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Validating the Performance Assessment: Hydrologic Monitoring of the Water Balance (ET) Final Cover at the Monticello Uranium Mill Tailings Disposal Site

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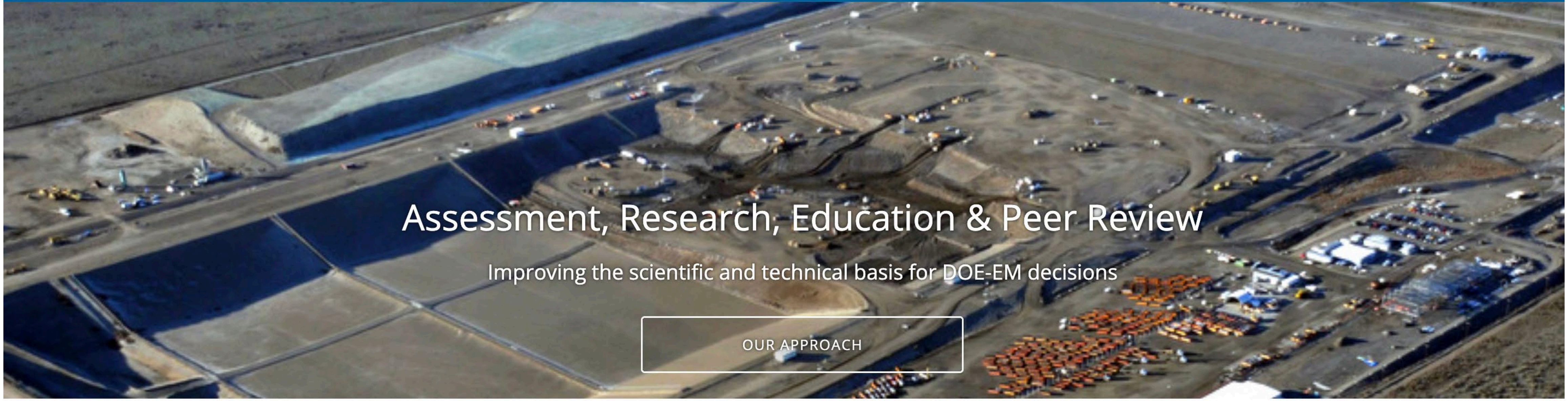
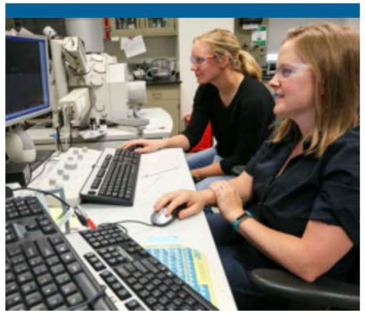


FEATURED

PEOPLE & ORGANIZATION

MARK YOUR CALENDARS!



EARLY CAREER PROGRAM

REVIEWS & REPORTS

INTERAGENCY PERFORMANCE & RISK ASSESSMENT COMMUNITY OF PRACTICE QUARTERLY MEETING

JUNE 18

1:00-2:30 PM ET

ALTERNATIVE DESIGN AND STABILIZATION CONCEPTS WITH GEOMORPHIC CONTOURING

Hosted by: U.S. DEPARTMENT *of* ENERGY

SPEAKER: MELVIN H. YAZZIE
LEGACY MANAGEMENT SUPPORT-RSI EnTech, LLC

TEAMS MEETING ID: 233 891 536 189

PASSCODE: kU96TK37

Collaborators:

- **Jody Waugh**, DOE-Legacy Management (ret.)
- **Bill Albright**, Desert Research Institute (ret.)
- **Preecha Apiwantragoon**, Chulachomklao Royal Military Academy
- **Aaron Tigar**, DOE-Legacy Management
- **David Holbrook**, DOE-Legacy Management

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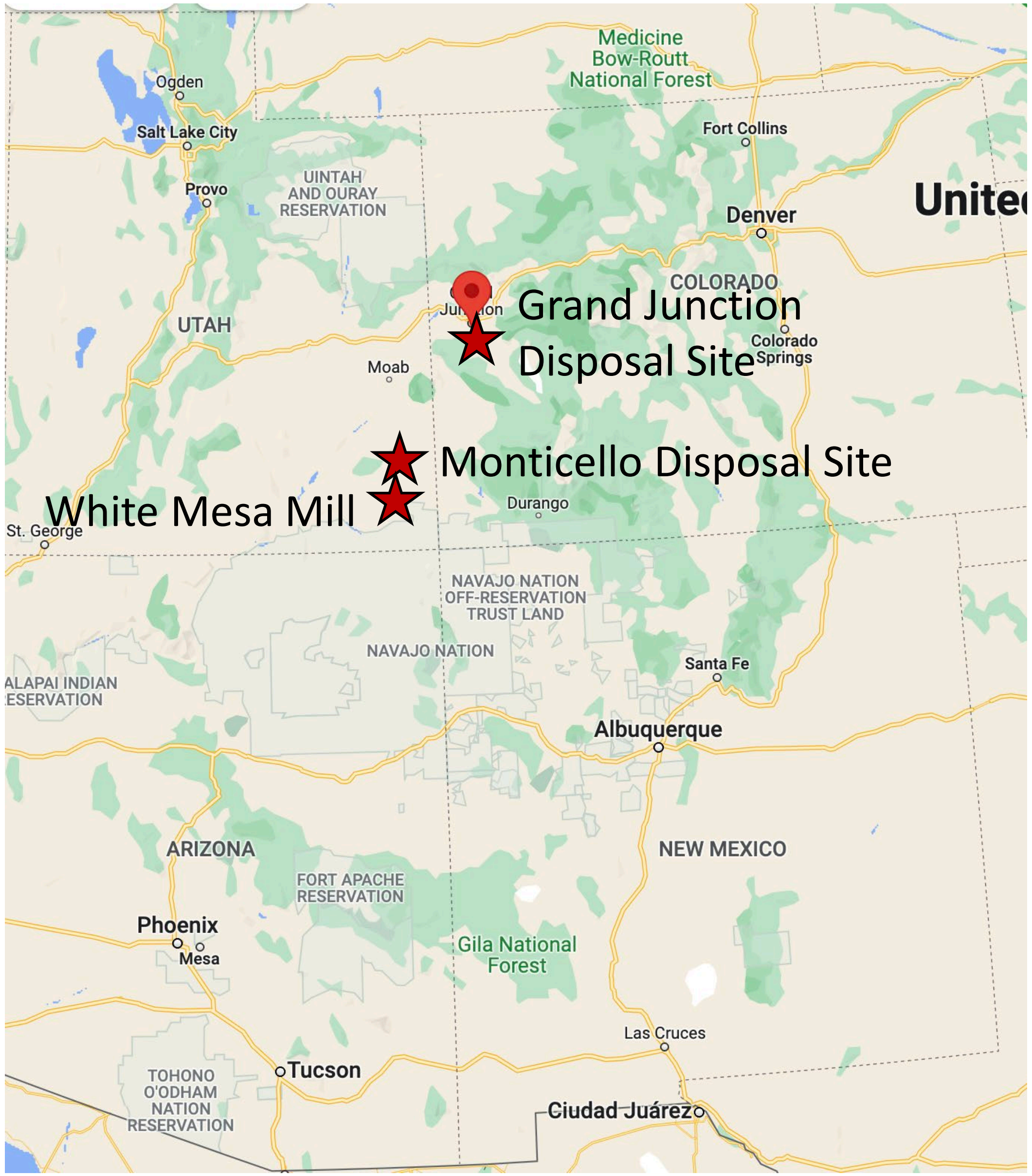
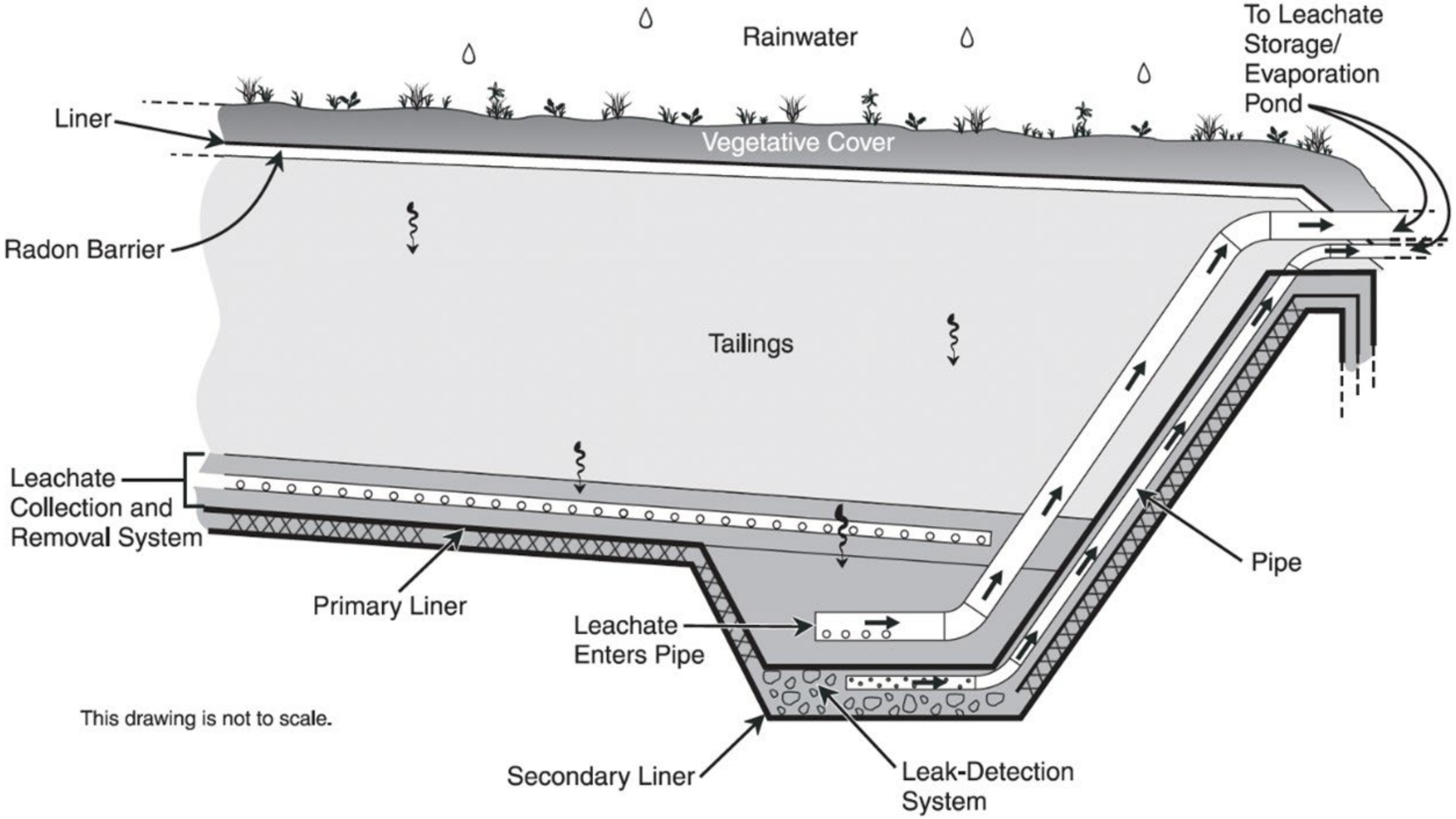
Cover Evaluation in the Colorado Plateau

