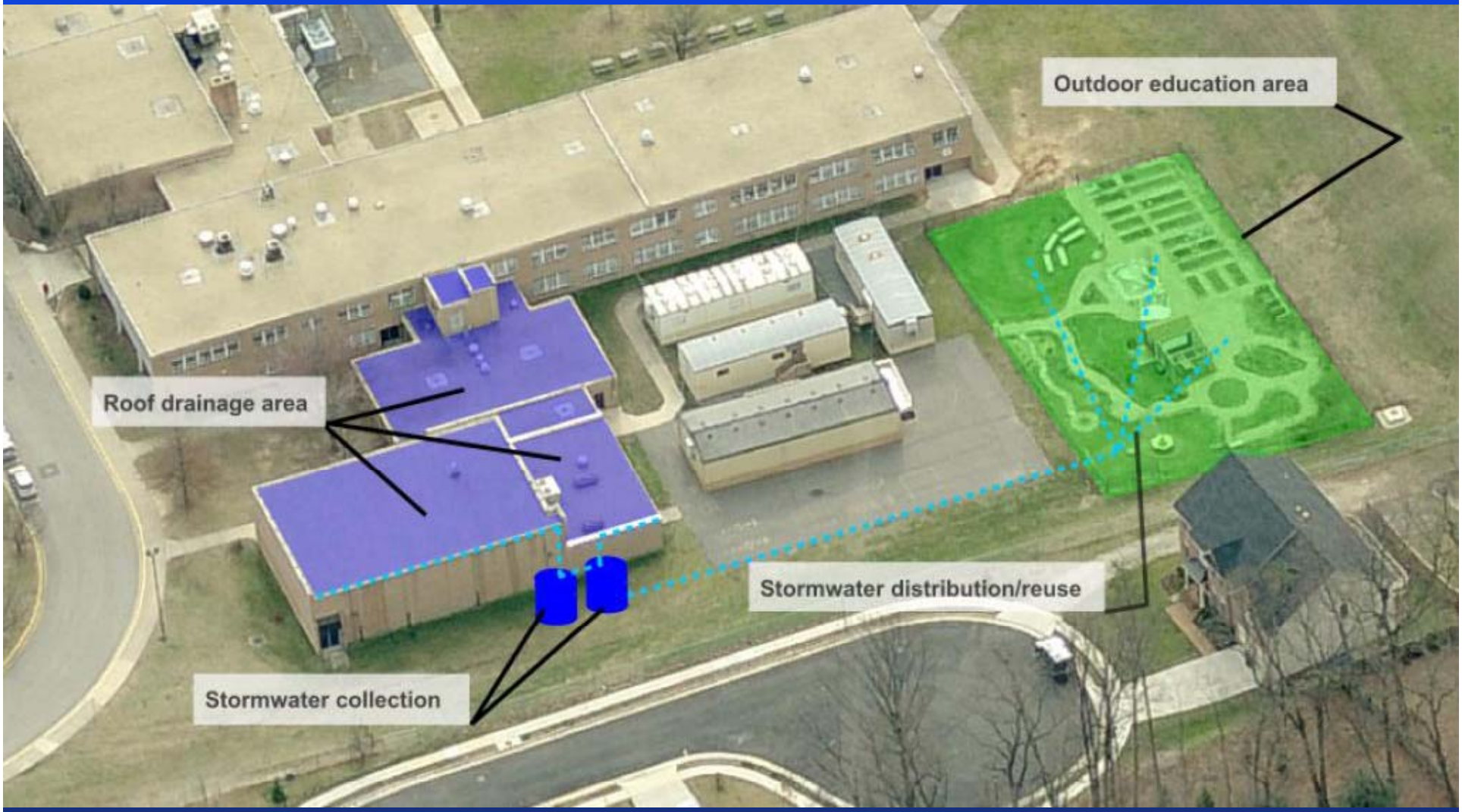
CENTER for WATERSHED STUDIES at VIRGINIA TECH

