Coast to Coast
Results From the 11 ACAP Field Sites

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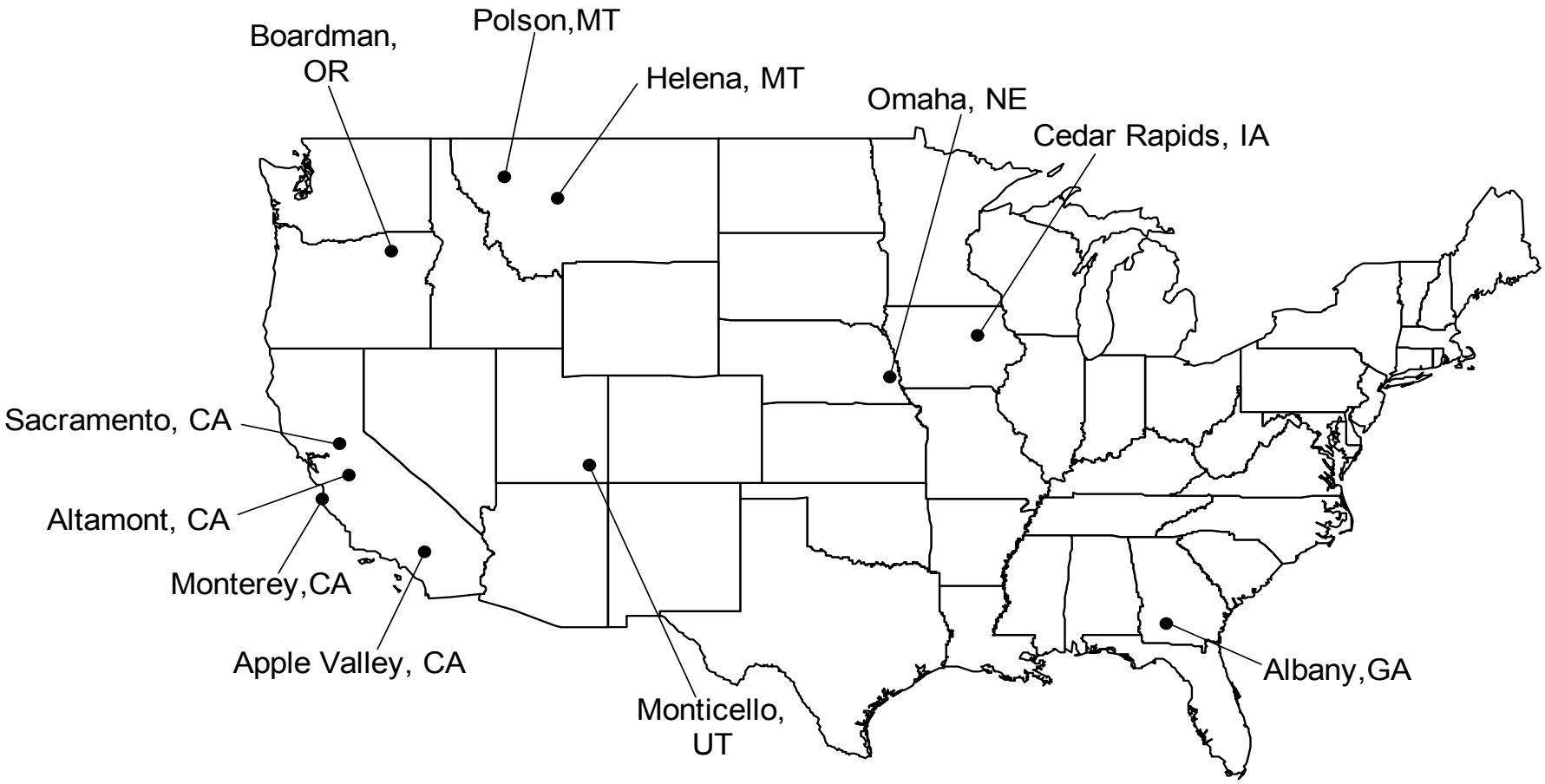
ACAP: The Field Program

- Nationwide: 11 sites, 7 states
- Large (10 X 20 m) drainage lysimeters
- Conventional covers
  - Composite
  - Soil barrier
- Alternative covers
  - Evapotranspiration (ET)
  - Capillary barrier
- Side-by-side demonstration at most sites

ACAP Site Locations

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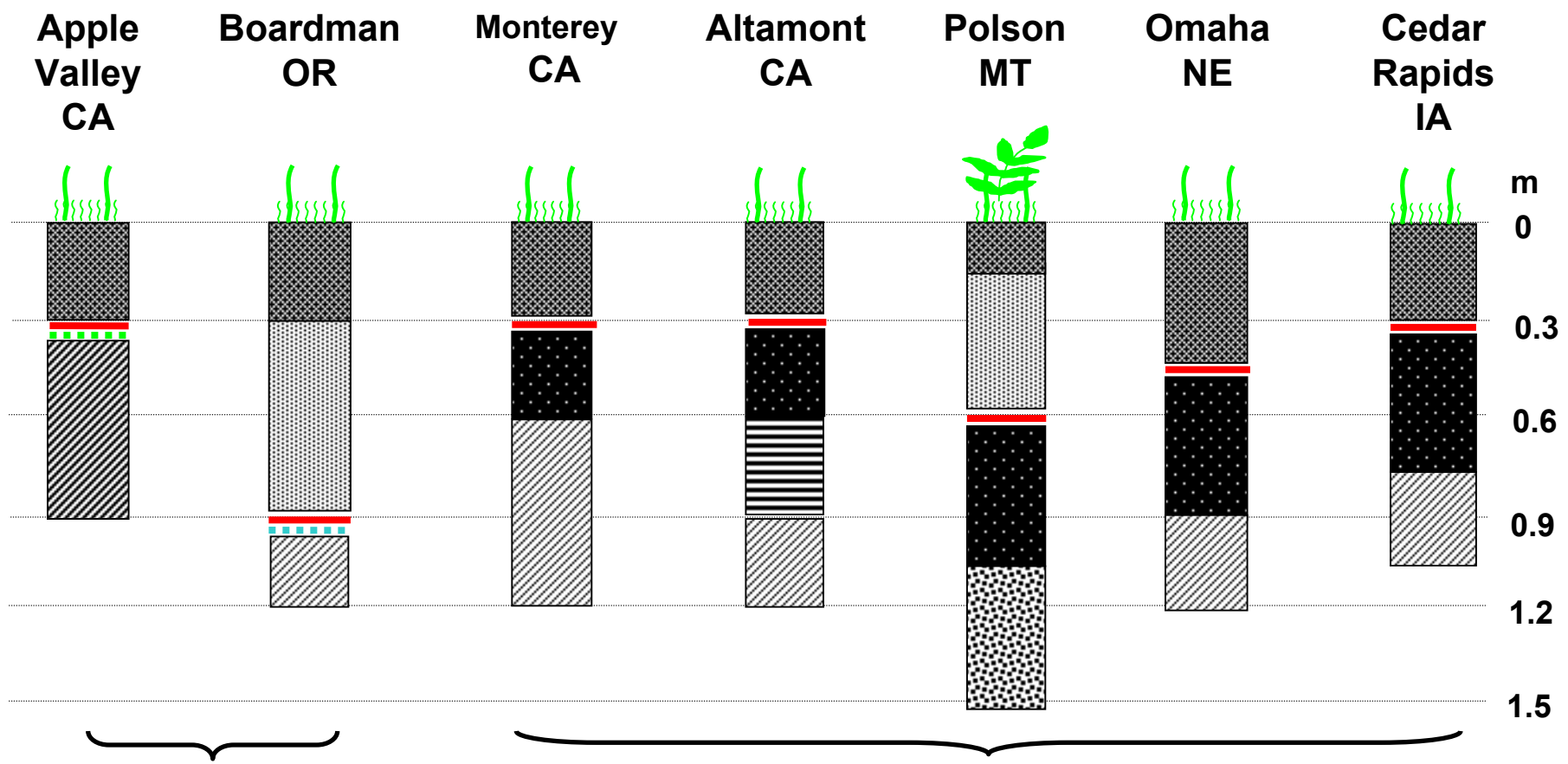
Conventional Composite Designs
Profiles

