

Evapo-transpiration Landfill Covers (Veg Caps)



*Steve Rock,
NRMRL
Cincinnati, OH*

Trees, soil and grasses as cover system





The Carson Continuum

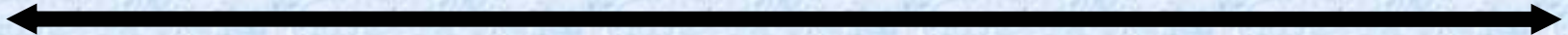
Cost, complexity, conventionality

*Natural
Attenuation*

*Water Balance,
Evapo-Transpiration*

*Simplified
Composite
Cover*

*Multi-layer
Composite
Cover*



*Each system needs site specific engineering
to determine appropriate applications*

Regulator Concerns

- Prevent:
 - physical contact with waste;
 - GW contamination;
 - gas escape
- Legal Equivalent to RCRA covers - ARARs
- Durability

VEGETATIVE COVER SYSTEMS

DEFINITION

- Long-term, self-sustaining cover of plants growing in and/or over contaminated materials
- Reduces risk to acceptable level
- Requires minimal maintenance

Phytoremediation Cap

- designed to minimize water infiltration and degrade waste.

- Mechanisms:
 - water uptake
 - root zone microbiology
 - plant metabolism

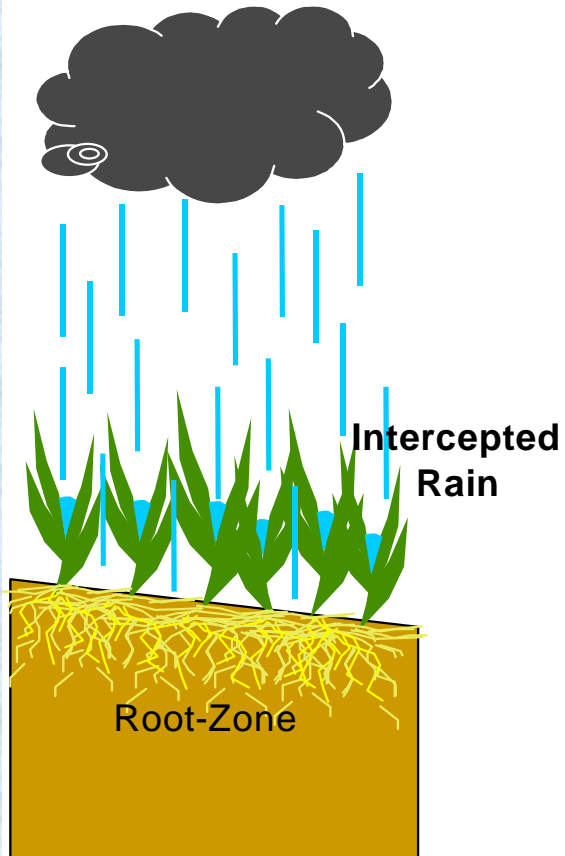
Evapotranspiration Cap

(ET or water-balance cover) -- is composed of soil/plants to maximize evaporation/transpiration process

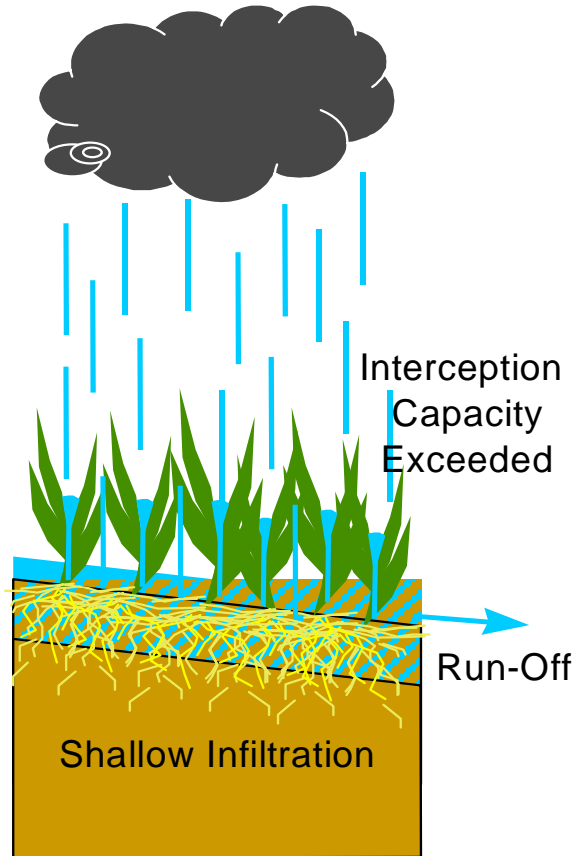
- Form of hydraulic control
- Risk reduction relies on leachate control
- water storage in soil/vegetation

Infiltration Control from a Vegetative Cover.