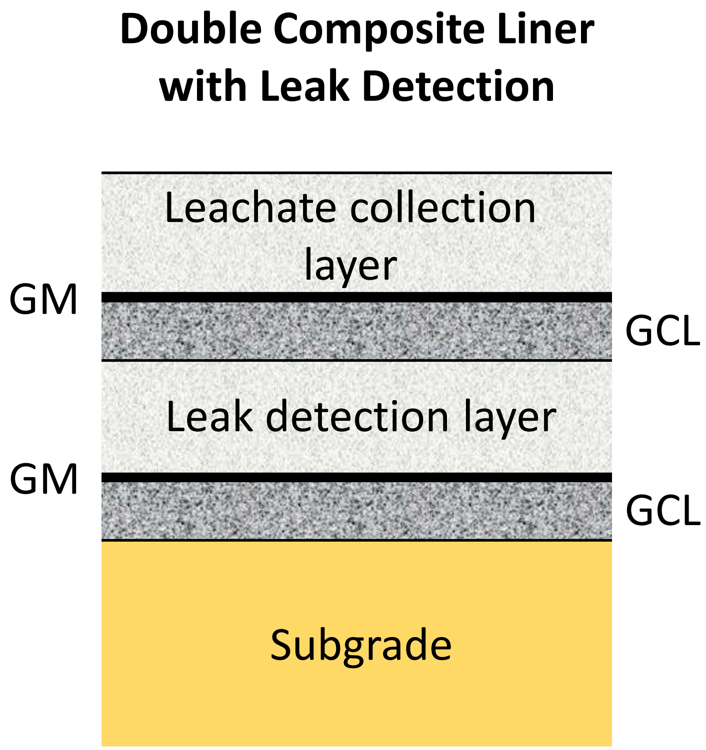


- Three U tailings disposal facilities on the Colorado Plateau – two DOE (GJDS, Monticello) and one commercial (White Mesa)
- Very different climates and precipitation. Monticello wettest. Grand Junction and White Mesa much drier.
- Grand Junction uses rock armor cover.
- Monticello and White Mesa use water balance cover with gravel-amended surface layer.


Town of Monticello
191
Disposal Cell Cover
(32 ac, 13 ha)
Lysimeter
7.5 ac (3 ha)
Google Earth
N

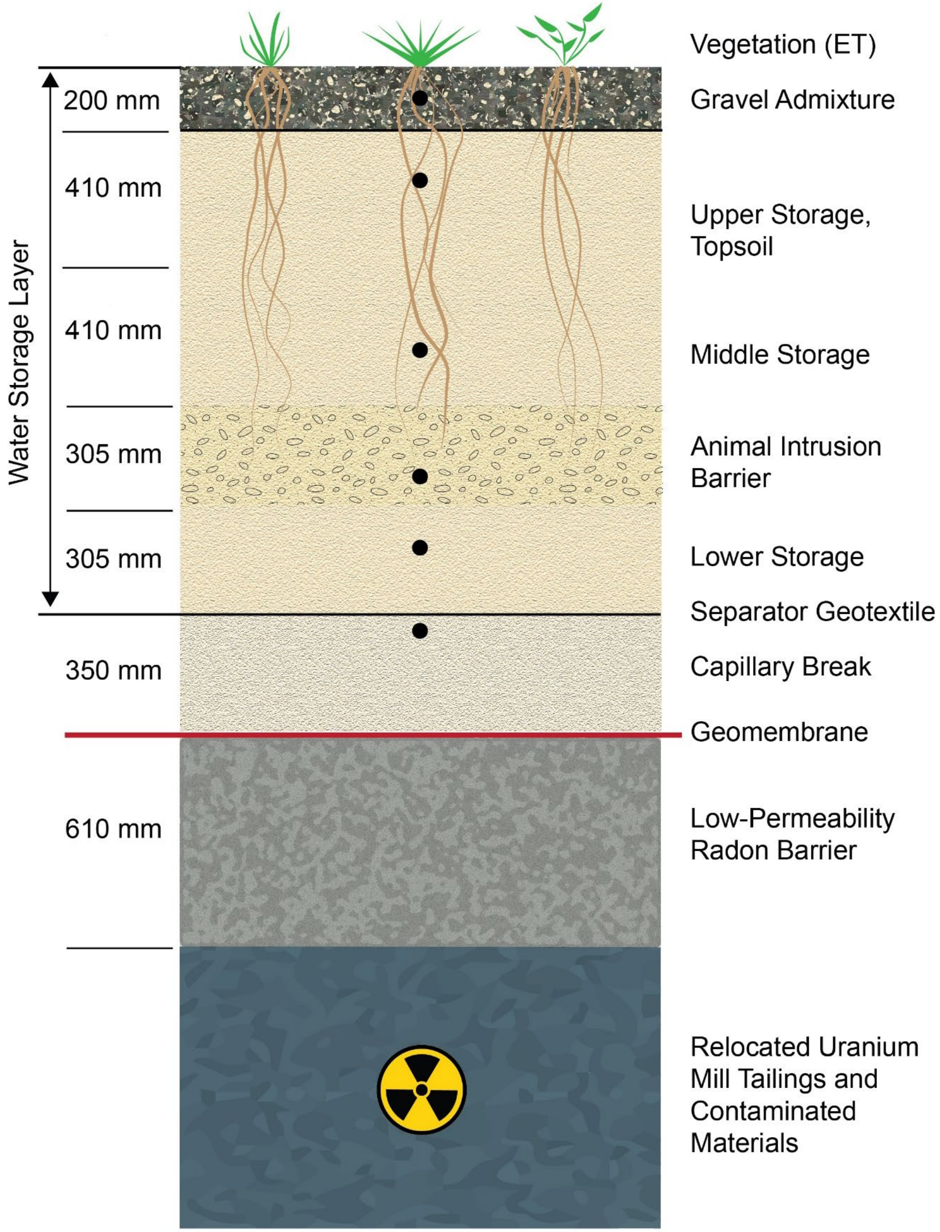
Monticello Disposal Cell





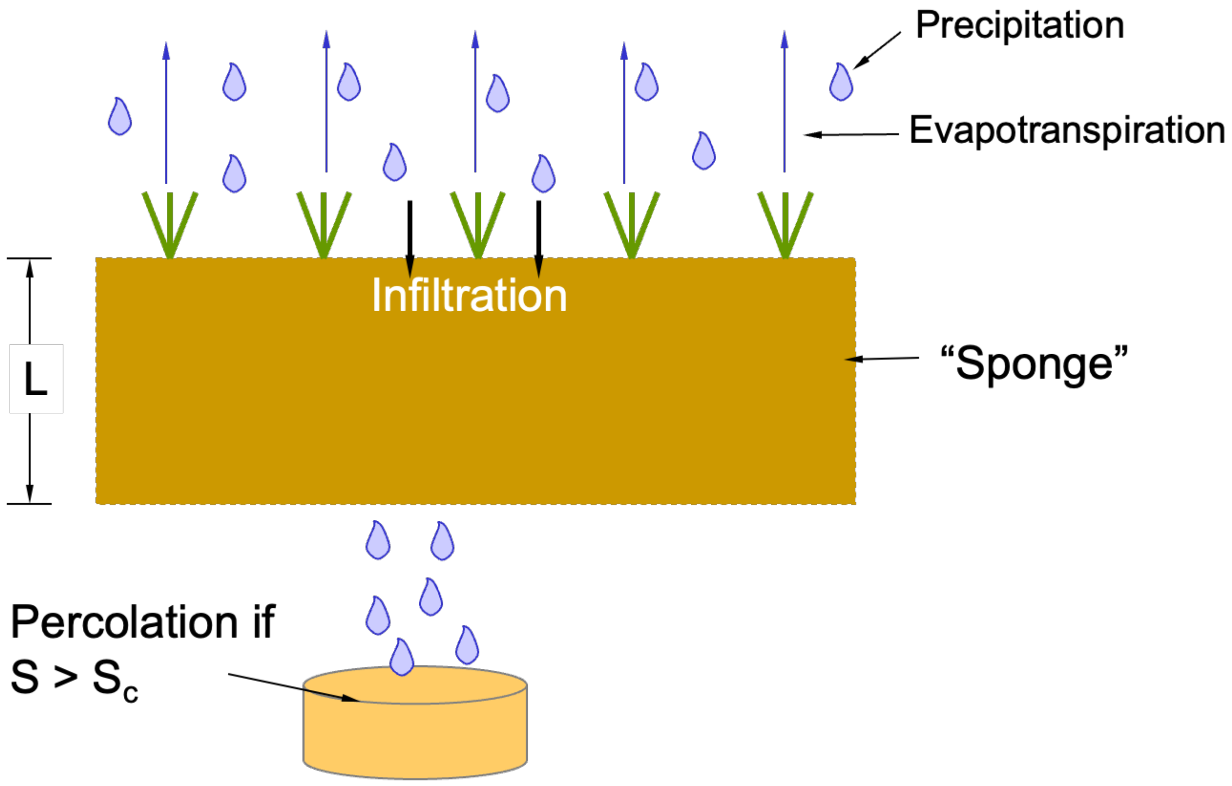
- Double composite-lined disposal facility with leachate collection and leak detection.
- 1.5-mm-thick HDPE geomembrane over geosynthetic clay liner (GCL, ~ 10 mm) for composite liner.
- Water balance cover on surface (*aka* ET cover).