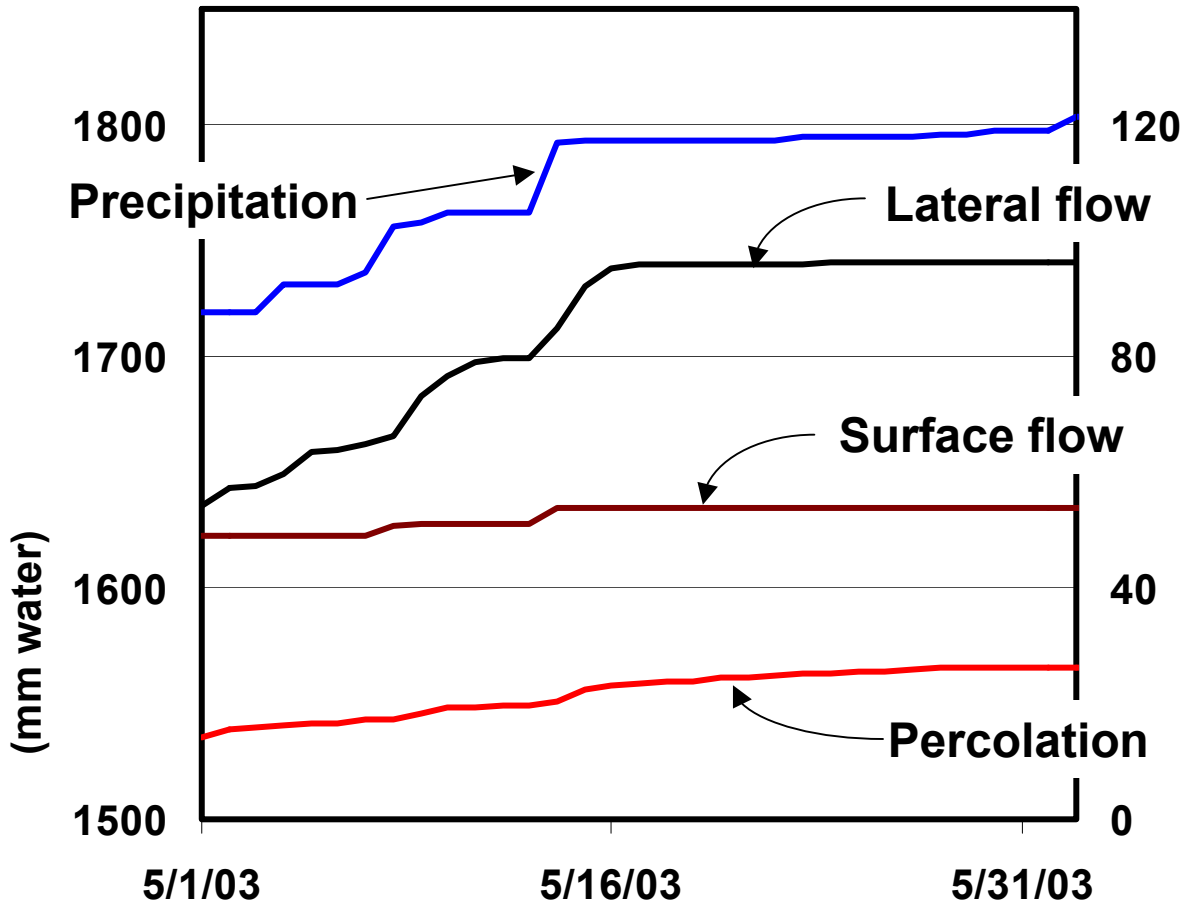


Conventional Composite Designs
Questions

- Lack of field-scale performance data
- Do composite covers allow any percolation?
- What are the environmental conditions and other factors that influence percolation
- Geomembranes – the importance of construction practice and quality control

Water Balance Components
Conventional Composite Cover, Cedar Rapids IA

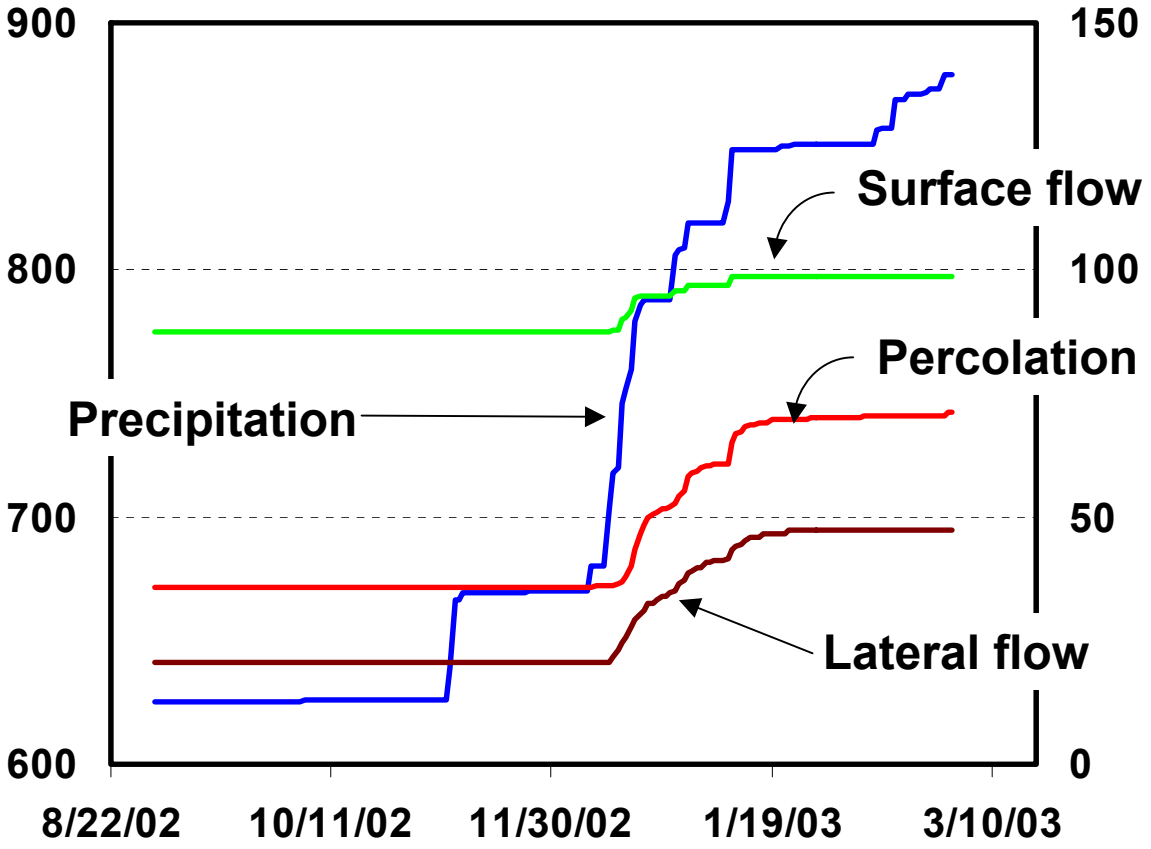
- Percolation rate correlated with
  - Heavy precipitation events
  - Surface flow
  - Lateral flow on geomembrane



Water Balance Components

Conventional Composite Cover, Marina CA

- Percolation coincides with precipitation, surface and lateral flow
- Relatively high rate of percolation
- No cushion between the geomembrane and the soil, punctures likely in geomembrane