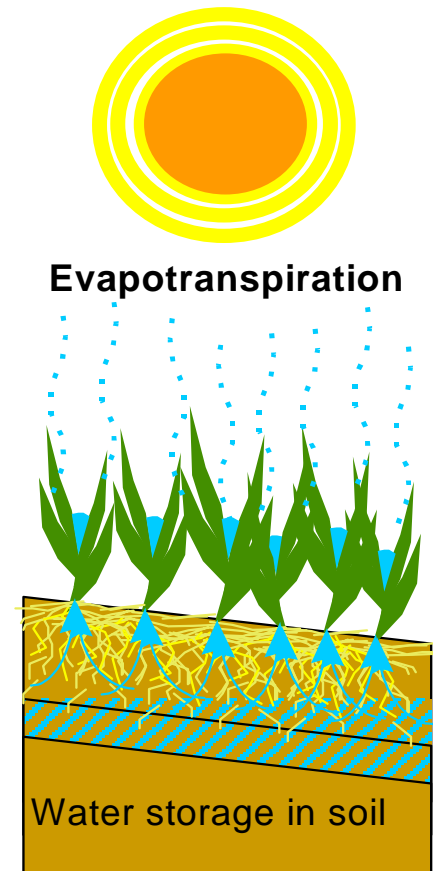
START OF RAIN
EVENT



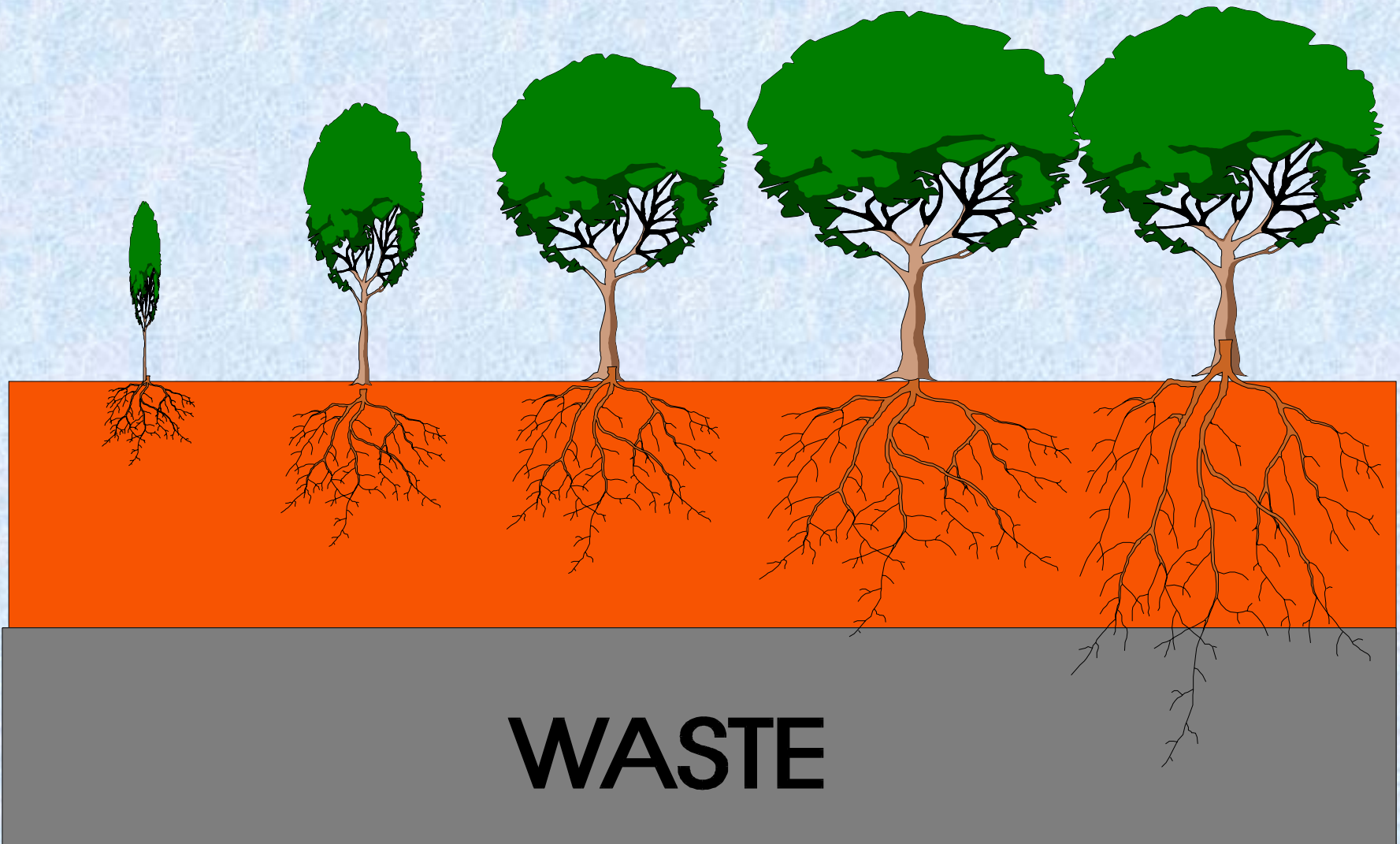
DURING RAIN
EVENT



AFTER RAIN
EVENT

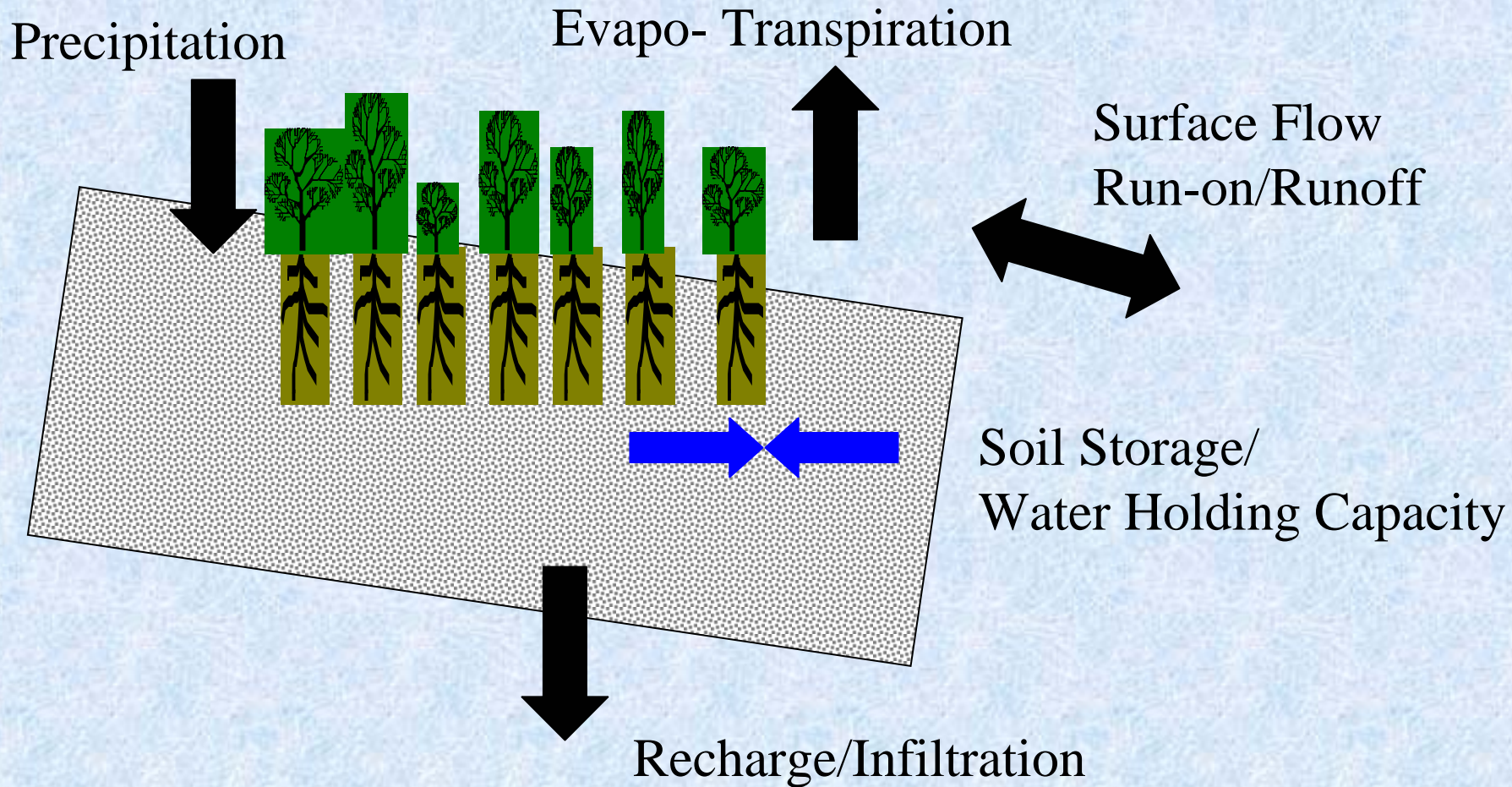


Tree Root Penetration Over Time



Hydrologic Components of ET Covers

$P = ET + \text{Runoff} + \text{Recharge}$



What should you look for in a Veg Cover Design Plan?

- Soil
- Climate
- Plant selection
- Planting Plan
- O and M, and Contingencies
- Modeling

Soil



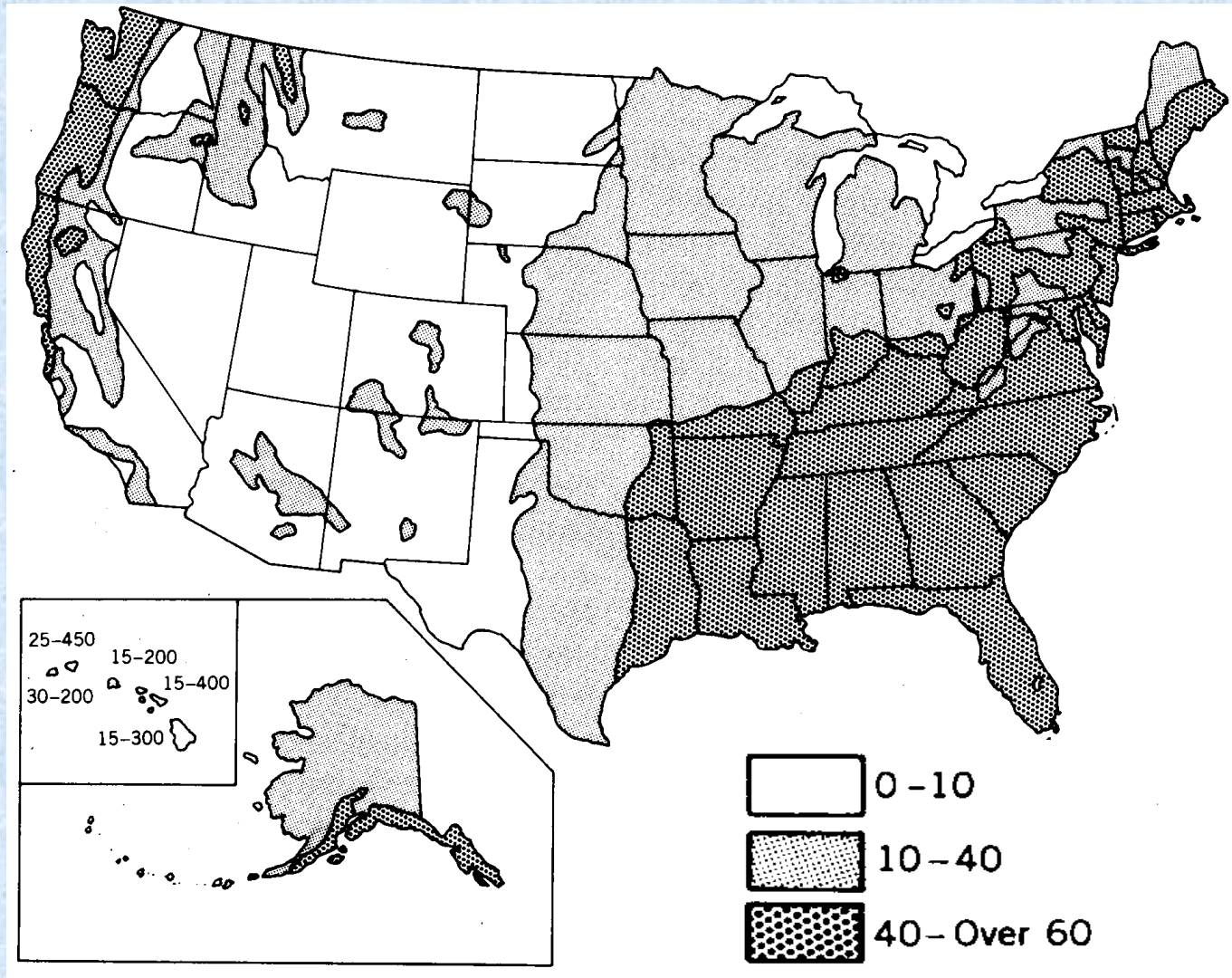
- Water Holding Capacity (Inches or %)
- Grain Size
- Organic Content
- Nutrient analysis