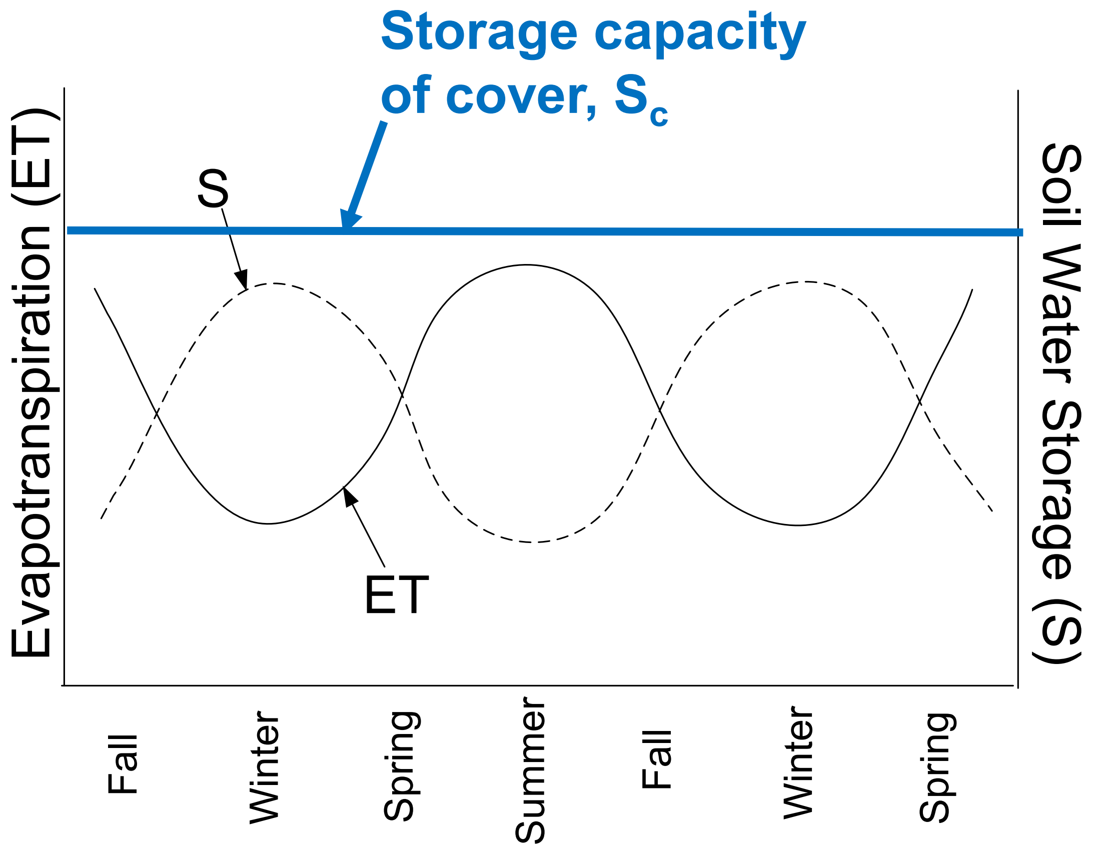
Monticello Water Balance Final Cover



- Water balance cover with 1.8 m thick storage layer and capillary break (sand). **Percolation from base intended < 3 mm/yr.**
- Gravel amended surface layer for erosion control while promoting capillary conduction – desert pavement.
- Biota intrusion layer – cobble with fine alluvium infill. **Prevents animal intrusion, not plant intrusion**.
- Underlain by composite barrier layer comprised of 1.5 mm HDPE geomembrane underlain by 0.6 m thick low-conductivity radon barrier.
- Monitoring August 2000 – December 2022 - **22+ years of data**.

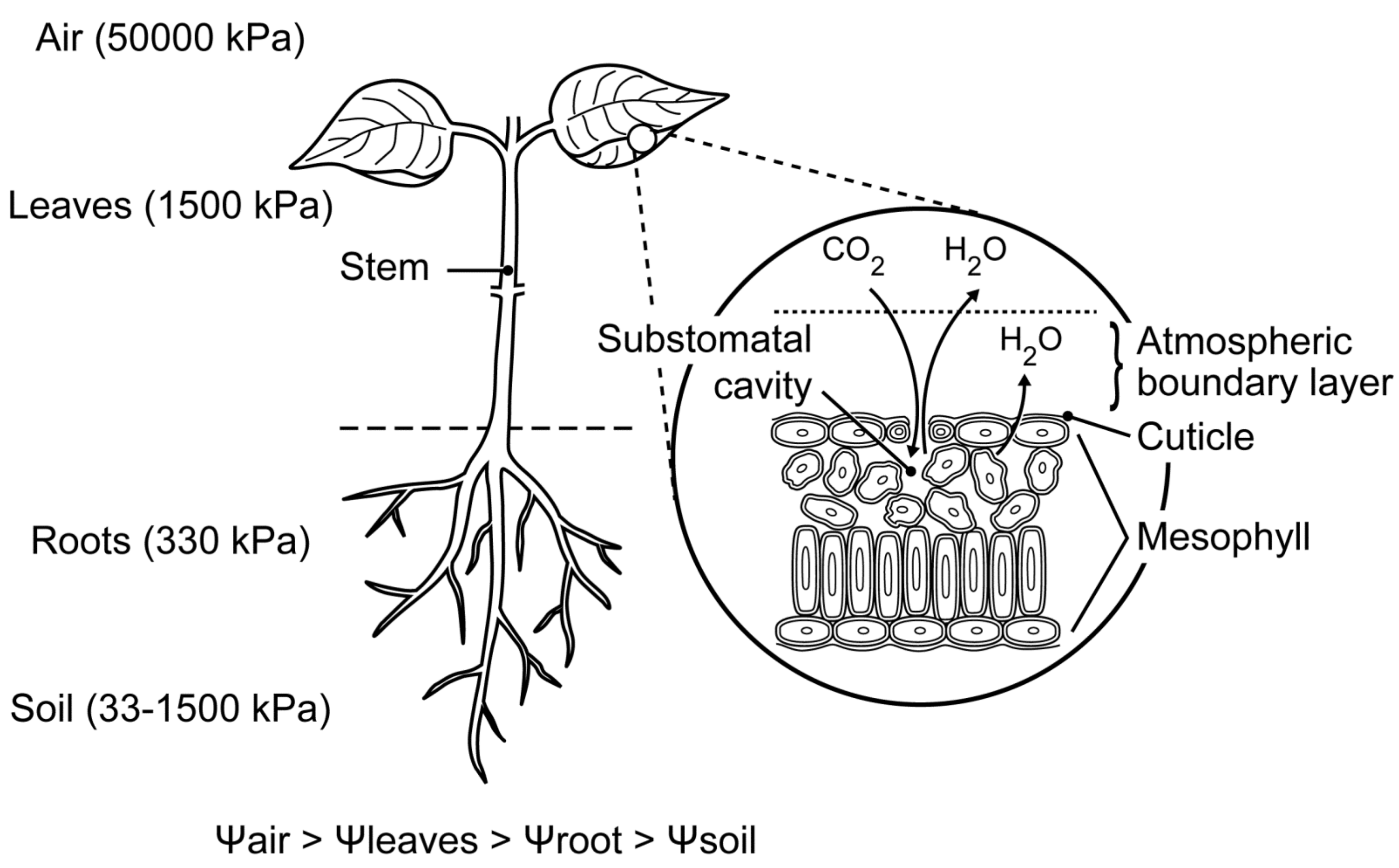
The “Balance” in Water Balance Covers





- Mimicking **natural ecosystem** in semi-arid and arid environments.
- Natural water storage capacity of finer textured soil – behaves like a sponge with fine pores that hold water. Sponge holds water until storage capacity (S_c) is reached.
- Remove stored water by evaporation and transpiration to replenish storage capacity (S_c) of cover.

Evaporation and Transpiration (ET)



- Plants function as **pumps that extract water at various depths** to support production of biomass.
- Diversity of plants in community that **extract water from different depths** in the profile.
- In semi-arid and arid climates, mature plant communities are highly opportunistic and **extract all available water from the profile each water year** (replenish sponge)

PET = potential evapotranspiration = **max ET for given meteorological condition.**

Performance Assessment of the Monticello Mill Tailings Repository

Background

The Monticello Mill Tailings Site is located in southeastern Utah, south of the town of Monticello (see image to the right). The present climate at Monticello is sub-humid, with an average annual precipitation of ~38 cm (15 inches) and an average annual temperature of 7.8 C (46 F). In 1941, the Monticello mill was constructed and used to process nearly a billion kilograms of ore. By 1960, when operations were terminated, approximately 2 million cubic meters of radioactive uranium mill tailings had been left behind from the operations. To contain the mill tailings, DOE began construction of a repository south of the original mill site in 1995, and in 1996 the construction of a composite double- liner system at the base of the repository was completed.

The cover was designed to mitigate the release of radon gas to the surface and to minimize water infiltration to the mill tailings. It consists of a thick topsoil layer with vegetation that can store precipitation and allow evaporation and transpiration via vegetation. This top layer overlies a coarse sand layer that acts as a capillary barrier and is intended to drain any infiltrating water laterally above a high-density polyethylene geomembrane. Beneath the geomembrane is a compacted clay layer that serves as a barrier to radon gas transport and water infiltration. The clay layer rests directly on top of the mill tailings. At the base of the repository beneath the mill tailings is a double composite-liner system composed of sand, two geomembrane liners, two geosynthetic clay-liners, and a transmissive leachate collection system. The entire repository is surrounded by Quaternary deposits consisting of sandy loam, clay, and pediment gravels.

Beneath the repository, two aquifers exist–a perched alluvial aquifer, as close as several meters below