- Illustrates importance of careful geomembrane installation

Conventional Composite Cover Data

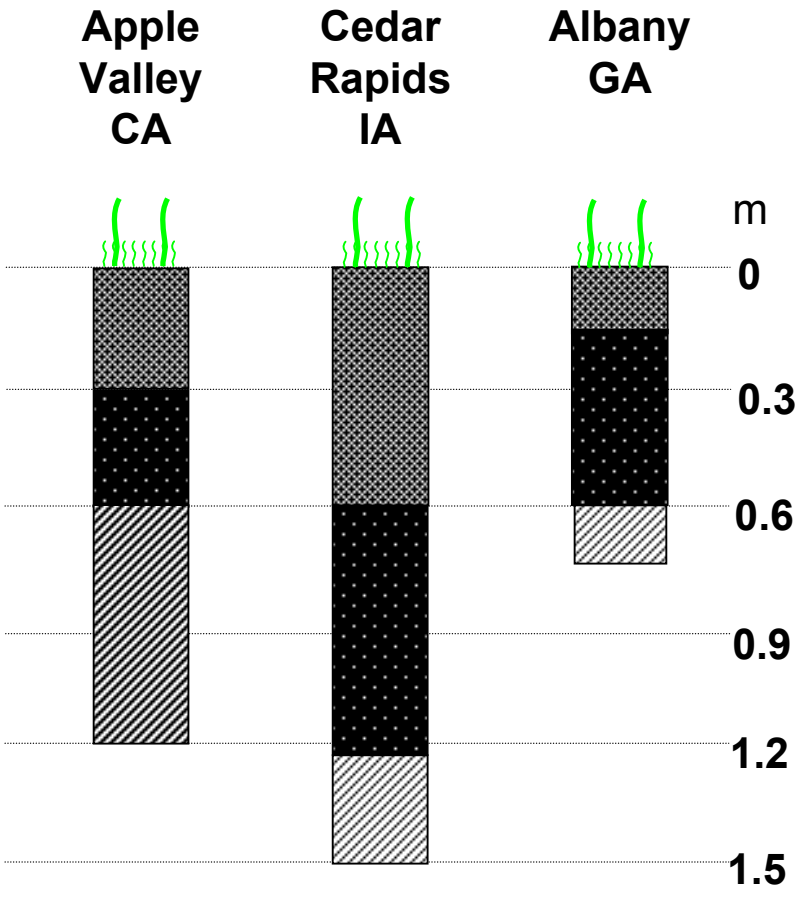
Site	Total (mm)	Average (mm/yr)
Altamont CA	4.0 (0.4%)	1.5 (0.4%)
Apple Valley CA	0.0 (0.0%)	0.0 (0.0%)
Boardman OR	0.0 (0.0%)	0.0 (0.0%)
Marina CA	71 (7.3%)	23 (7.3%)
Polson MT	1.5 (0.1%)	0.4 (0.1%)
Omaha NE	16 (1.1%)	6.0 (1.1%)
Cedar Rapids IA	27 (1.4%)	12 (1.4%)

(% = percent of precipitation)

Conventional Composite Covers
Discussion

- Perform well at all locations
- Average percolation typically <1.5% of precipitation
  - <1.5 mm/yr at arid/semi-arid/subhumid sites
  - <12 mm/yr at humid locations
- Percolation often linked to heavy precipitation events and lateral flow
- Damage to geomembrane greatly increases percolation rate
- Construction practice and quality control are very important

Conventional Soil Barrier Designs
Profiles

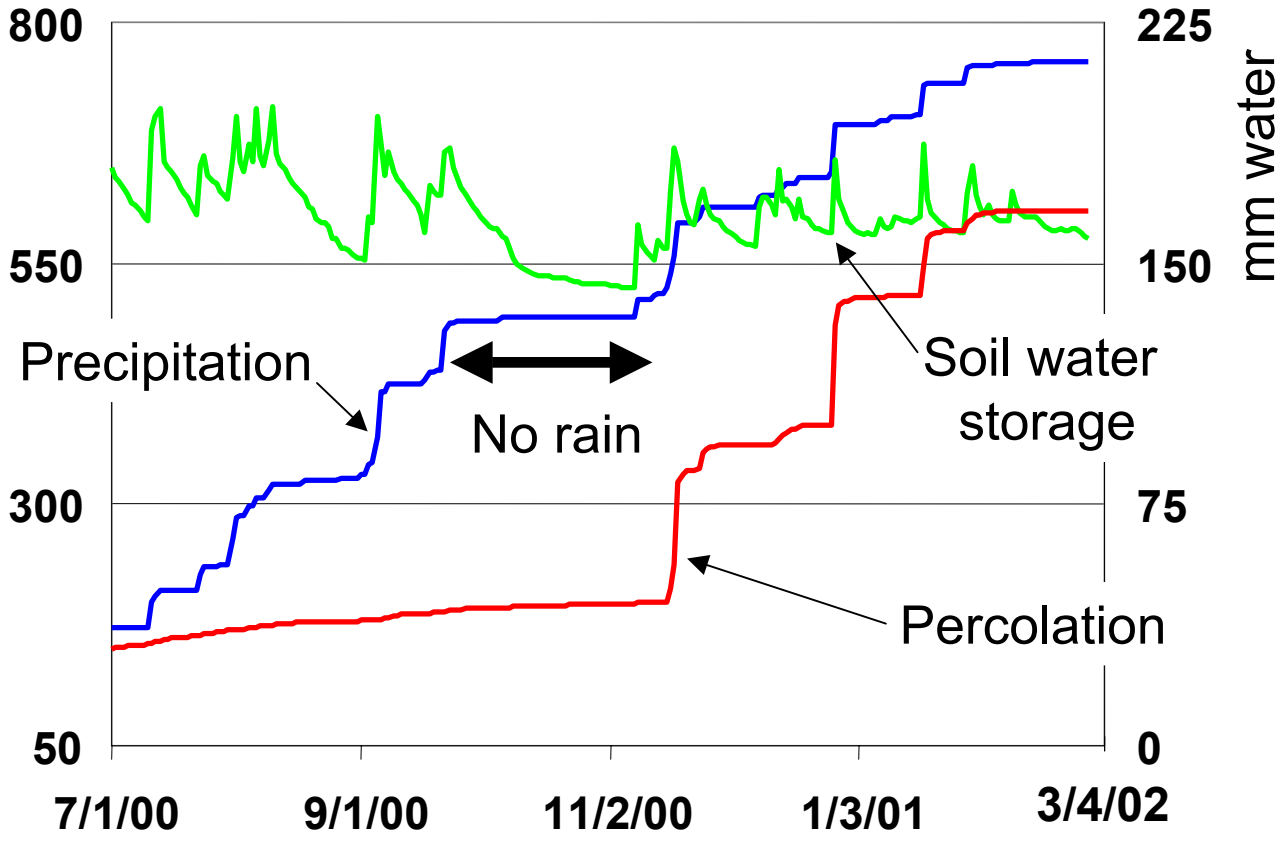


Conventional Soil Barrier Designs
Questions

- Performance requires long-term and large-scale stability of compacted clay layers
- Lack of field-scale data including important environmental stresses that contribute to pedogenesis in clay layer
  - desiccation
  - freeze / thaw
  - roots
- Do defects heal when water content increases?

Water Balance Components
Conventional Soil Barrier Cover, Albany GA

- Soil dried for first time during 6-week drought
- Change in response of percolation to precipitation events
  - Quantity
  - "Stair step" response



- No evidence that defects in clay barrier healed when soil water increased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Conventional Soil Barrier Cover Data

Site	Total (mm)	Average (mm/yr)
Apple Valley CA	0.0	0.0 (0.0%)
Albany GA	623.7	195 (17.1%)
Cedar Rapids IA	113.6	52 (6.0%)

(% = percent of precipitation)

Conventional Soil Barrier Covers
Discussion

Percolation at humid locations

- 52 - 195 mm/yr
- 6 – 17 % of precipitation

- Percolation response to precipitation events changed at both humid sites
  - Percolation quantity increased
  - Temporal response increased
- Insufficient data at arid Apple Valley CA site
- GA cover de-construction: see poster