Climate

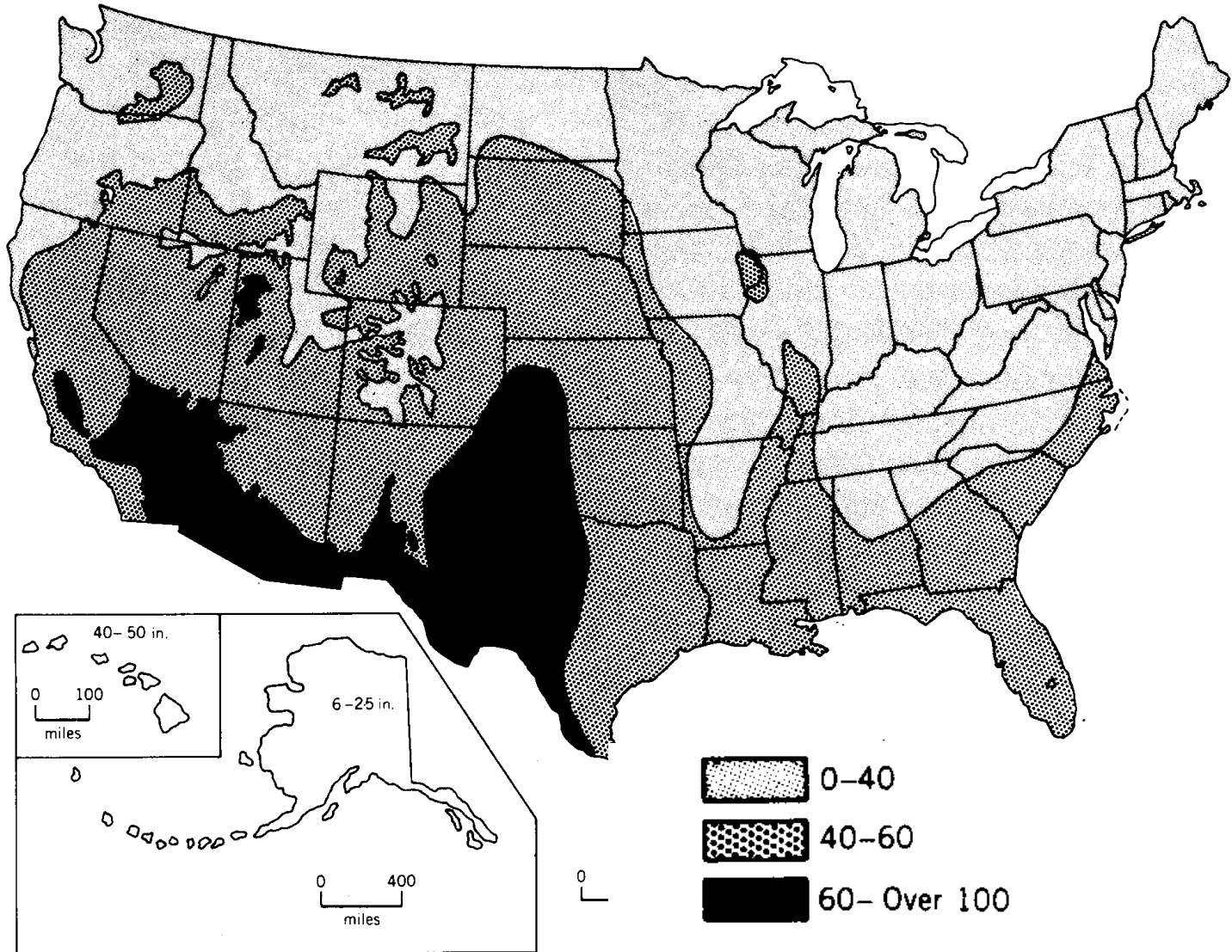
- Precipitation
 - annual total
 - monthly distribution
- Growing Season
- Potential Evapo-transpiration
 - sun
 - humidity
 - wind



Annual Precipitation in Inches

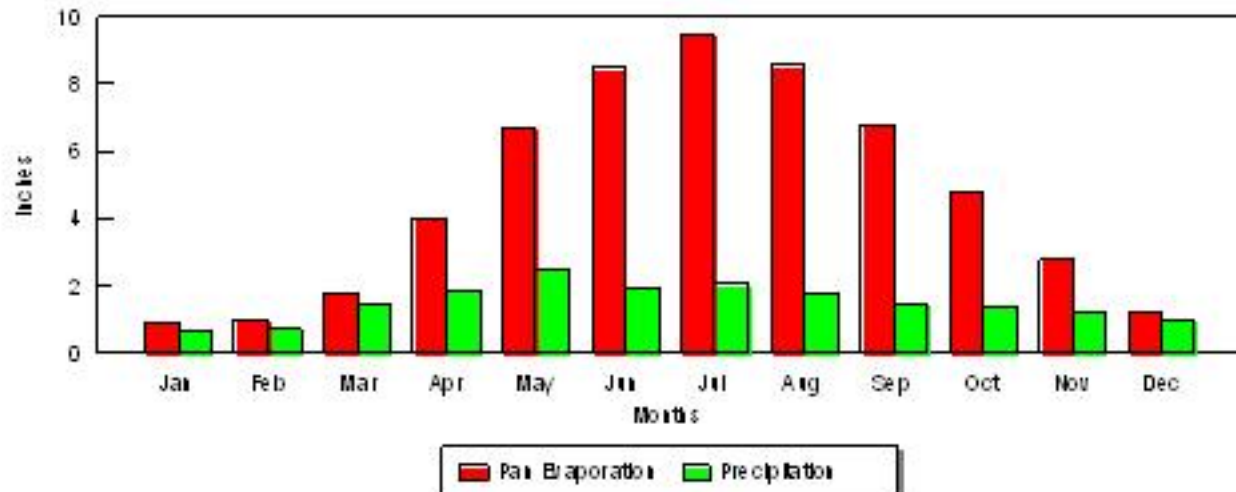


Pan Evaporation in Inches



Rainfall and Pan Evaporation

in the Denver Area: 1959 - 1994



Unanticipated Climate Effects

Average rainfall = every year is either wetter or dryer



Alamogosa Desert



El Niño year

Plants



- Suited to site
 - climate
 - altitude
 - salt
- Rooting depth
 - roots in waste ok?
- Monoculture?
- Native

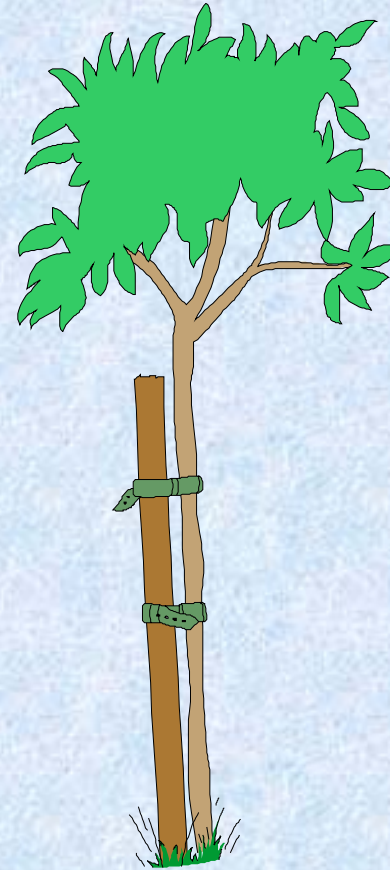
Design for Arid and Semi-Arid Climates (<20’')

- Unconsolidated native soil to frost line
- Mixed Local plants:
Prairie grasses
- Shallow root zone;
70% in top three feet



Cover Design for Wet Climate (20+’')

- Hybrid poplar or willow
- Roots will reach 8 -10 feet
- Plant into soil/waste
- 1000 Trees per acre
- 5-25 gallons/tree/day during growing season



Planting Plan

- Timing
- Soil Amendments
- Technique
- First Season TLC
 - irrigation
 - weed control
 - Herbivore Control



*Albany, Ga.
First growing
season.*



O & M, Contingencies



- Replacement (10-20%)
- Inspections
 - animals
 - insects
 - nutrient, water stress
- Thinning/pruning
- Mowing