Simulation/Operation of RHS Systems (Work in Progress)

LID Design/Implementation
Science Museum, Richmond

- Bioretention
- Permeable Pavement
- Rainwater Harvesting
- Vegetated Roof

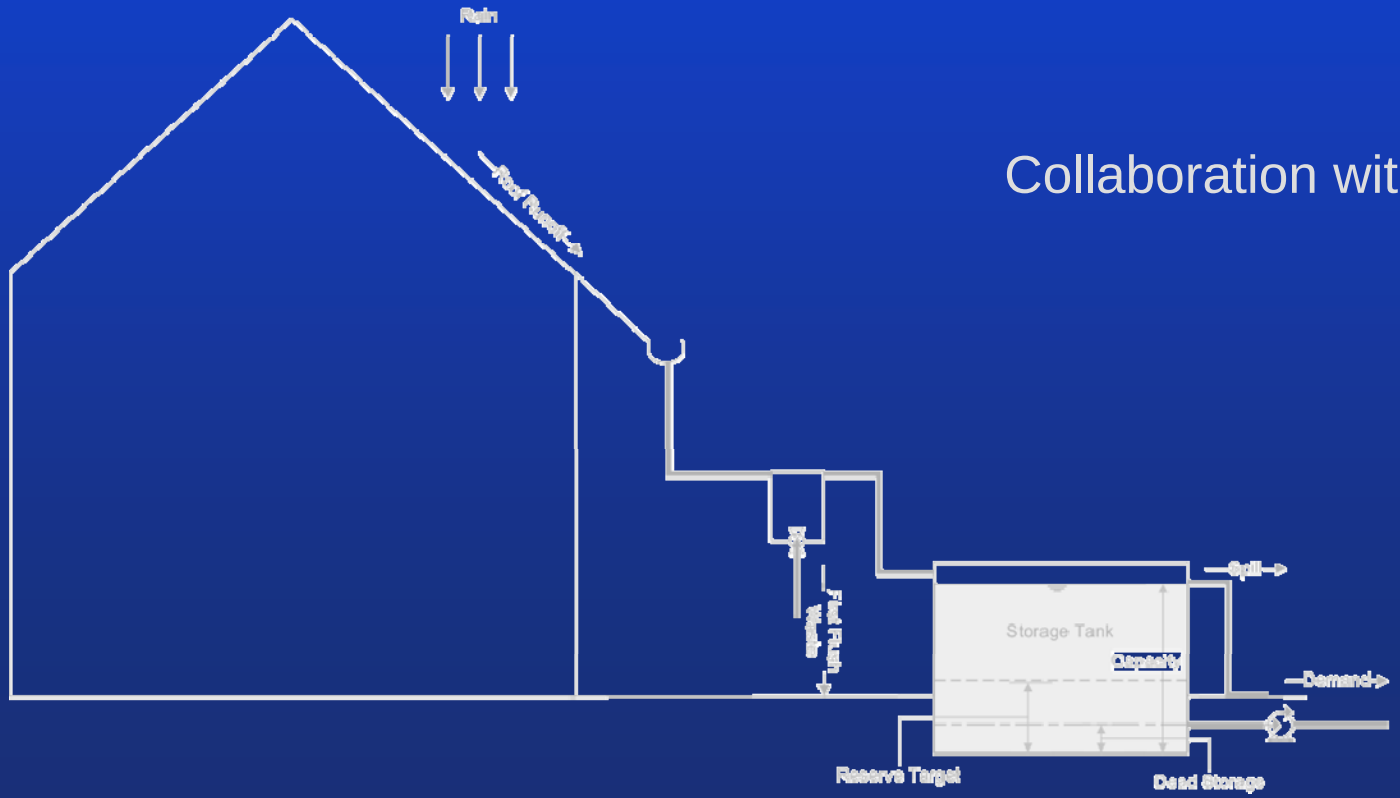
Clermont Elementary, Alexandria



CENTER for WATERSHED STUDIES at VIRGINIA TECH

Development of Rainwater Harvesting System Rule Curves

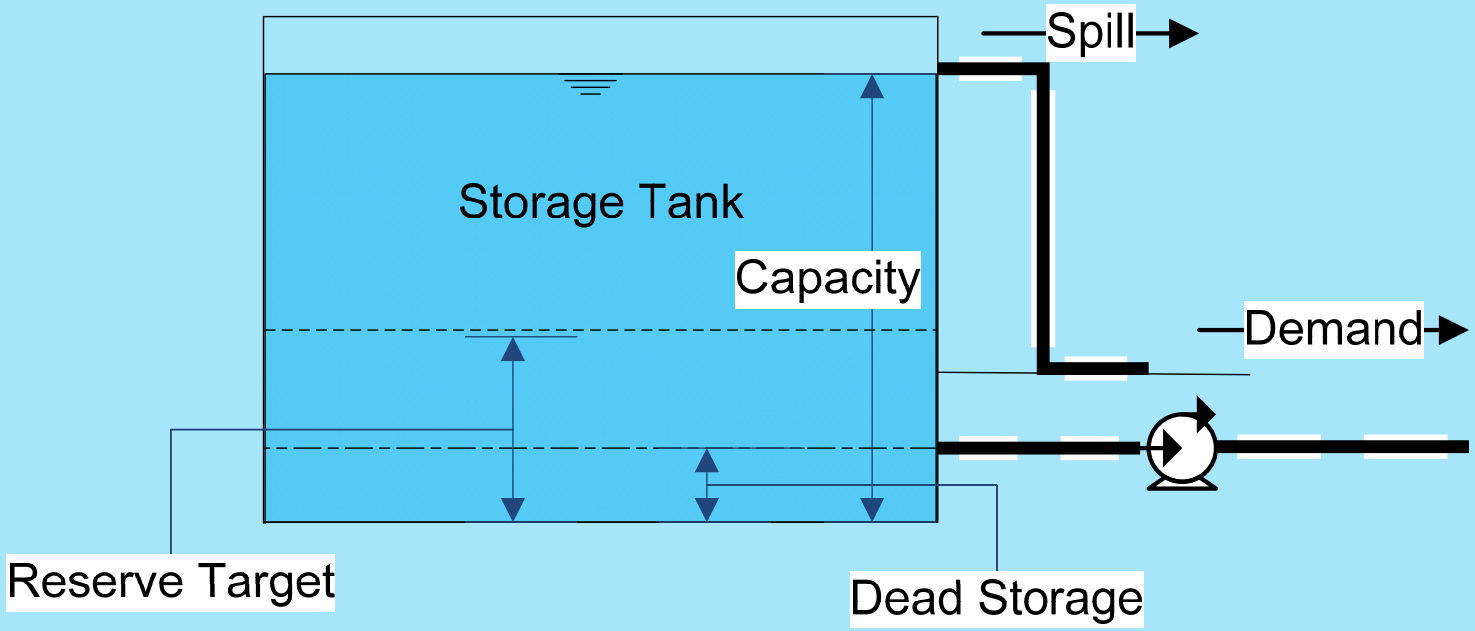
- RHS is currently given a 40% runoff credit (but only for 50% of runoff volume)
- Objective: Use simulation model and duration analysis to develop generalized rule curves for WQ credits



Collaboration with T. Younos

Operational Dynamics

- Reserve Target
- Time of Emptying
- Dead Storage



Summary

- Screening Tool
  - Average Climatology
  - Water Budget
- Center for Watershed Protection Method
  - Water Budget
  - Interevent Time Probabilities
- Proposed Rule Curves
  - Water Budget
  - Simulation
  - Duration Analysis

CENTER for WATERSHED STUDIES at VIRGINIA TECH

Questions?

Contact Info: David Sample, dsample@vt.edu
(703)361-5606x128