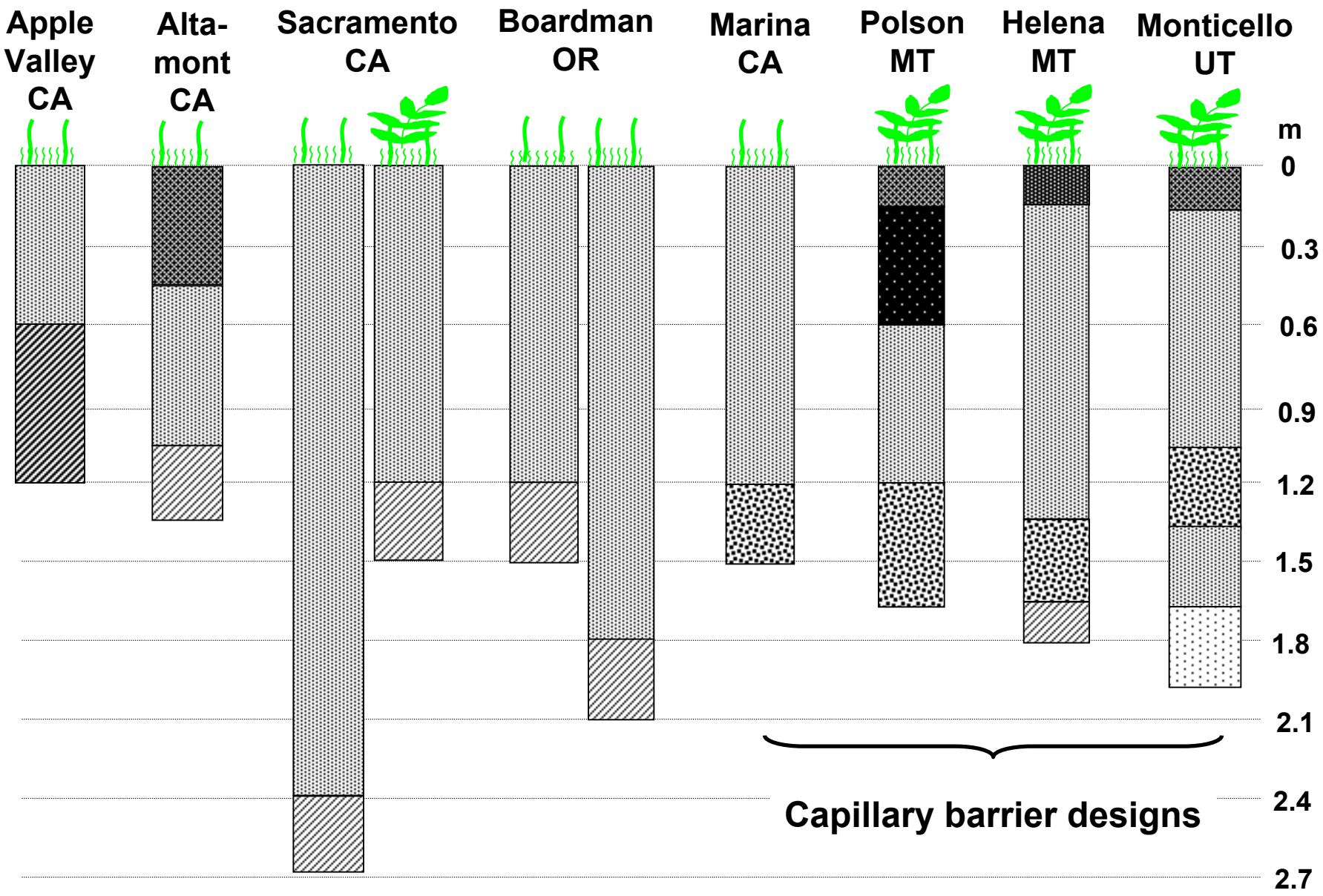
Summary: Conventional Designs

- Composite designs
  - Restrict percolation to low (<12 mm/yr) levels at all locations
  - Percolation typically coincides with flow on membrane
  - Require careful construction practice and QA
- Soil barrier designs
  - Performance quickly (<2 yrs) degrades
  - Percolation probably due to preferential flow through macro-features related to desiccation, freeze/thaw, roots
  - Damage likely to persist
  - Probably not suitable for near-surface applications that require low-permeability barrier

Alternatives Covers
Questions

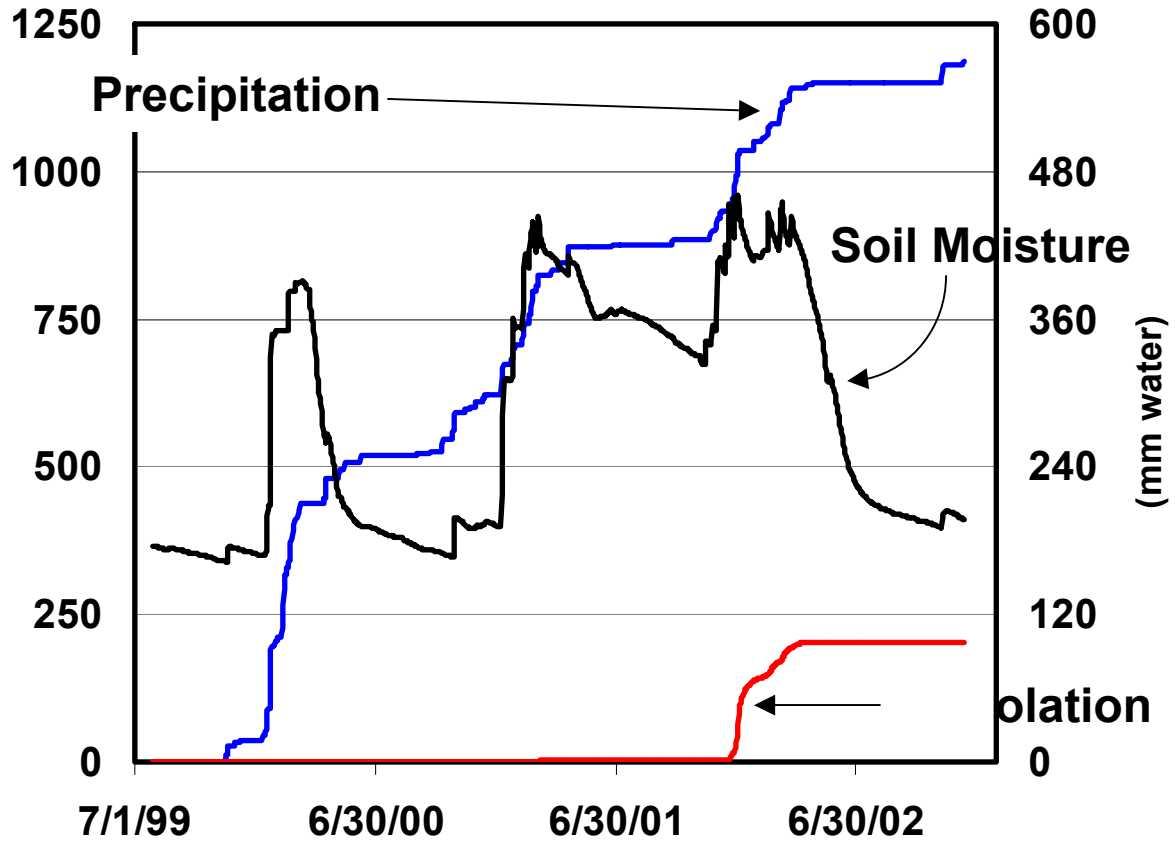
- Need for field-scale performance data
- In what environments is the store-and-release conceptual design appropriate?
- Are there spatial or scale concerns with preliminary designs based on available water storage capacity (field capacity – wilting point)?
- Can covers that rely on store-and-release principles control water balance at humid locations?
- Do we understand the mechanisms that affect performance?