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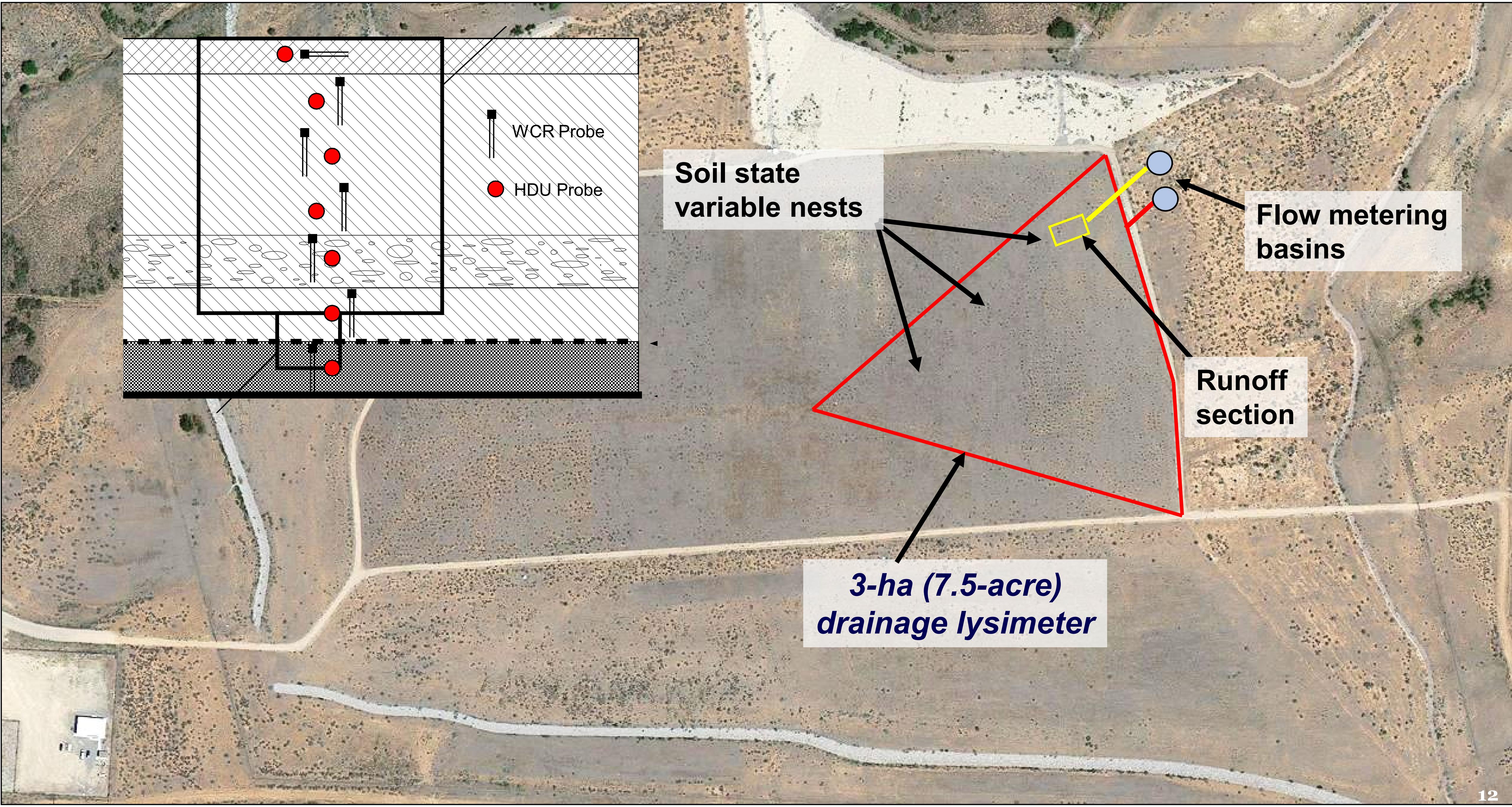
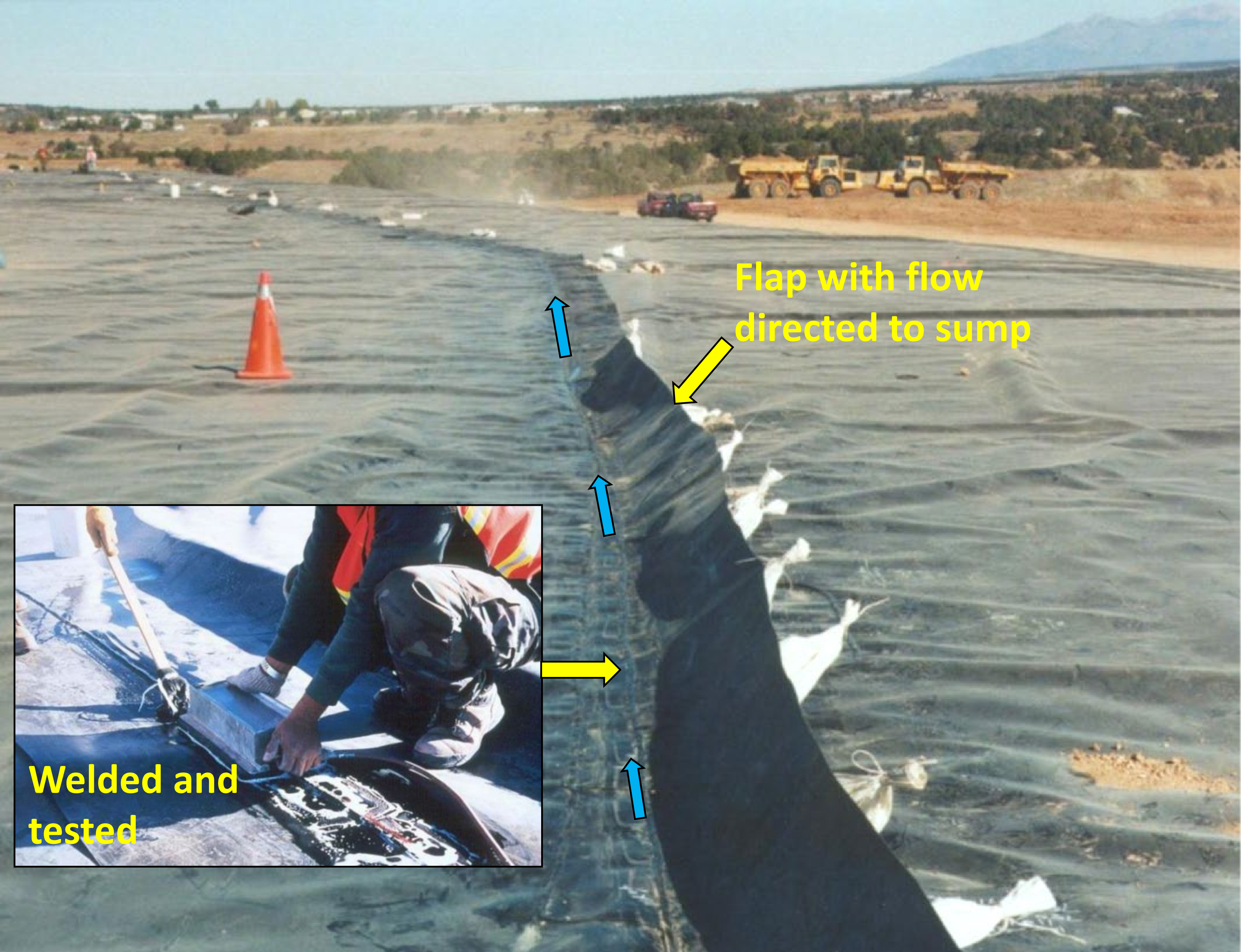
Cover percolation rate < 3 mm/yr

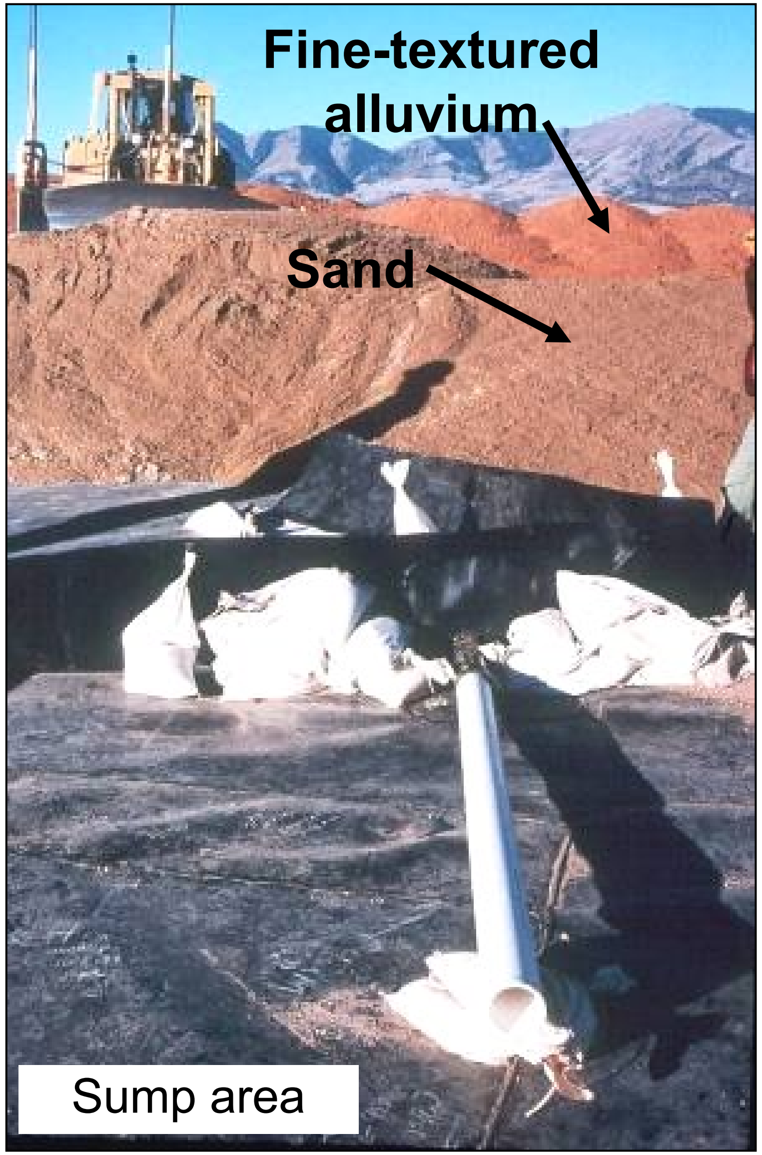


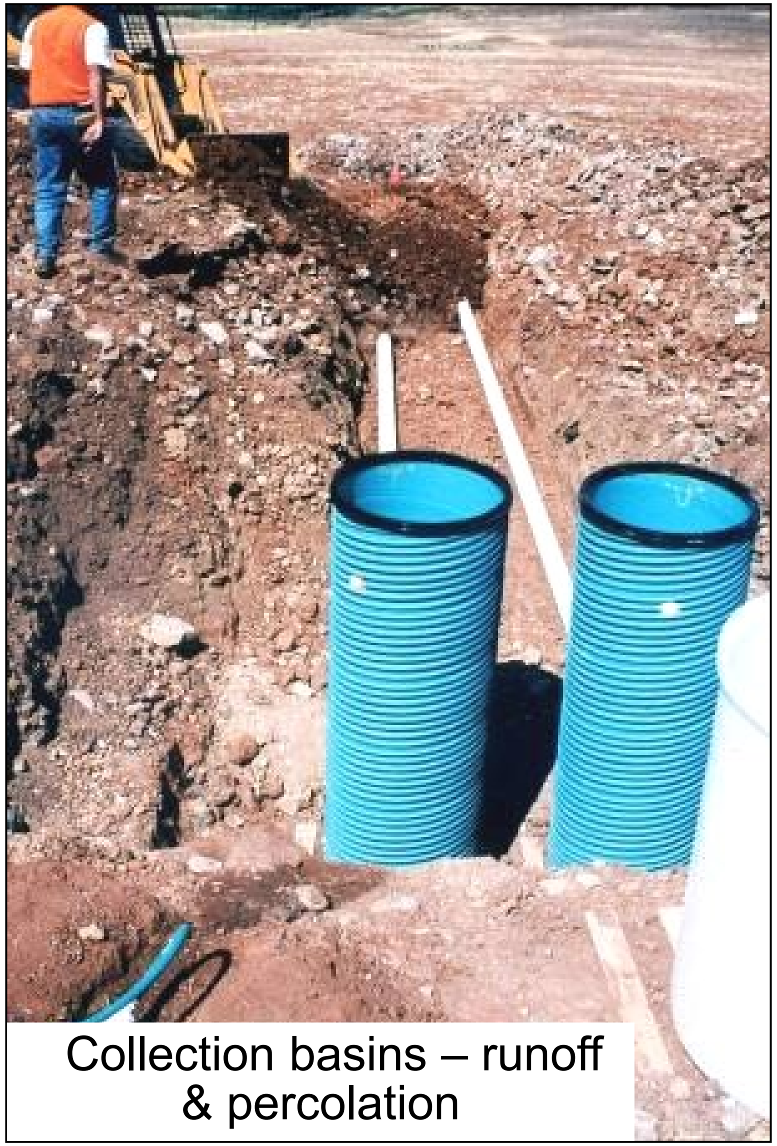
WCR Probe
HDU Probe
Soil state variable nests
Flow metering basins
Runoff section
3-ha (7.5-acre) drainage lysimeter