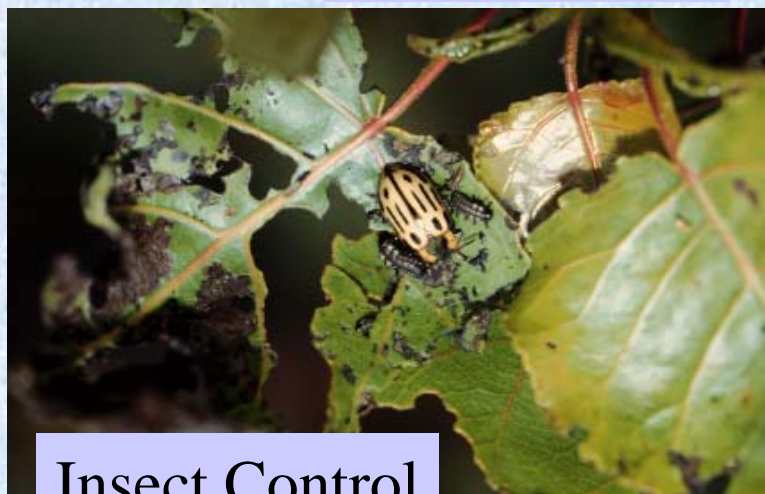
Phyto Specific Cost Elements



Electric Fence



Replanting 10-20%



Insect Control



Hawk poles to control rodents

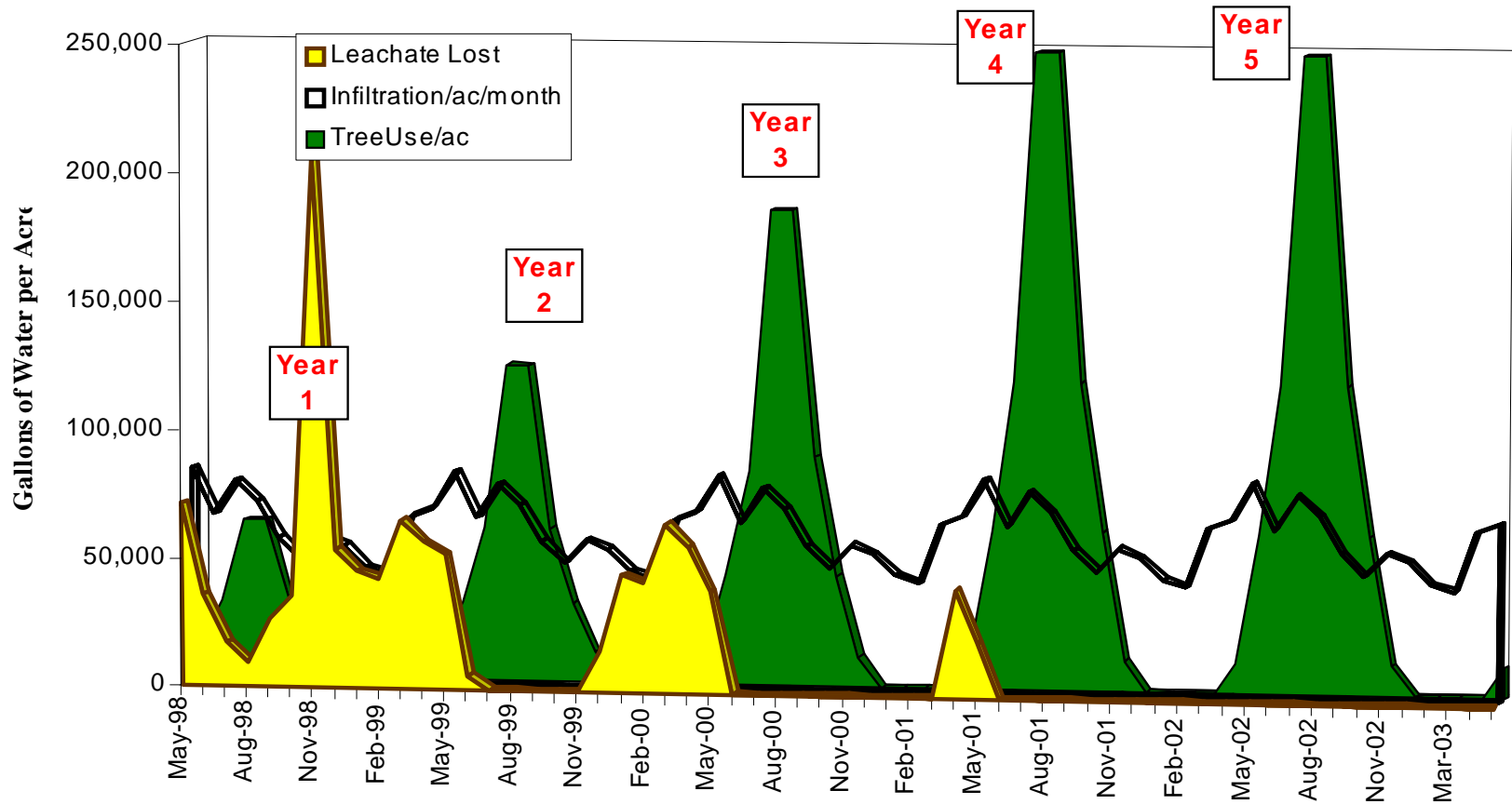
Chris Rog

Models

- HELP
- EPIC
- UnSat-H
- Hydrus 2d
- Home-grown



Water Use by *TreeMediation*® Cover Trees and Leachate Production at GreenII Landfill



When is an ET Cap Appropriate?

- A) Where *Water Balance* is protective of groundwater.
- B) When *Gas Capture* is not an issue.
- C) Where conventional covers may not be feasible.
- E) All of the above.