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



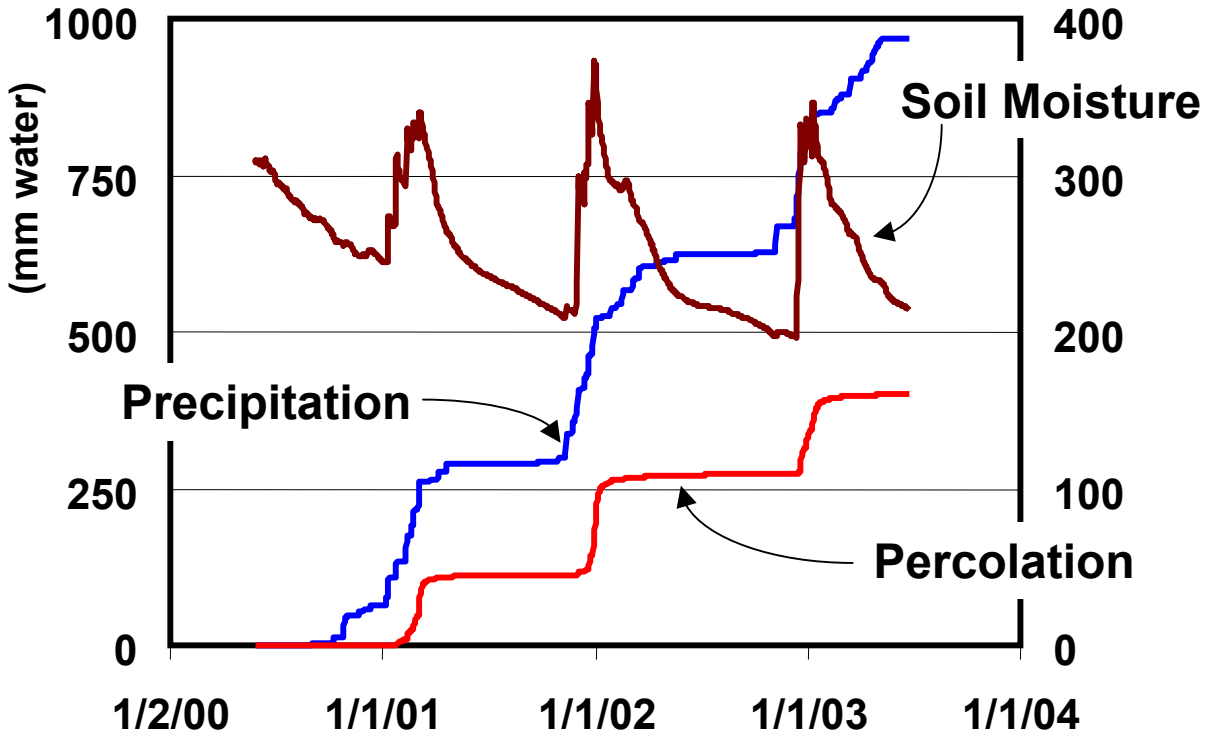
Water Balance Components
Alternative Cover, Sacramento CA

- Low transpiration rate during summer of 2001
- Result was percolation following winter



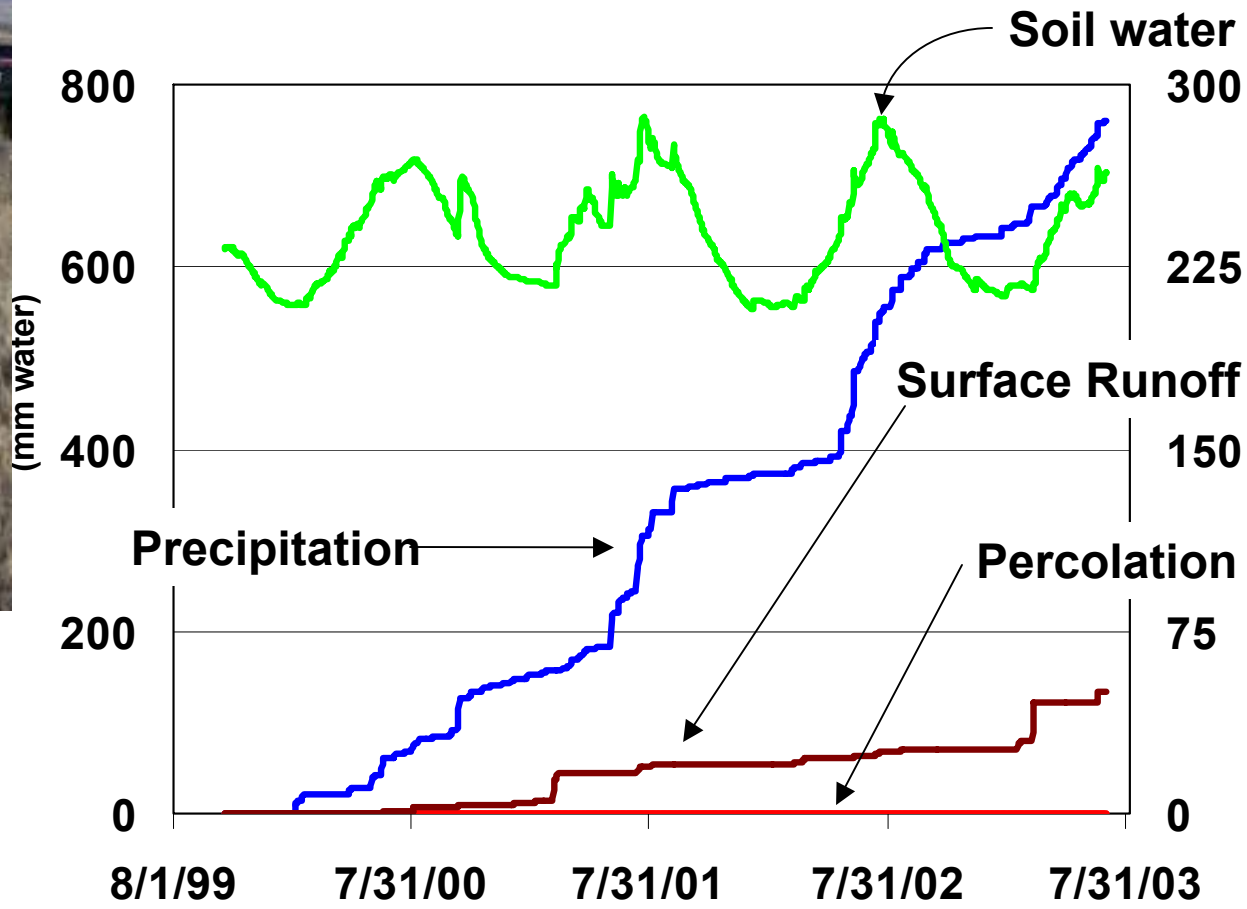
Water Balance Components
Alternative Cover, Marina CA

- 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

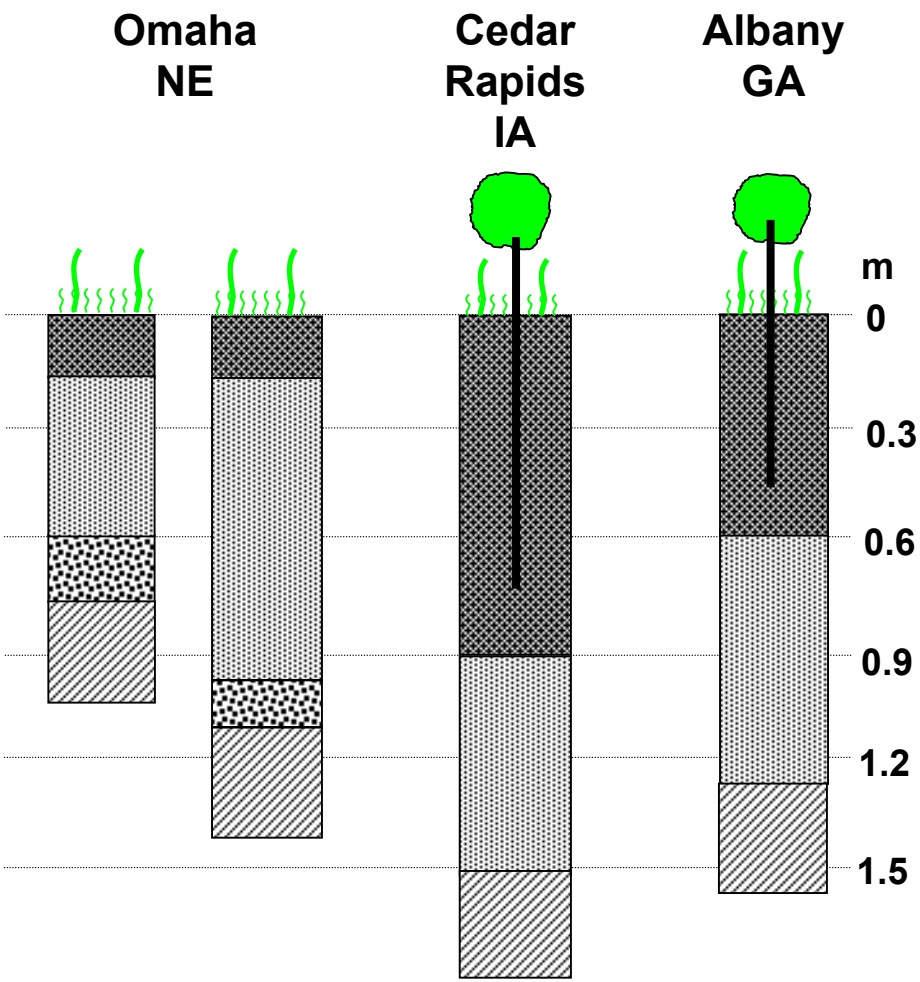
Alternative Cover Performance
Arid/Semi-Arid/Sub-Humid Sites