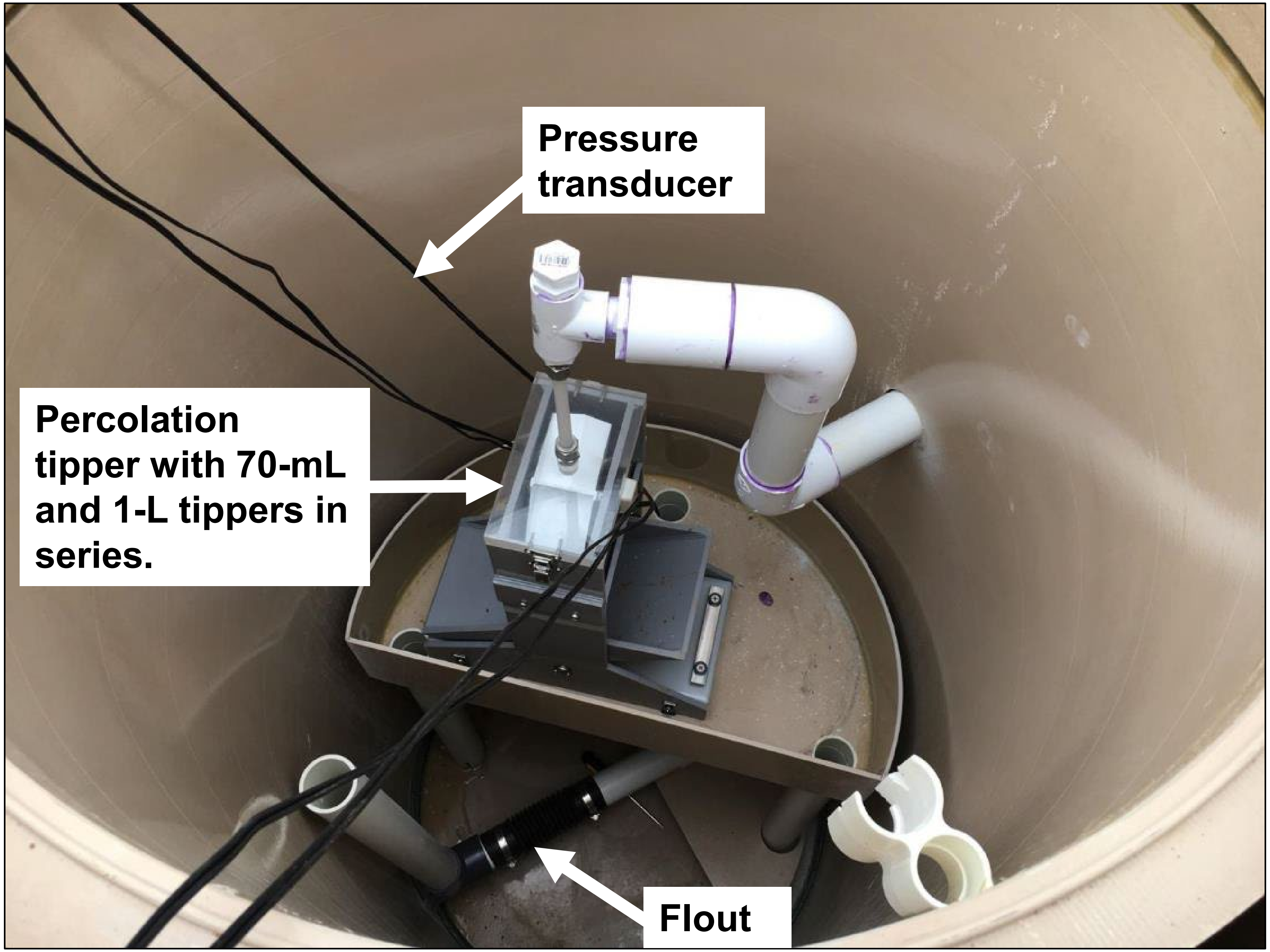
- Perimeter of lysimeter defined by flap welded directly to HDPE geomembrane at base
- Flow directed to collection basin for metering.

Instrumentation for Monitoring Moisture and Flows





Flow Metering Basins



Flout – Floating Outlet


Big sagebrush
Artemisia tridentata
Ts’ahtsoh
Western wheatgrass
Pascopyrum smithii
Tł’oolé

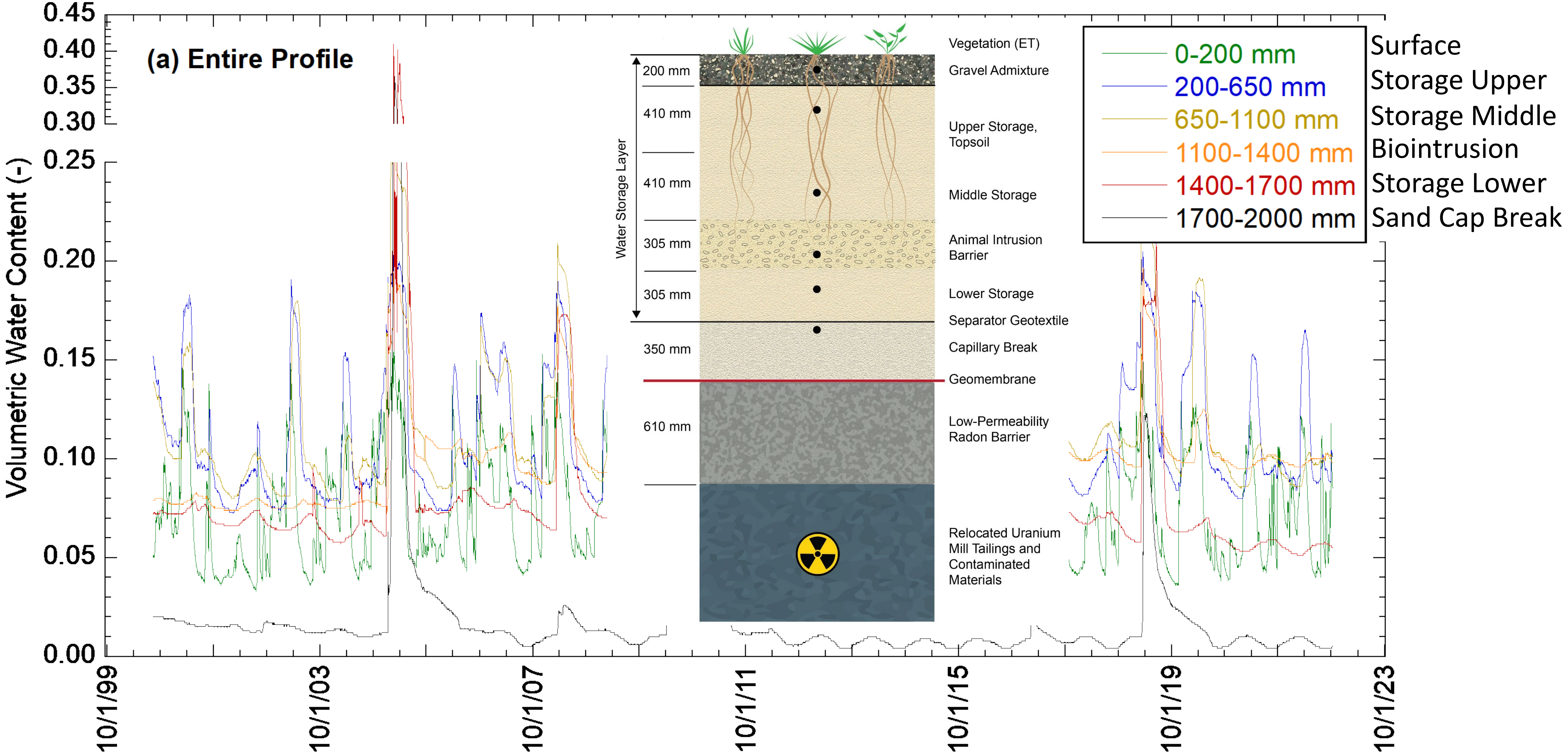
Monticello Water Balance Data

Annual Precipitation and Percolation

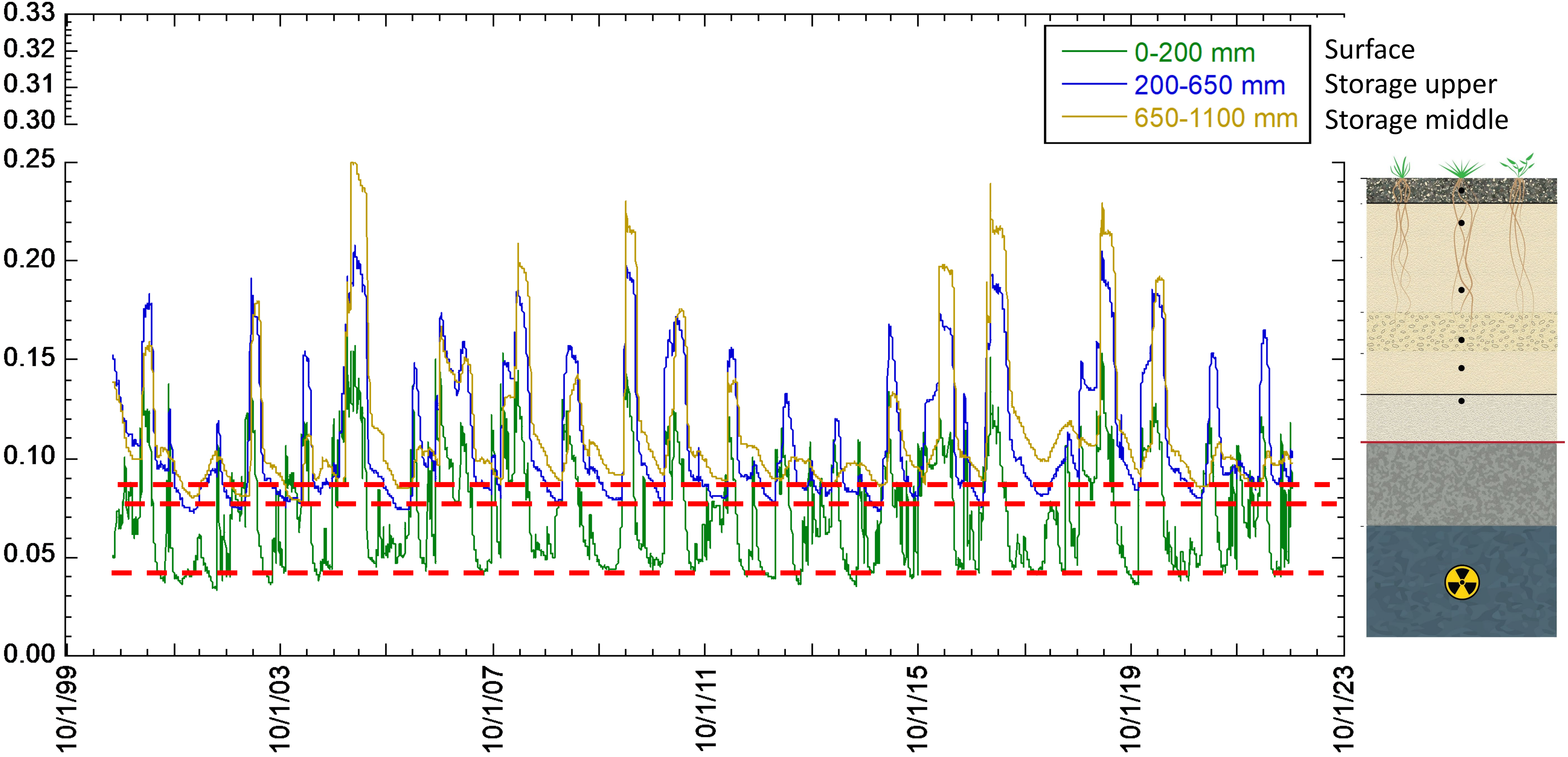
- Five years in record with sufficient moisture accumulation to transmit percolation.
- Three years had sufficient moisture for percolation to carry over into the following water year.

Water Year = **October 1- September 30** – consistent with natural water cycle in desert southwestern US.