Monitoring ET Covers

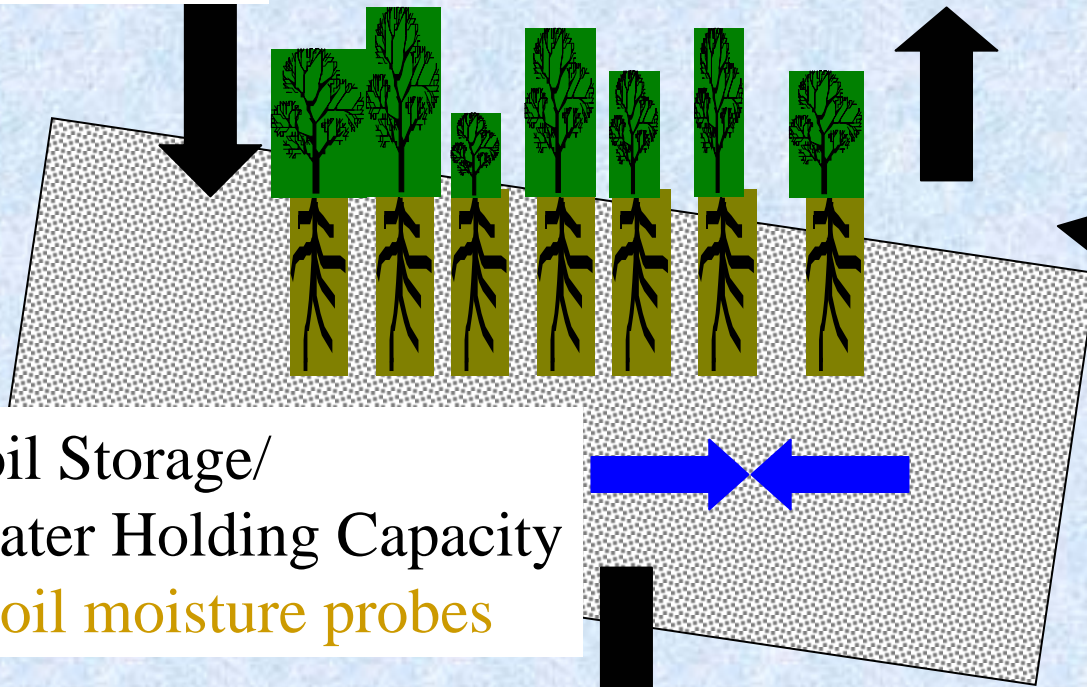
Precipitation
=Rain gauge

Evapo- Transpiration
=Weather Station w Penman Equation

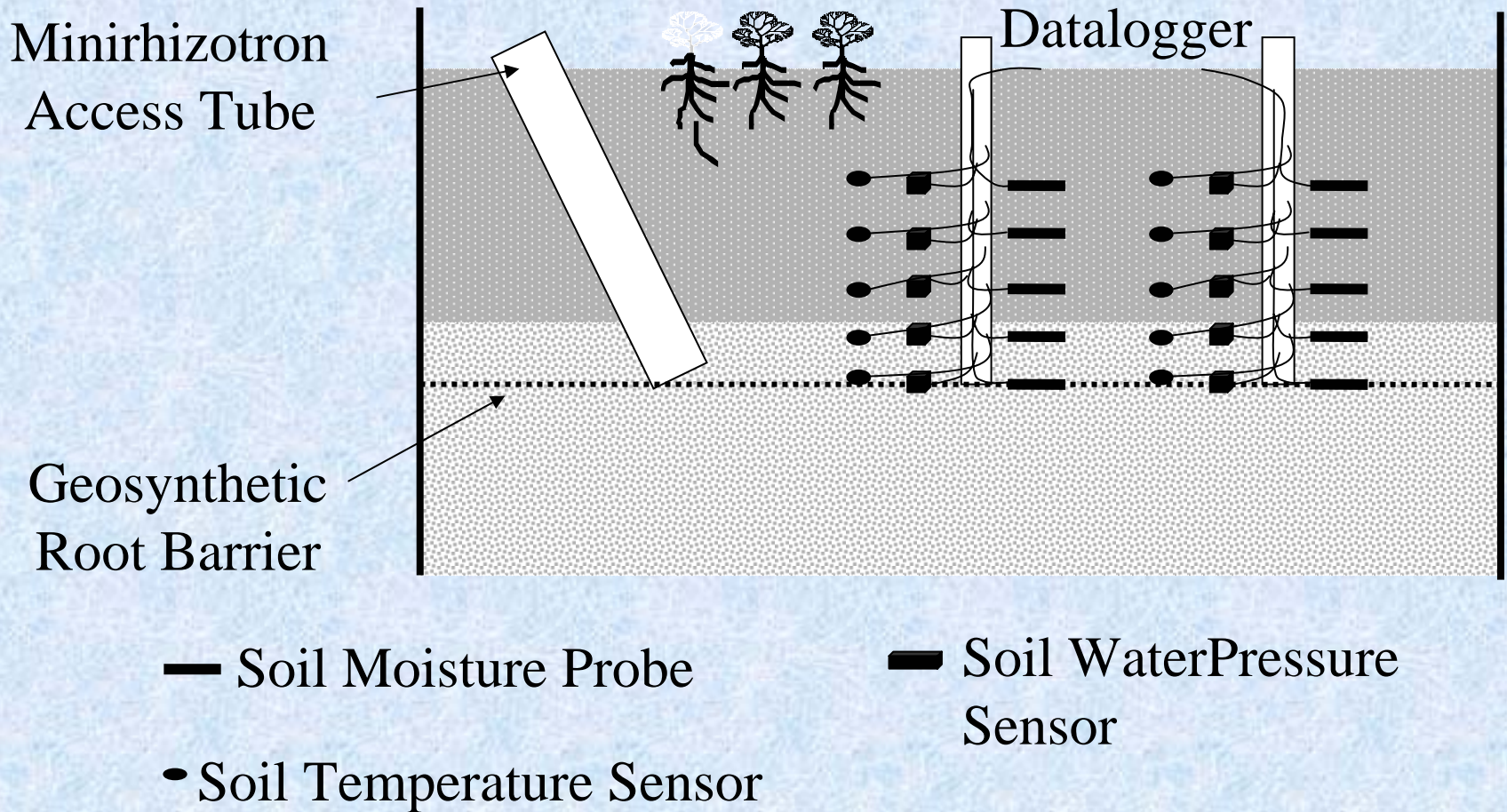
Surface Flow
Run-on/Runoff
=weir collection

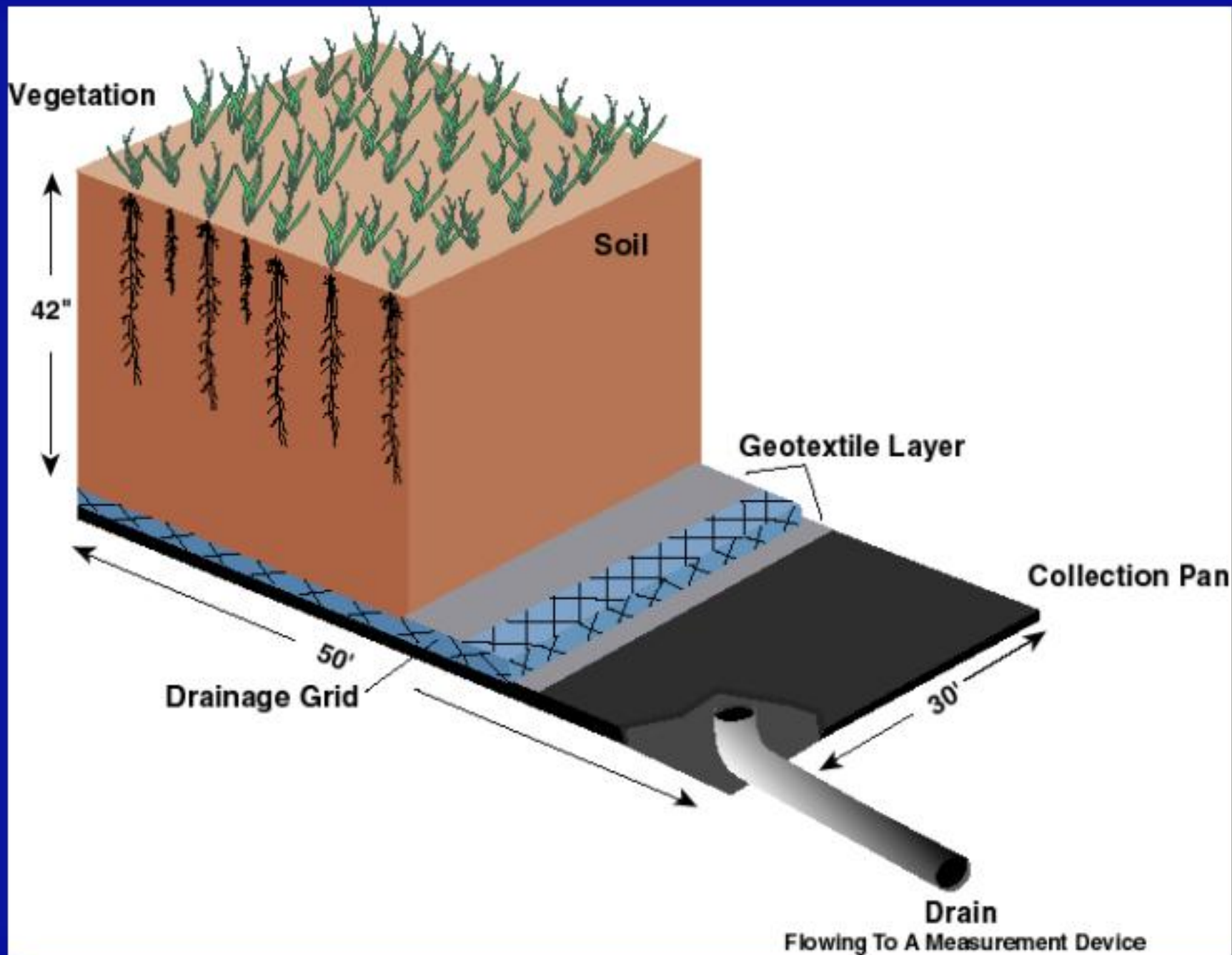
Soil Storage/
Water Holding Capacity
=soil moisture probes

Recharge/Infiltration
=lysimeter bottom drain tipping bucket



Vadose Zone Monitoring Station







Checking grade of the subgrade near sump.

Aerial view of lysimeter lined with geomembrane.





Connection between sump boot and percolation pipe.



Staking root barrier.

Completing first layer of soil above root barrier.



Placing soil along braced sidewall geomembrane.