Monolithic Designs	
Site	**Percolation (mm/yr)**
Altamont CA	1.5 (0.4%)
Apple Valley CA	0 (0%)
Boardman OR (1220 mm)	0 (0%)
Boardman OR (1840 mm)	0 (0%)
Sacramento CA (1080 mm)	27 (7.4%)
Sacramento CA (2450 mm)	2.2 (0.6%)

Capillary Barrier Designs	
Site	**Percolation (mm/yr)**
Helena MT	0 (0%)
Polson MT	0 (0%)
Marina CA	52 (16.5%)
Monticello UT	0 (0%)

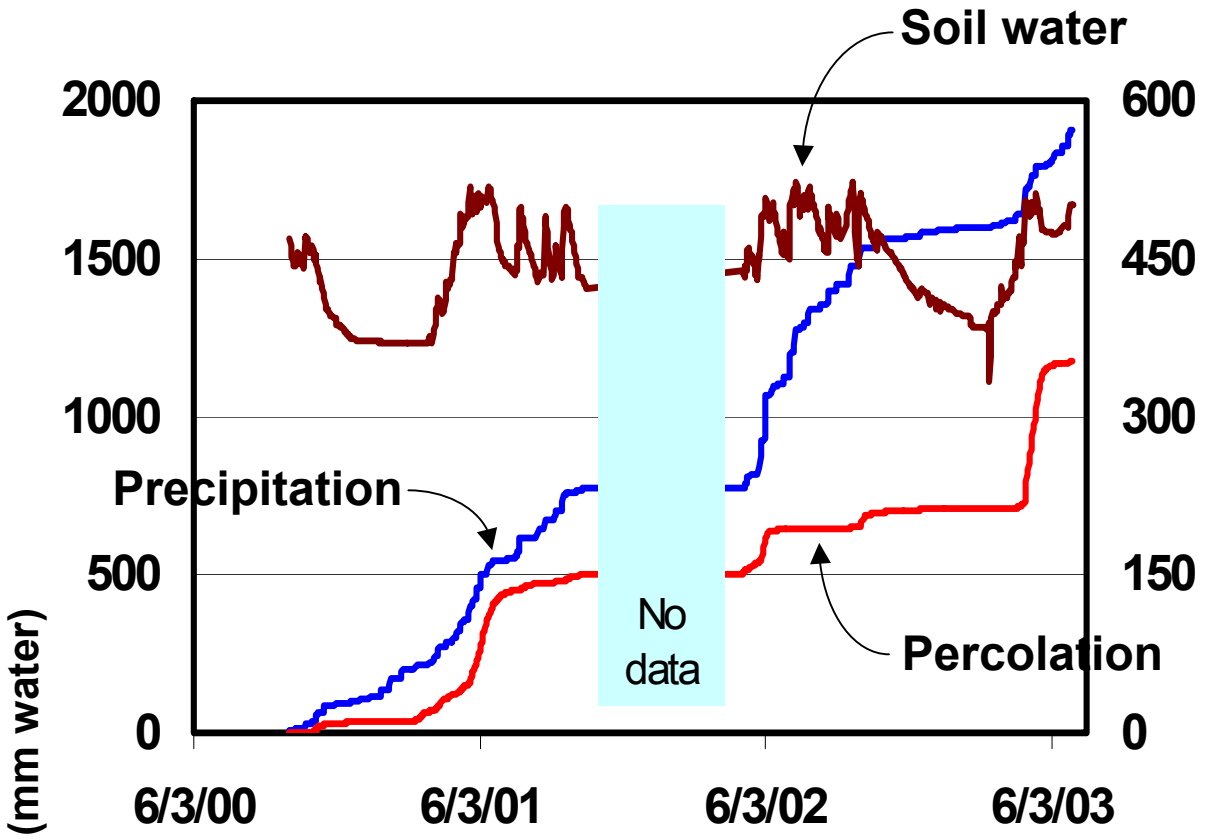
(% = percent of precipitation)

Alternative Designs: Humid Locations



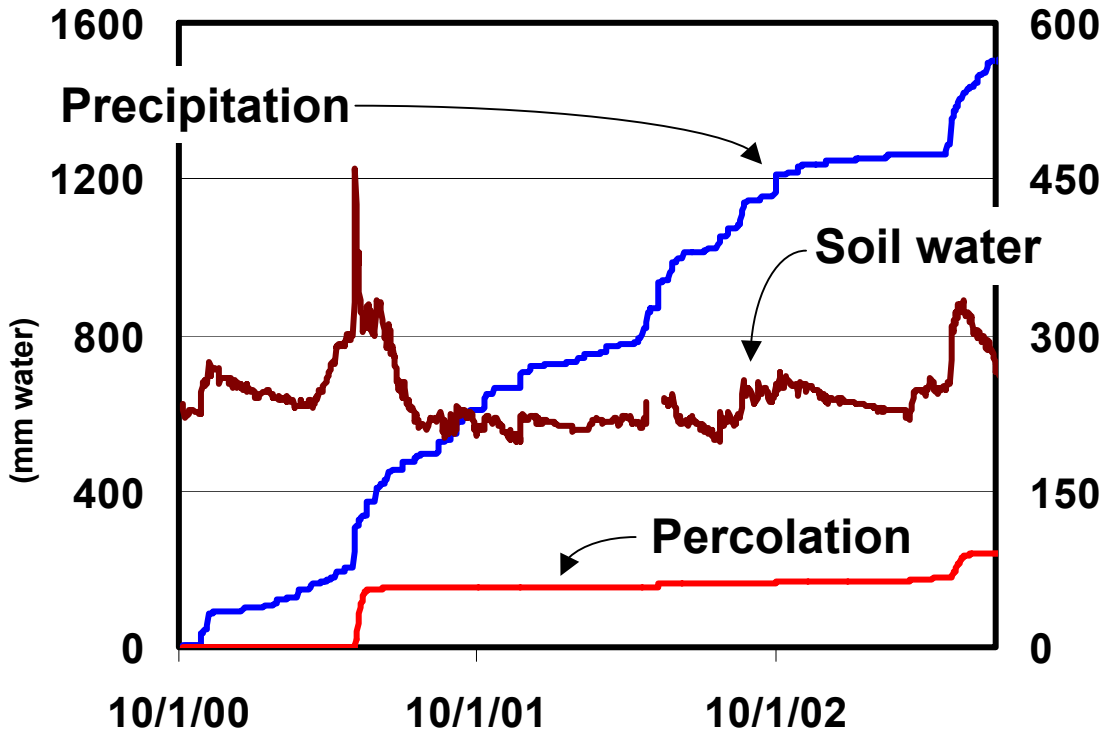
Water Balance Components
Alternative Cover, Cedar Rapids IA

- High precipitation
- Extended periods when precipitation > ET
- Probably exceeds capacity of soil/plant system to achieve low percolation rates