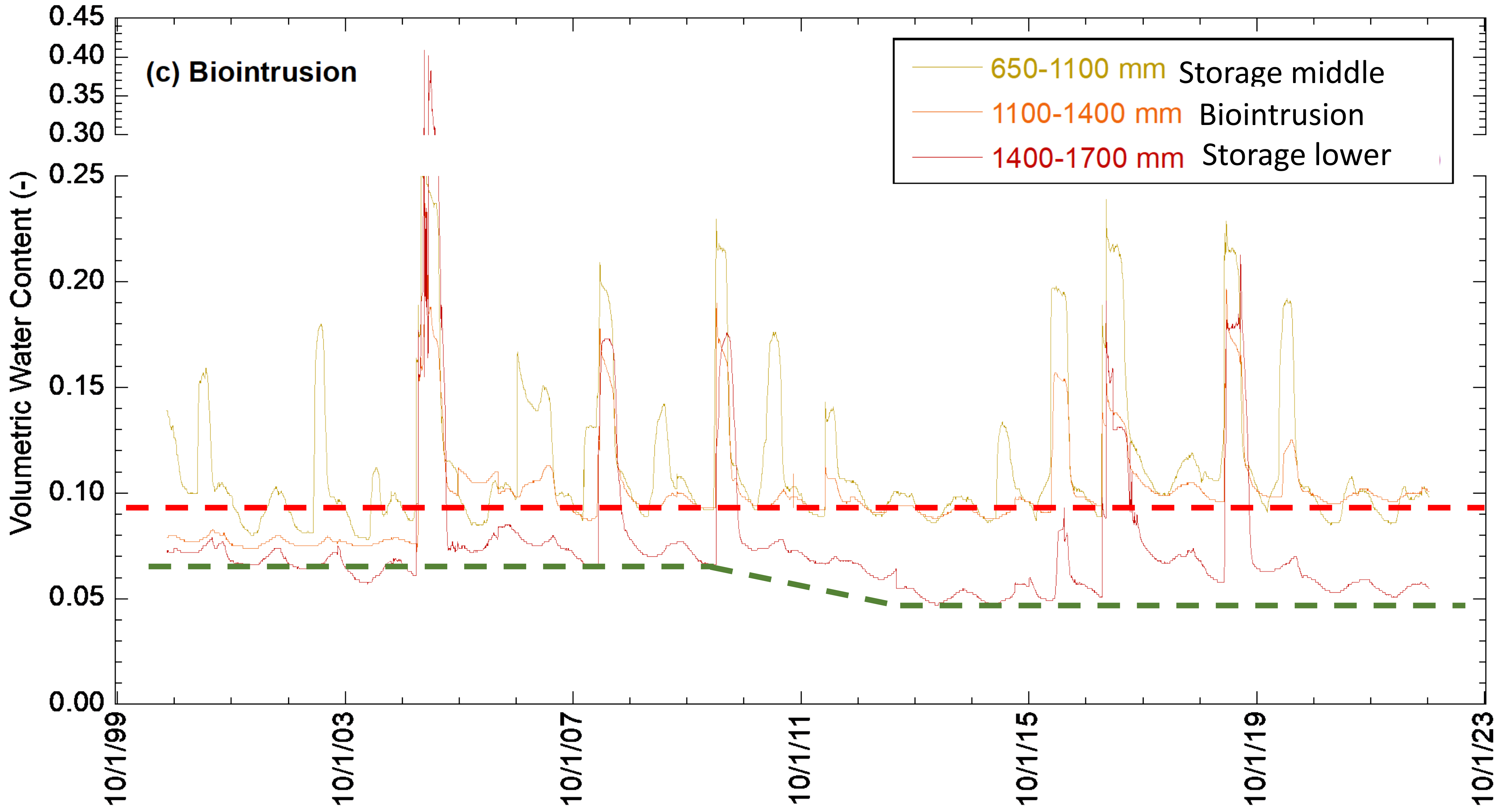
Monticello Water Content Record

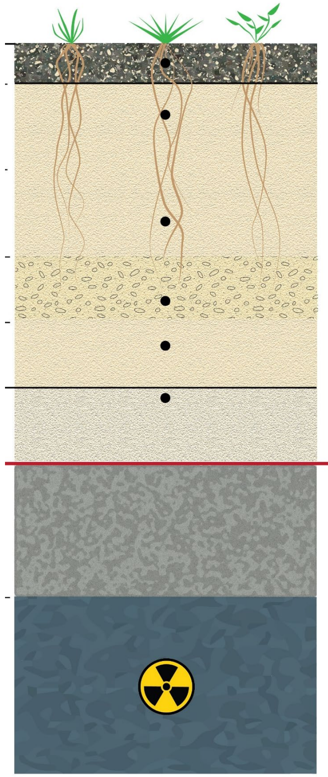


Monticello Water Content – Upper Profile

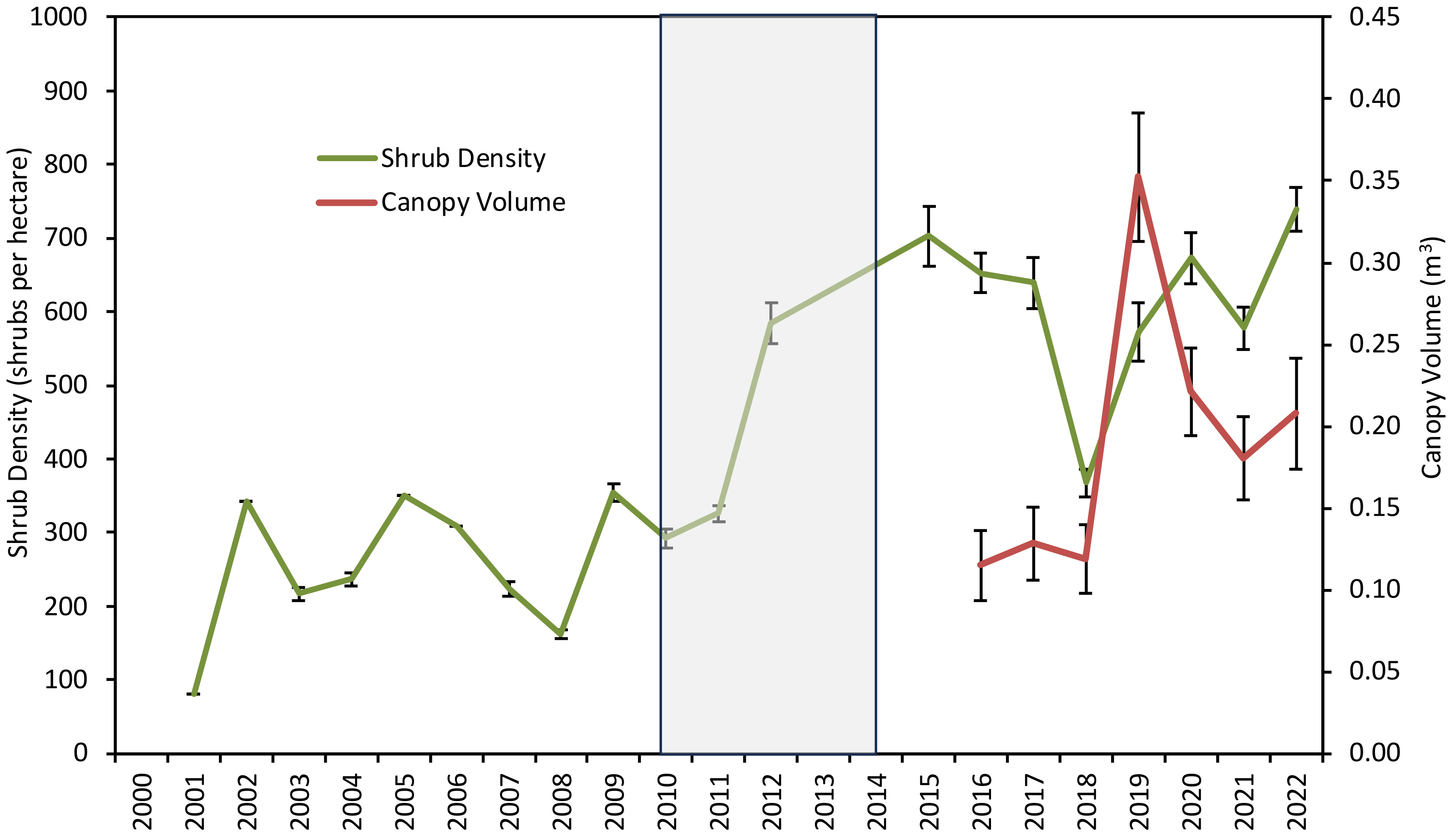


Monticello Water Content – Deeper in Profile



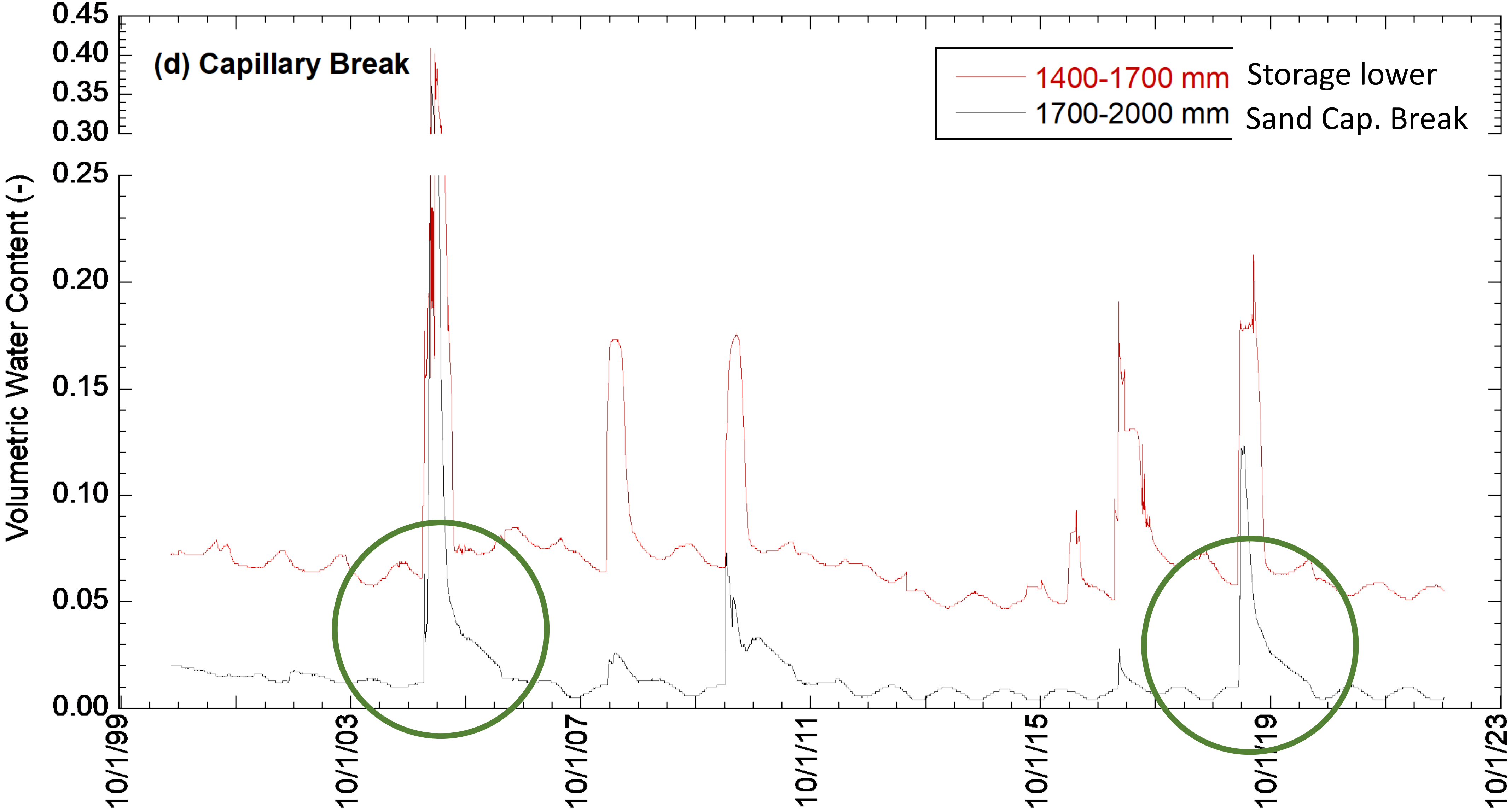


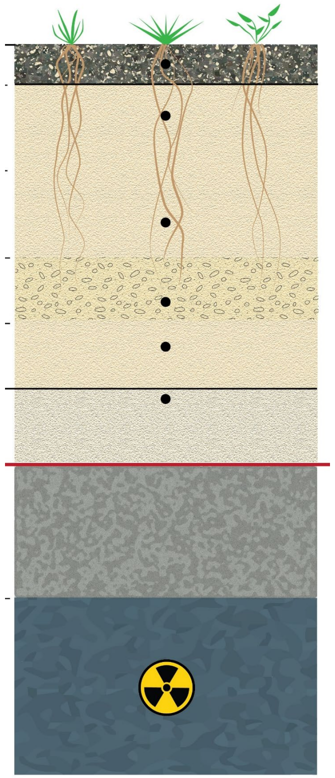
Impact of Deep-Rooted Shrubs on Hydrology



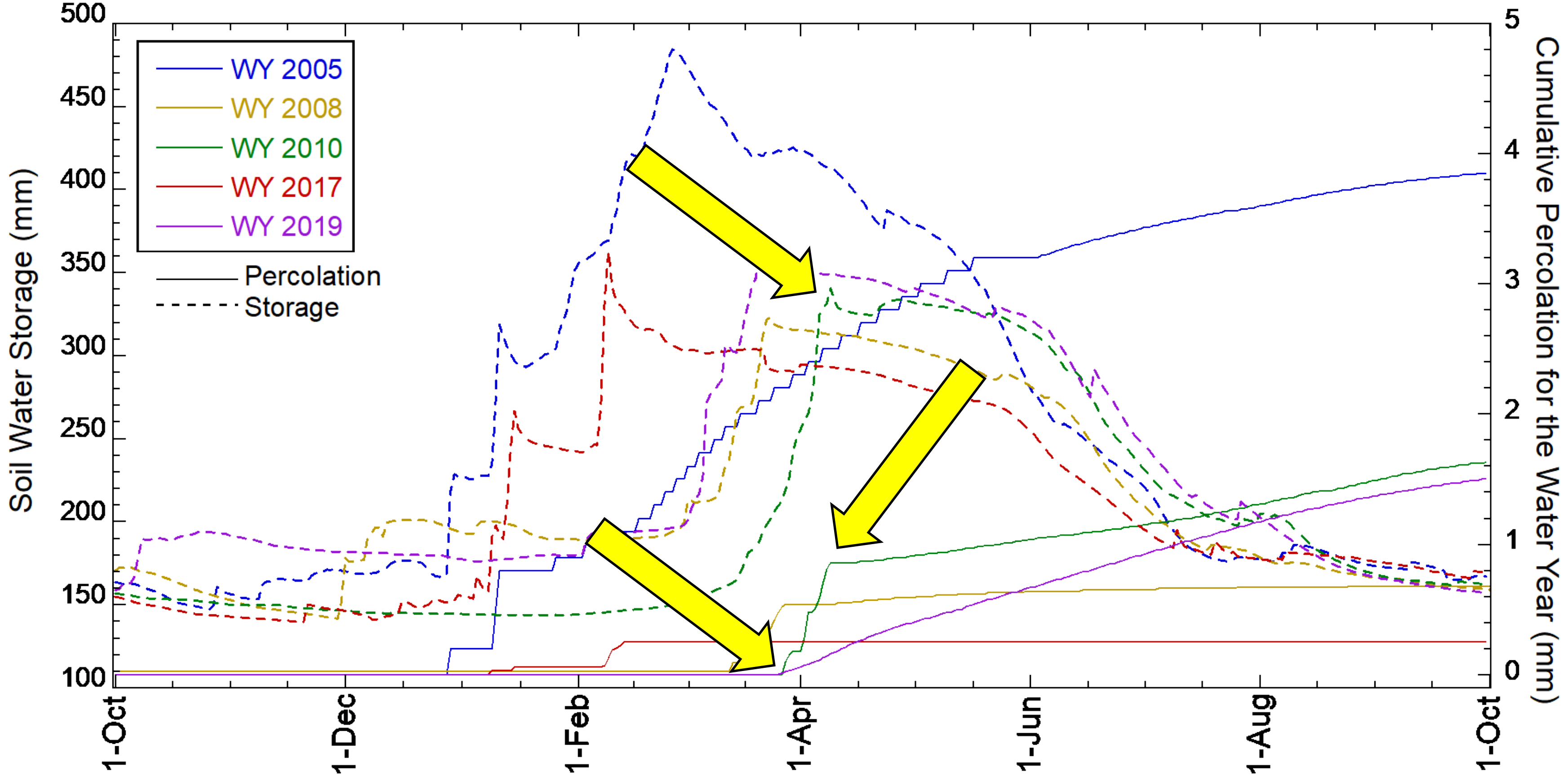
- Increased density of deep-rooted shrubs from 2010 – 2014 provides greater removal of water deep in profile.
- Reduced water contents in lower storage layer, providing cover with additional storage capacity.
- Lower percolation rates afterwards despite wettest year in the record.

Monticello Water Content – Capillary Break