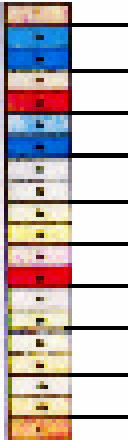
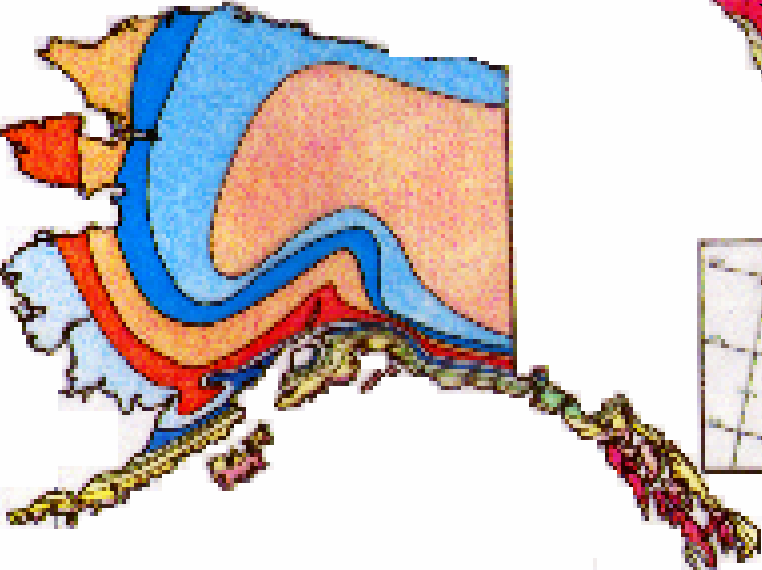
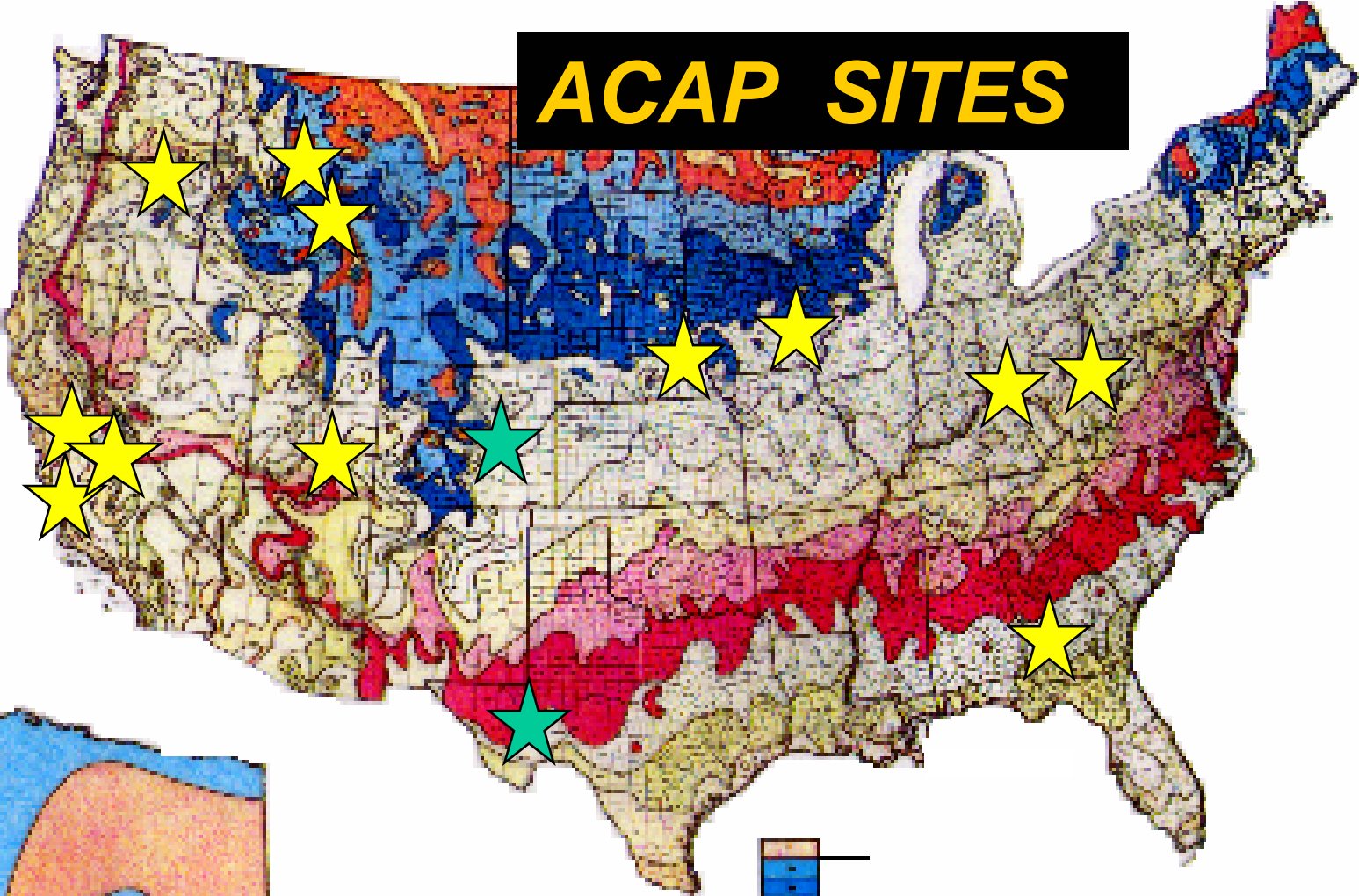
Percolation Collection Instrumentation



Conduit routed to weather station/datalogger.