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



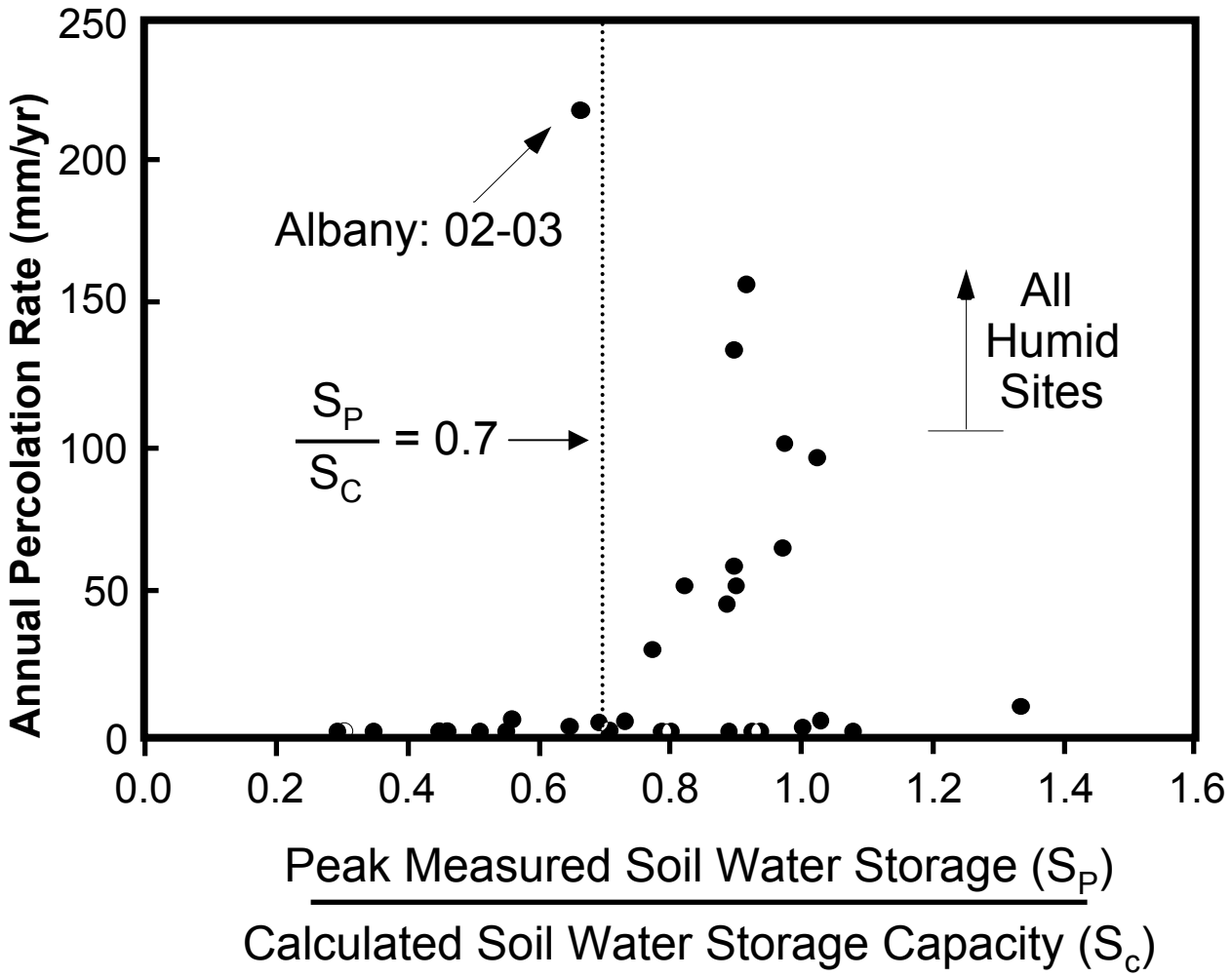
Alternative Cover Performance
Humid Locations

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%)

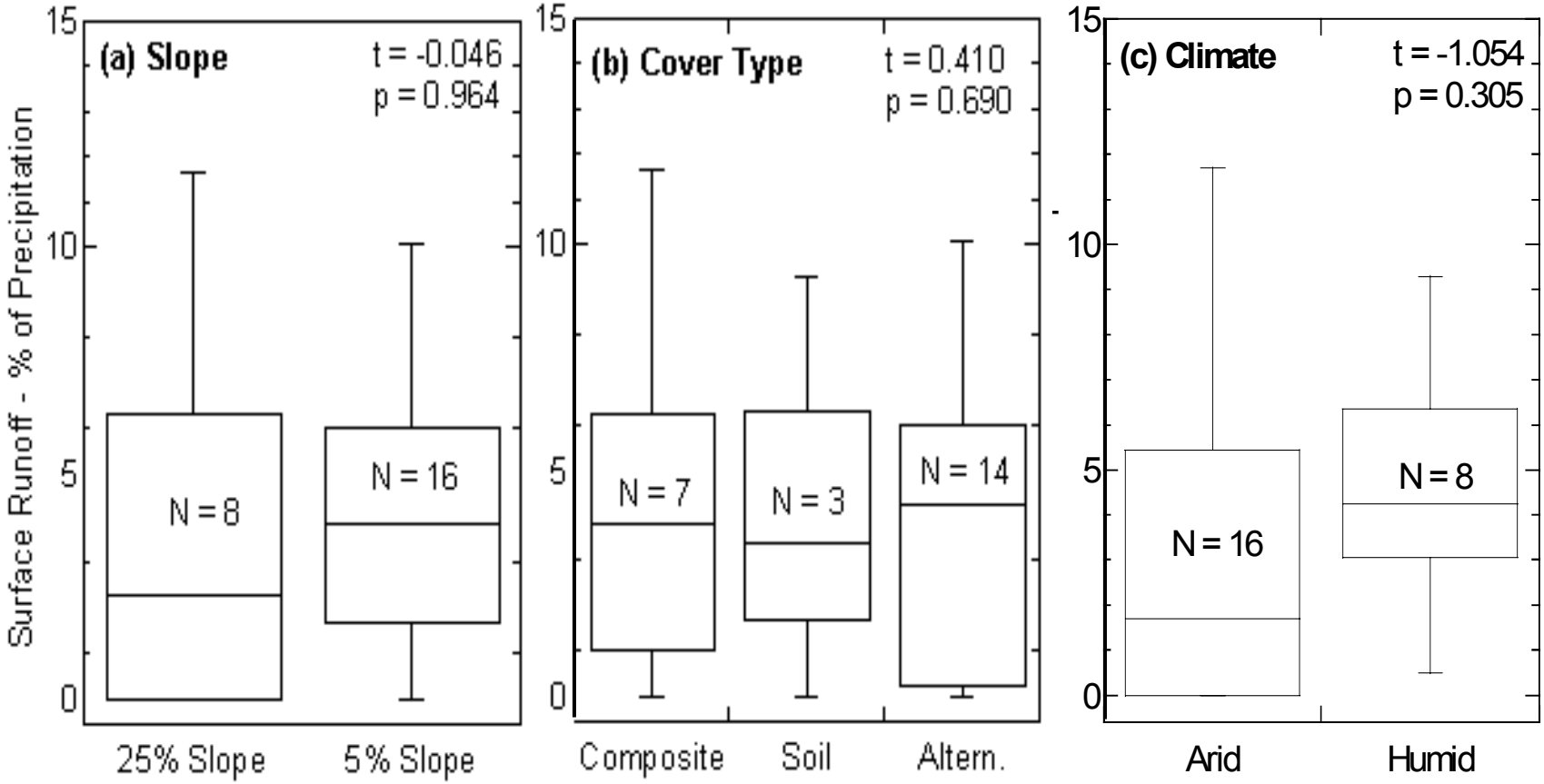
(% = percent of precipitation)

Effective vs Calculated Water Storage Capacity

- Differences between calculated and observed storage capacity
- Preferential flow may account for some unexpected flow
- May be basis for factor-of-safety decisions