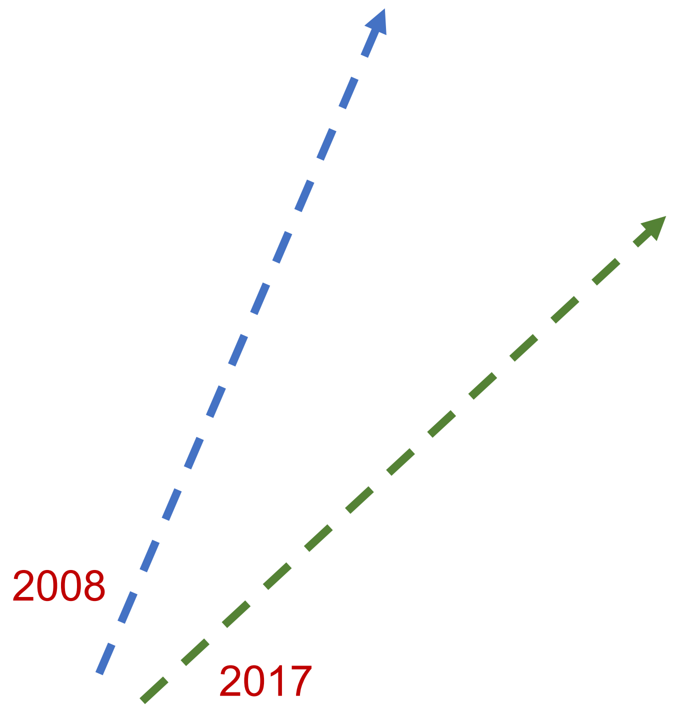
Soil Water Storage and Percolation



Nearly all stored water returned as ET.
Tiny fraction is percolation

- Accumulation of water results in initial slug of percolation.
- Followed by slow drain-down of stored water, long period of percolation tailing.
- Percolation tailing extends into following water year for wetter years.
- Timing influences tailing. Earlier storage – less tailing.

Percolation and Precipitation



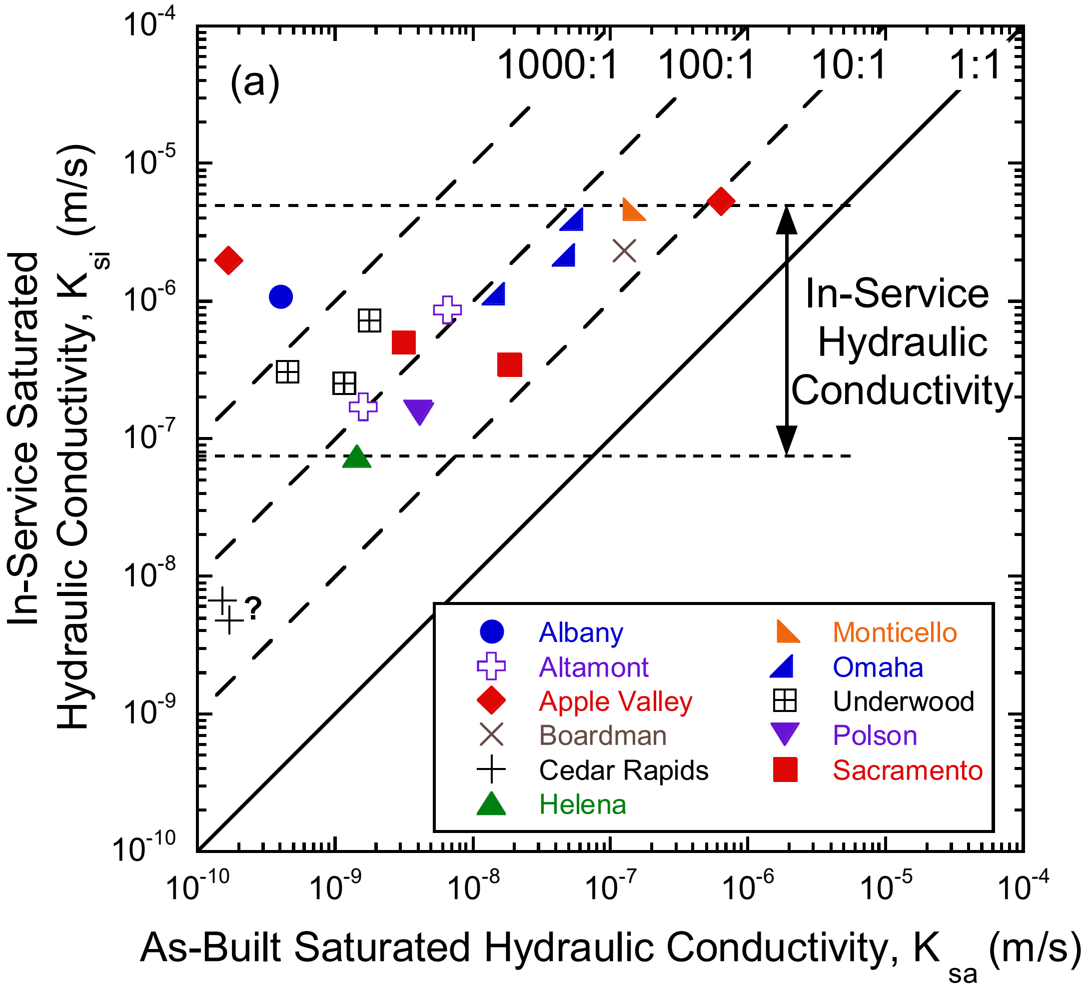
- One year exceeds performance goal of 3 mm/yr.
- Average annual percolation rate = **0.4 mm/yr**.
- Percolation increases as Fall-Winter precipitation increases, but no firm relationship.
- Timing and type of precipitation as important as magnitude.