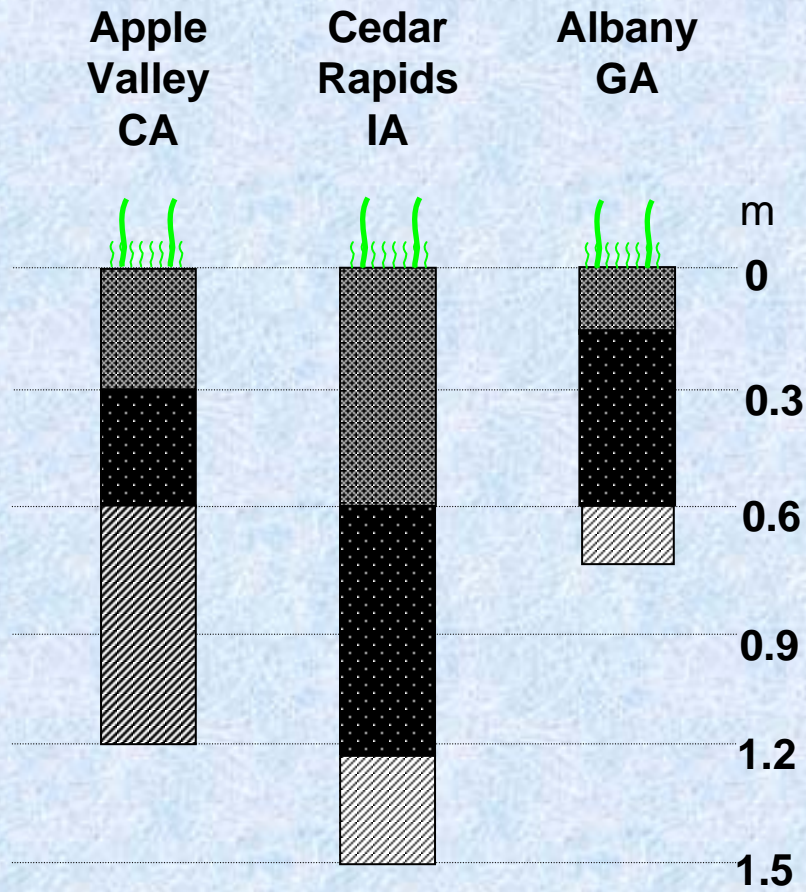


ACAP SITES

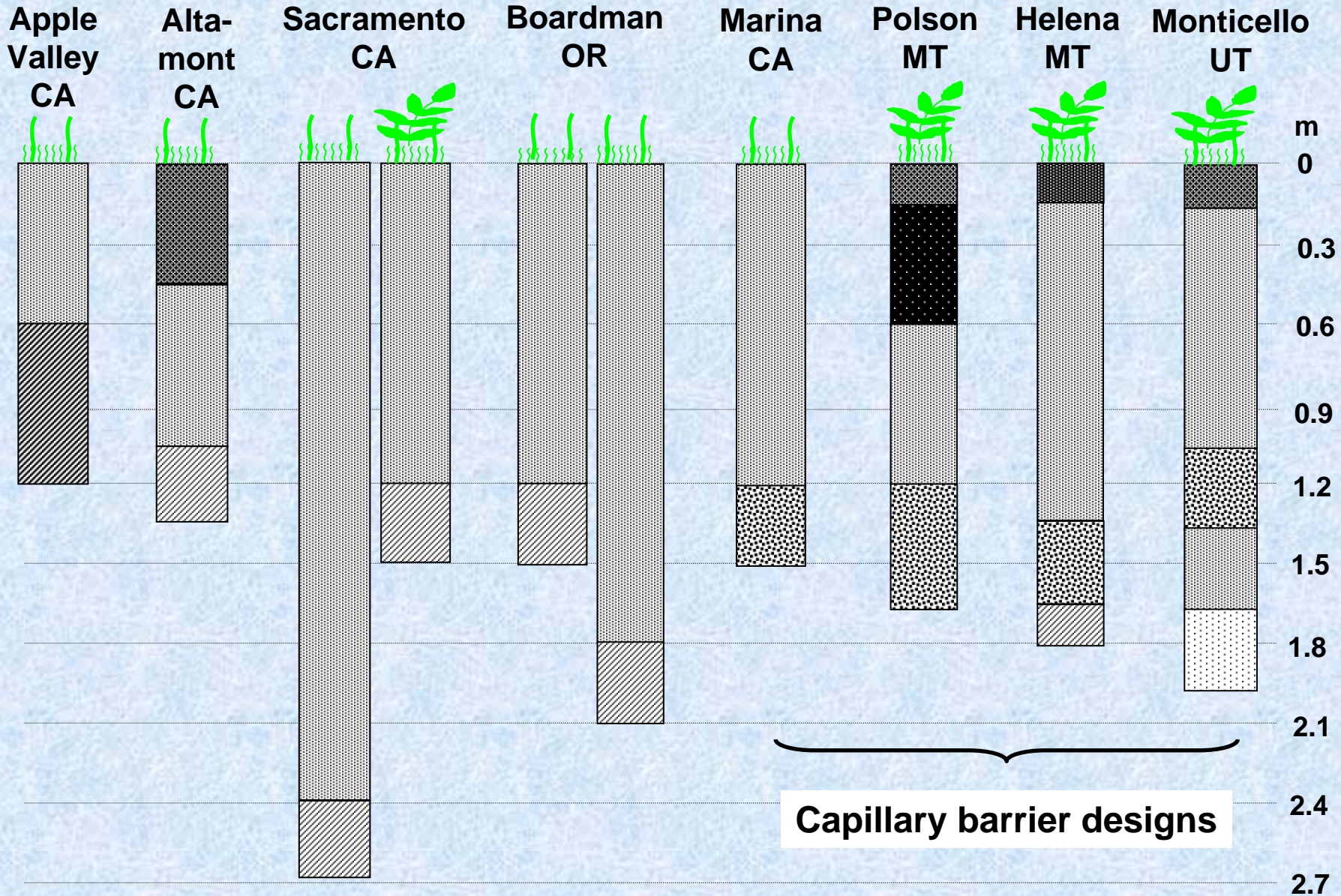


- ★ Complete
- ★ By Others

Conventional Soil Barrier Designs Profiles



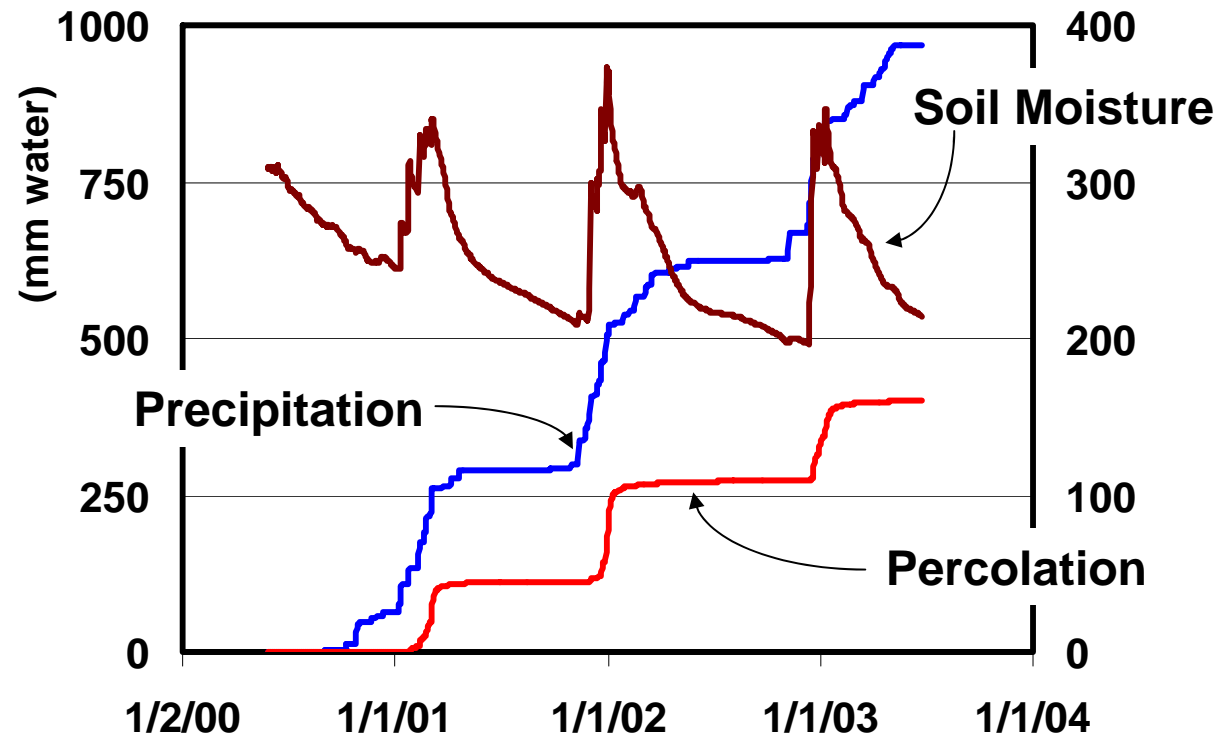
Alternative Designs: Arid/Semi-Arid/Sub-Humid Locations



Water Balance Components

Alternative Cover, Marina CA

- Water storage capacity lower than expected
- Effective storage capacity (300 mm) lower than calculated (385 mm)
- Drainage when storage capacity exceeded

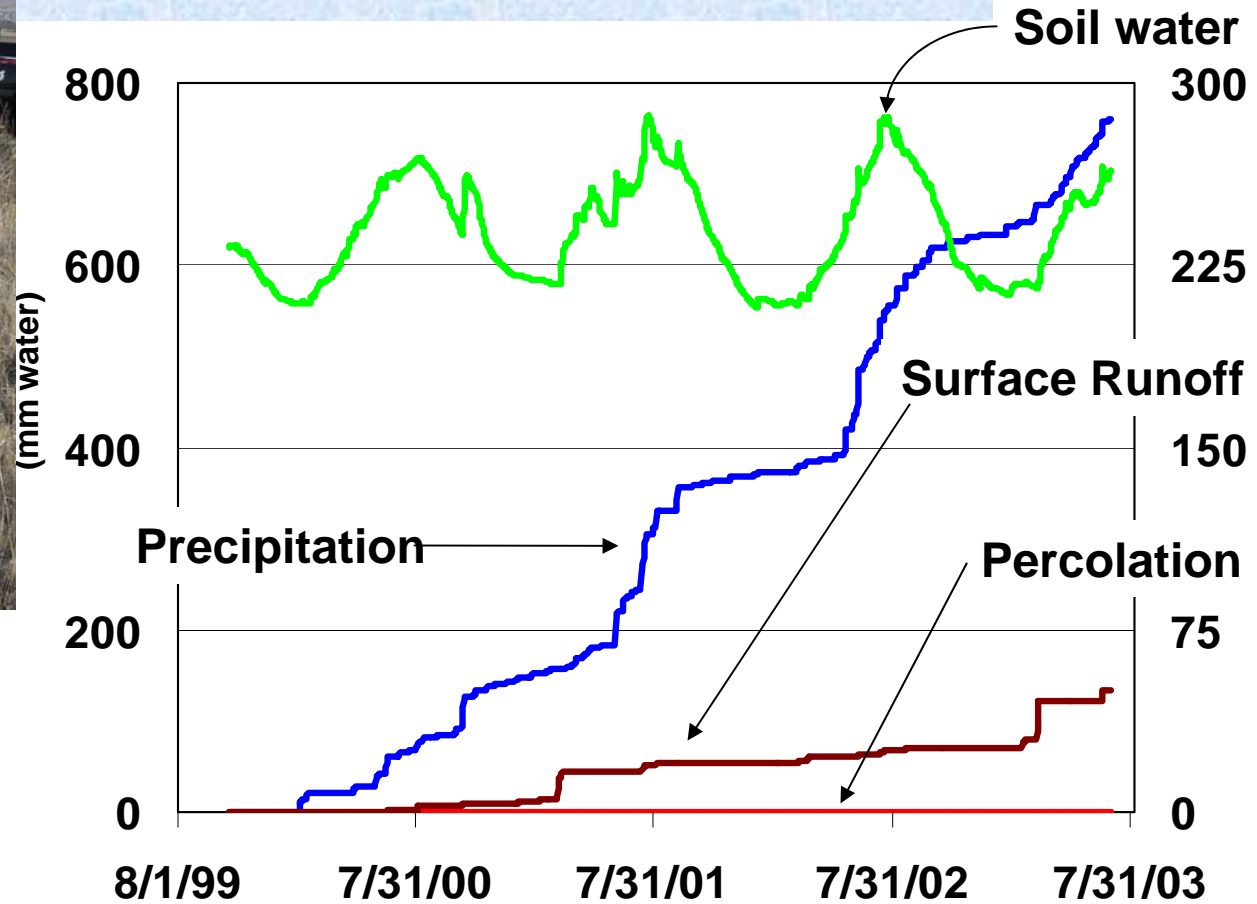


Water Balance Components

Alternative Cover, Helena MT



- Seasonal precipitation pattern
- Seasonal fluctuations in soil water content
- No percolation