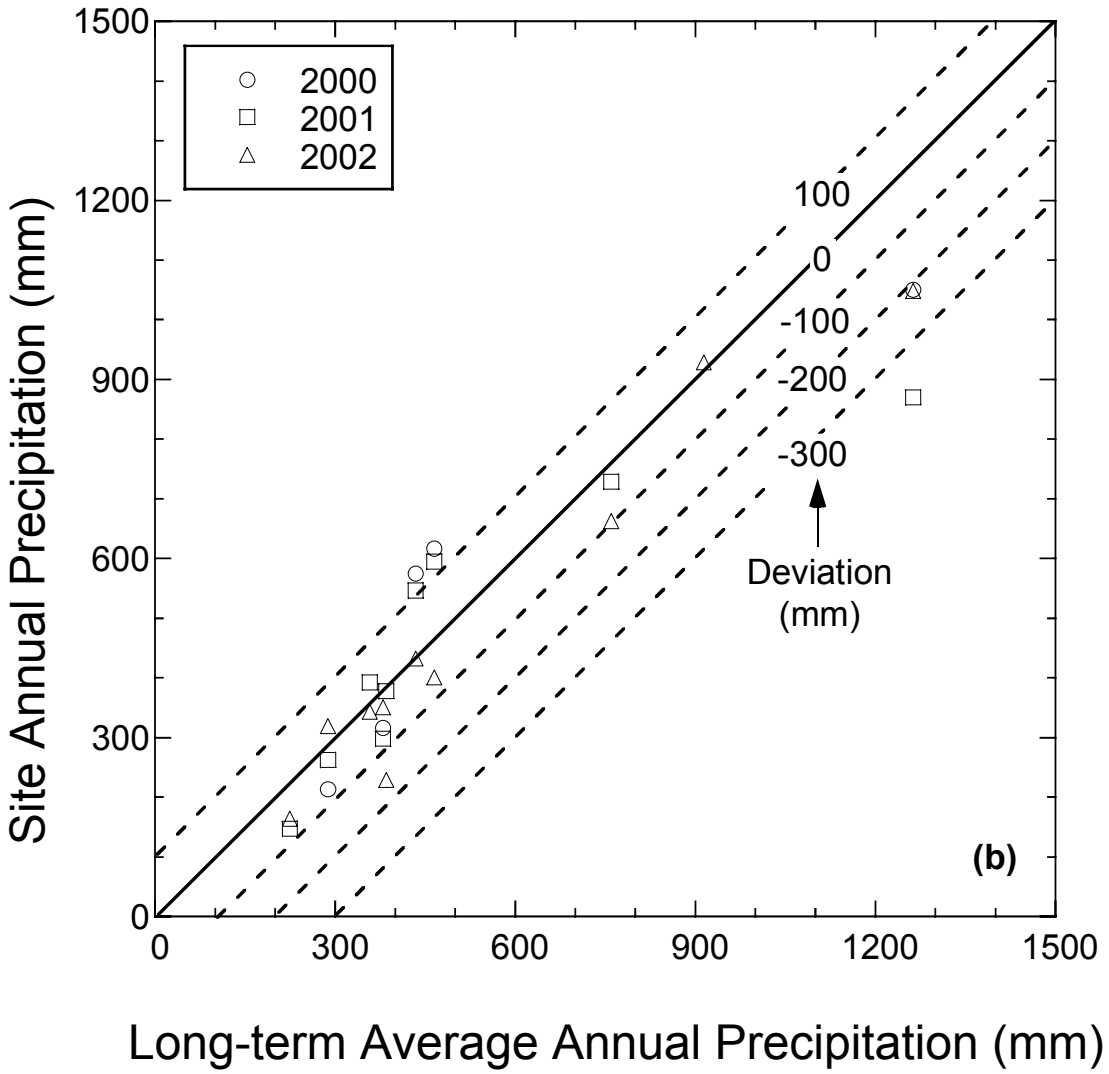


Surface Runoff



Precipitation During Test Period

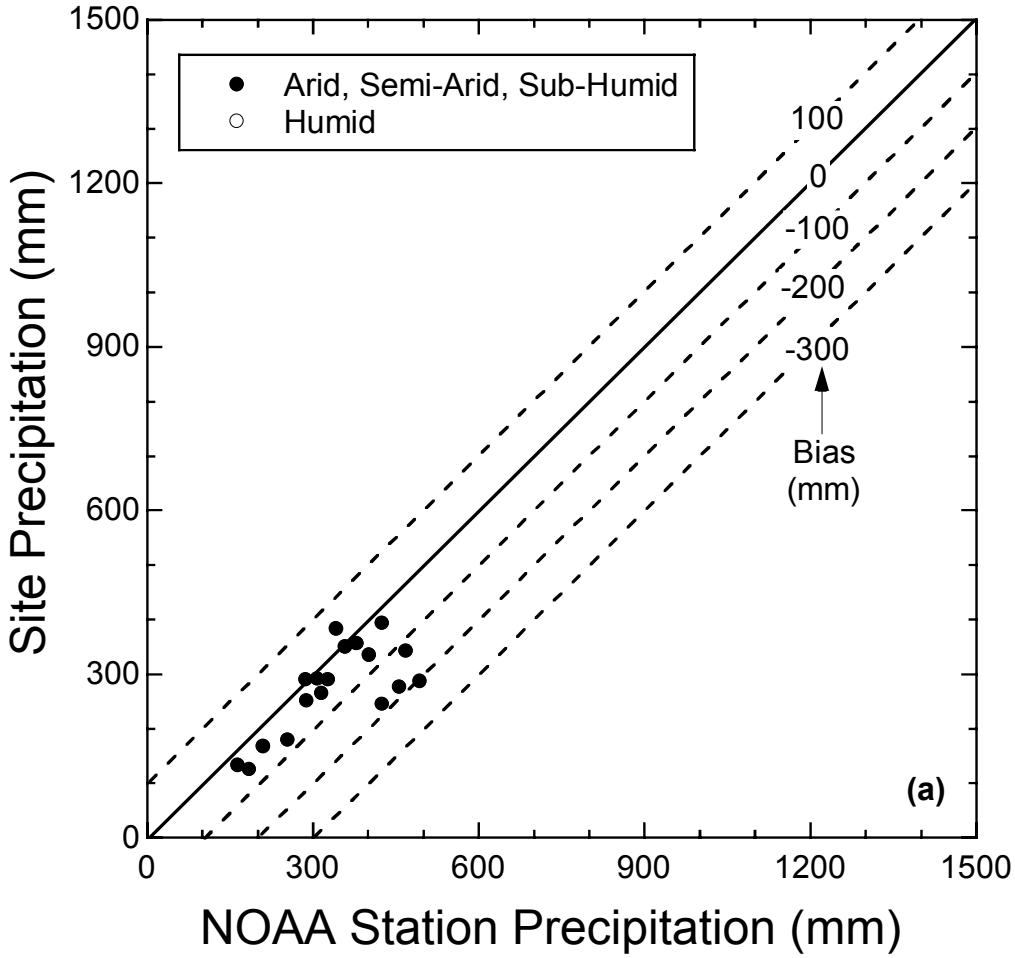
- Arid/semi-arid/sub-humid sites “typical”
  - Median % bias -5%
  - Range +42, -39 %
- Humid locations somewhat below normal
  - Median % bias -14%
  - Range +1, -36 %



Precipitation
Comparison of ACAP Site to NOAA Data

ACAP site precipitation data
- Range: +76, -247 mm
- Most 0 - 100 mm below NOAA station data

- Reasons
  - Spatial variability
  - No shielding on gauges
  - Location on test sections



Alternative Designs
Discussion

- Very low (<2mm/yr) percolation rates at 7 of 10 covers at arid/semi-arid/sub-humid locations
  - Annual variation in transpiration capacity at Sacramento CA cause of anomalous behavior
  - Insufficient soil water storage capacity at Marina CA
- Higher (33-160 mm/yr) percolation rates at humid locations.
- Preliminary calculations of water holding capacity can underestimate apparent capacity by 0-25%
- Successful design requires careful attention to:
  - Site characterization
  - Water balance mechanisms

Future Directions

- Observation is a step toward understanding
- Design tools require additional understanding of important mechanisms
  - Some covers very predictable
  - Others retain some mystery
- Need model improvement
- Much to be gained from destructive sampling of the ACAP covers
  - Understanding as-built vs as-is conditions
  - Short-term pedogenesis
  - Plant community characteristics