In-Service vs. As-Built Hydraulic Properties

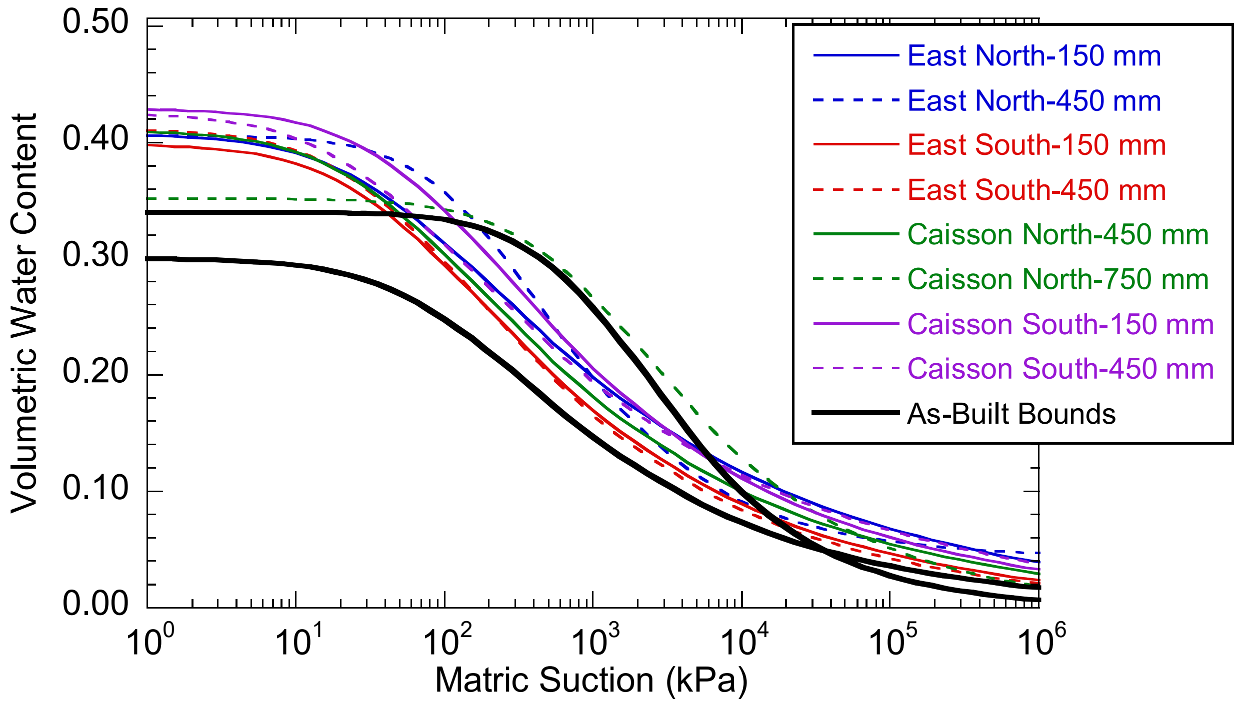
Two-Stage Borehole Tests

Large-Scale Block Sample

In-Service vs. As-Built Hydraulic Properties

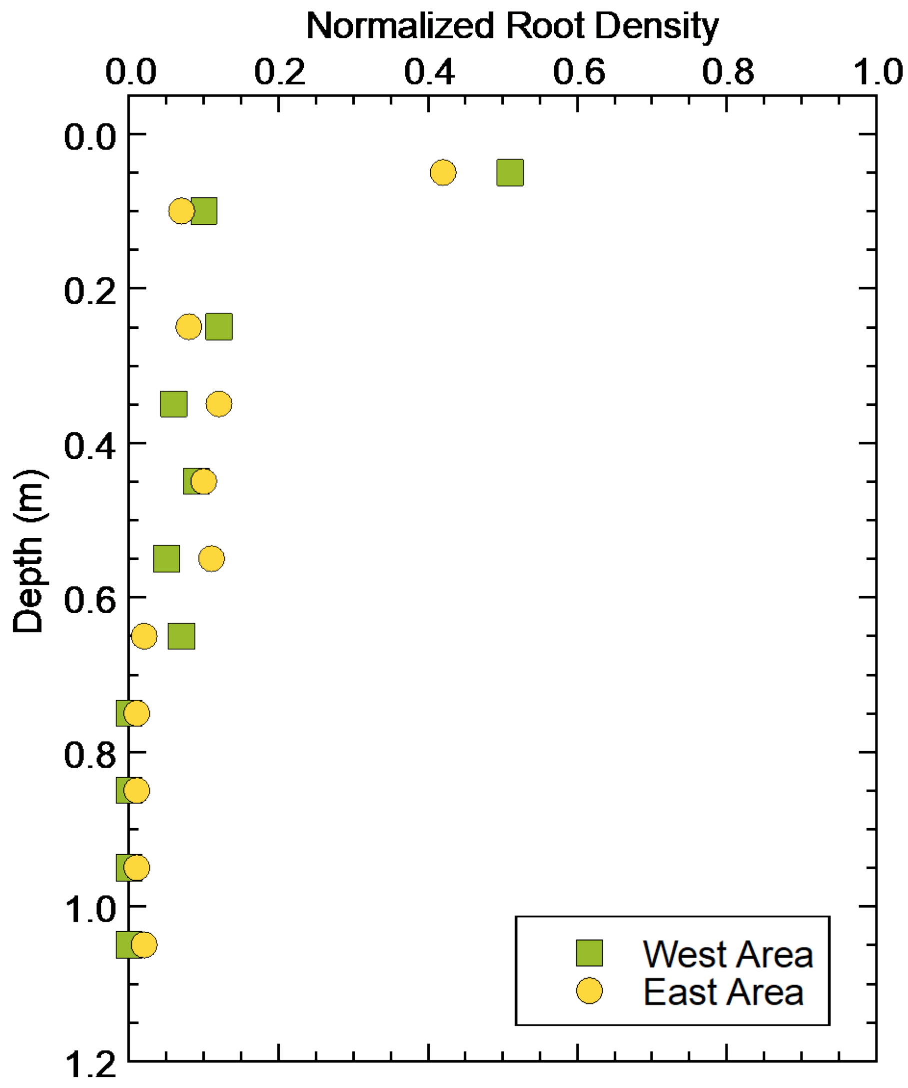


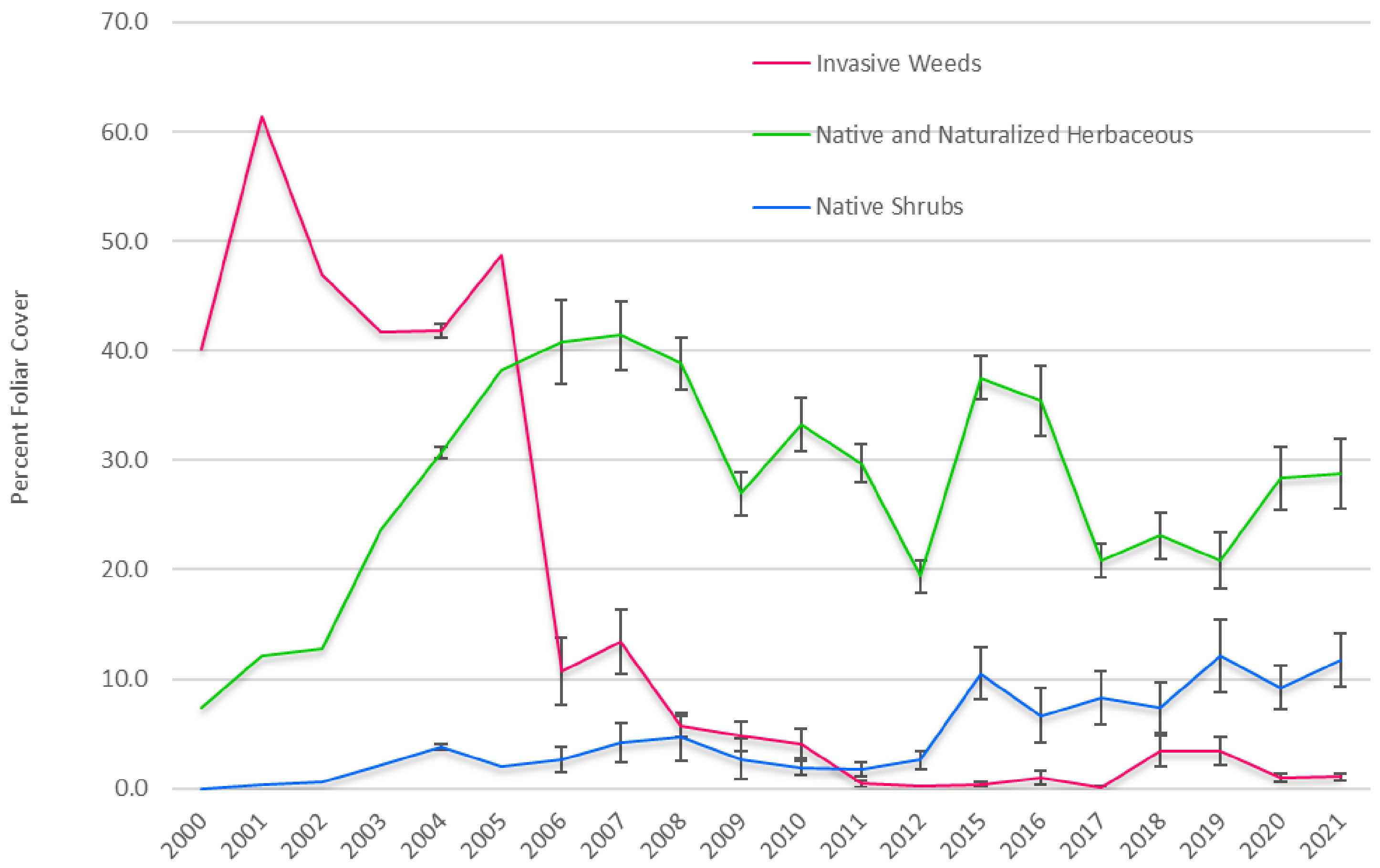
Saturated Hydraulic Conductivity



Soil Water Characteristic Curve (water retention)

In-Service Vegetation Properties





Summary and Conclusions

- Highly effective cover implemented based on design congruent with local hydro-ecosystem in semi-arid environment. Nearly all precipitation returned to atmosphere via evaporation and transpiration.

- Average annual percolation = 0.4 mm/yr - meets 3 mm/yr goal in performance assessment.

- Peak annual percolation rate = 4.0 mm/yr early in record, before more diverse plant community established with deep-rooted shrubs.

- In-service properties of soils and vegetation differ from as-built and from design – complicates PA. NUREG CR-7028 and CR-7288 provide guidance.