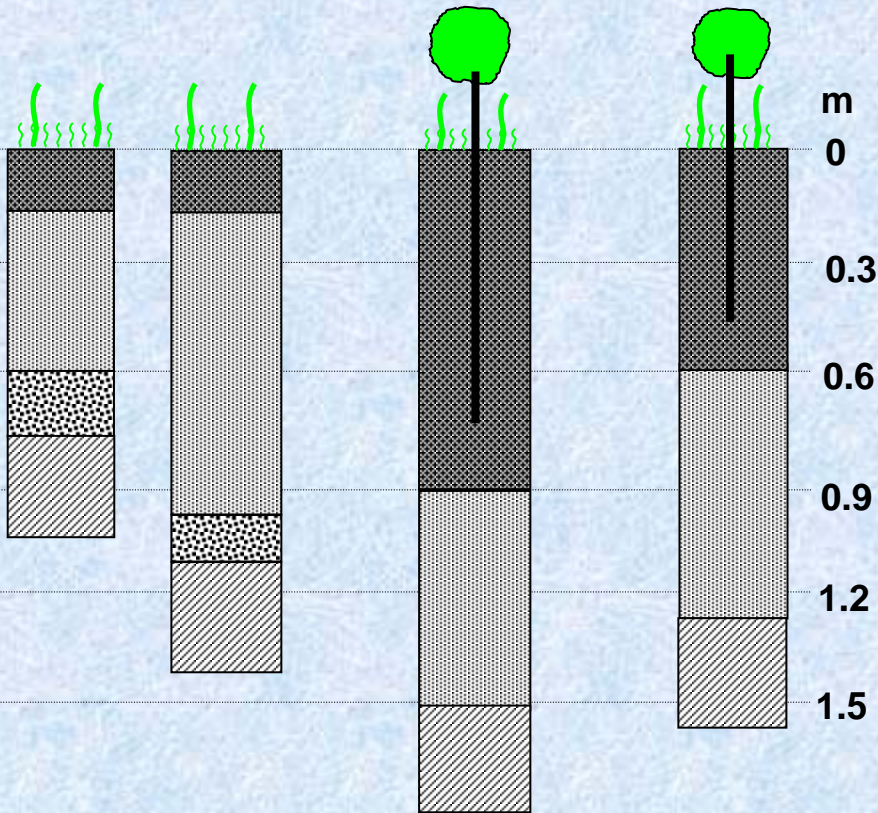


Alternative Designs: Humid Locations

Omaha
NE

Cedar
Rapids
IA

Albany
GA

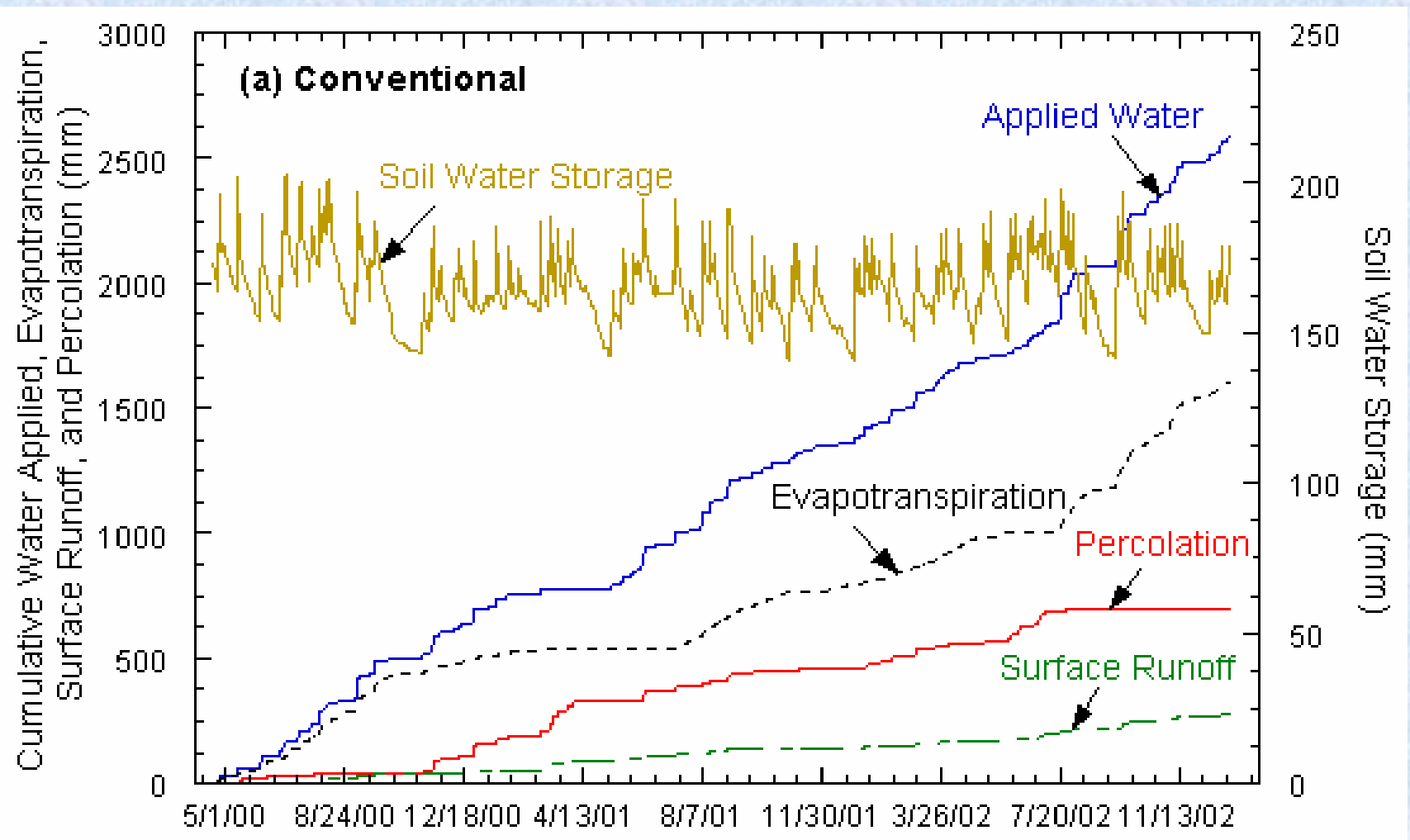


Alternative Cover Performance Humid Locations

Site	Percolation (mm/yr)
Albany GA	123 (10%)
Cedar Rapids IA	160 (18%)
Omaha NE (thin cover)	57 (10%)
Omaha NE (thick cover)	33 (6%)

(% = percent of precipitation)

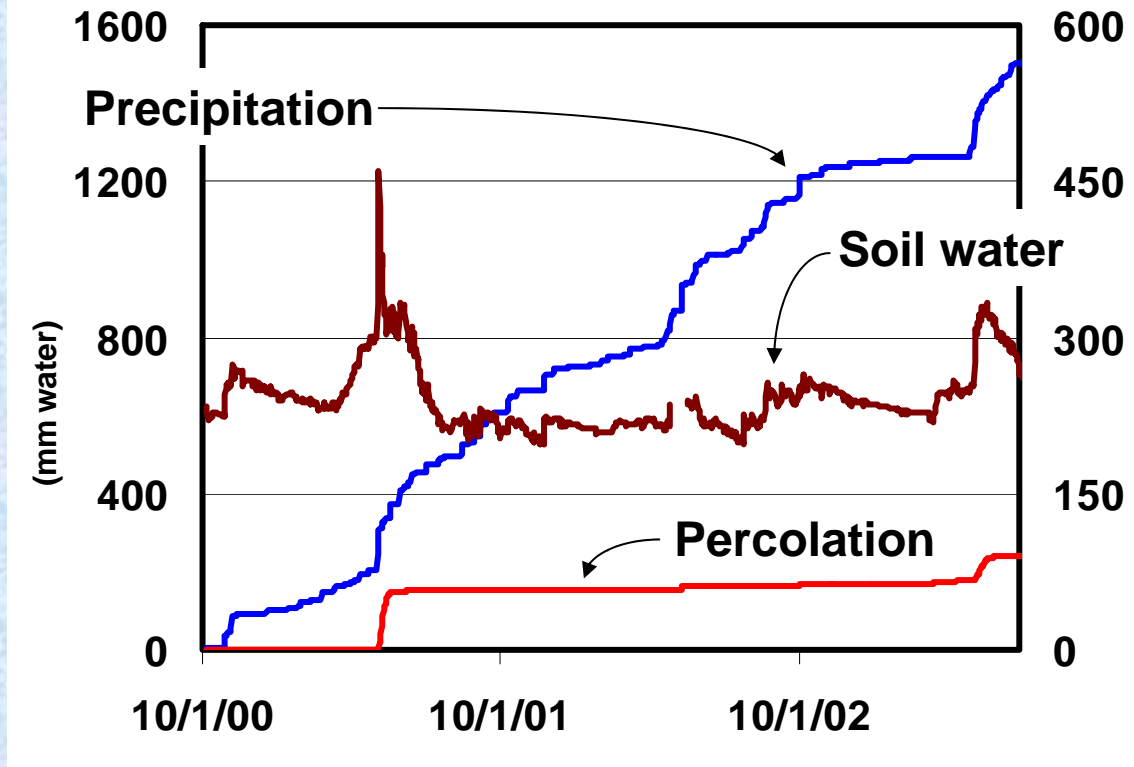
Georgia Compacted Clay Cap



Water Balance Components

Alternative Cover, Omaha NE

- Moderate precipitation
- Percolation occurs late spring
- Improvements in design and factor-of-safety considerations may provide acceptable performance



Equivalency Clause

RCRA requirements “or equivalent”

Equivalent to 10^{-5} or 10^{-7} materials, or Equivalent performance.

Paradigm problems. How do you translate a percolation standard into a performance standard?

Where do you measure for equivalence- top of waste or under waste?

What is baseline- or How well do RCRA covers work?

ET Cover/Phyto Web Resources

www.clu-in.org. search for “phytoremediation”; Introduction to Phytoremediation and 12 other documents

www.dri.edu information on ACAP sites

www.itrcweb.org Veg Cap Team, case studies and Technical and Regulatory guidance document in development

www.rdtf.org bibliography and searchable database of sites