Soil Moisture Observations to Support Water Management in the Upper Yampa: Accomplishments and Next Steps

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Photo courtesy of Chris Hylen
Upper Yampa Soil Moisture Monitoring Network

Key Sponsors:
Upper Yampa Water Conservancy District
Colorado River District
Colorado Water Conservation Board

Goal: Establish new long-term soil moisture measurements to provide data and scientific insight on the reduction of snowmelt runoff by dry soils

Phase II Components:
● Install 8 additional soil moisture monitoring stations.
● Replicate Phase I data dissemination methods to make data readily and openly accessible to water managers and users.
● With stakeholder input, demonstrate station utility in context of other observations in the basin.
Soil Moisture Monitoring Network Goals

● Understand water supply during a changing climate
  ○ Establish a baseline for long term monitoring and future incorporation into hydrologic models
● Understand how soil moisture and snowpack relates to spring runoff and river flows
● Provide situational awareness to water managers and the community
● Provide data that can be used for research applications and improving process-based understanding
## Cluster Analysis

<table>
<thead>
<tr>
<th>Cluster</th>
<th>%</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.8</td>
<td>highest precip/elevation/slope, wide range of aspects, scrub, less dense forest</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>low-mid precip, low/mid elevation, forested, S/W aspect, low-mod slope,</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>low precip/elevation/slope, NE-SE facing, pasture/developed</td>
</tr>
<tr>
<td>4</td>
<td>8.6</td>
<td>low-mid precip, low/mid elevation, moderate slopes higher and more extreme when compared to similar clusters, S/W facing, forested</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>lowest-mid precip, low/mid elevation, lower slopes, E facing, mix of land cover</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>low precip/elevation/slope, W-facing, developed land/pasture</td>
</tr>
<tr>
<td>7</td>
<td>9.8</td>
<td>mid/high precip/elevation, some higher slopes, S/W facing, less dense forest</td>
</tr>
<tr>
<td>8</td>
<td>7.8</td>
<td>mid/high precip/elevation, some higher slopes, N/E facing, less dense forest</td>
</tr>
</tbody>
</table>
Additional considerations over the cluster analysis included:

- Distribute sites across elevations and spatially throughout the watershed
- Prioritize stations that were within the CBRFC mid-elevation zone 6500-8500 ft (1981-2590 meters)
- Incorporate stakeholder and partner feedback
Existing Hydrometeorological Stations

- 12 SNOTEL Stations
  - 3 including soil moisture
    - Lynx Pass (607): since 2002
    - Lost Dog (940): since 1999
    - Dry Lake (457): since 2003
- Storm Peak Lab (various aerosol and meteorological sensors)
- 2 CoAg (ET and plant water use)
- 36 USGS Stations
Station Installation

**Location:** Upper Yampa Headwaters  
40.22171, -106.86308  
**Elevation:** 9488 ft / 2982m

**Measured Variables – in near real time:**

*2-minute data*
- Soil Temp and Moisture at 6 depths:  
  - 2, 4, 6, 8, 20, 40 inches  
- Air Temperature  
- Relative Humidity  
- Solar Radiation  
- Precipitation  
- Wind Speed and Direction at 10m  
- Air Pressure  
- Fuel Temperature and Moisture

*15-minute data*
- Snow Depth

CW3E and YVSC staff conducting station maintenance in 2023

Soil pit  
Pilot station

Center for Western Weather and Water Extremes  
Scripps Institution of Oceanography  
UC San Diego  
Yampa Valley Sustainability Council  
Colorado Mountain College
Project Partnerships

• Colorado Basin River Forecast Center (CBRFC)
• Aspen Global Change Institute (AGCI)
• United States Forest Service (USFS)
• USDA- National Resources Conservation Service (NRCS)

AGCI and YVSC staff visiting iRON site in 2021

CW3E, YVSC, CMC, and NRCS staff at a SNOTEL site in 2023

CW3E/YVSC/CMC research intern conducting fieldwork in 2022
USDA-NRCS Soil Pits

CW3E/YVSC/CMC, under NRCS supervision, digging soil pits at NRCS stations (Bear River and Buffalo Park) in 2023
SKI: Observations in Water Year 2023

Fall wet-up period
● Initial soil moisture wet-up at 10-cm depth in Oct and at 50-cm depth in early Nov.
● Snow accumulation in early Nov at nearby SNOTEL Lynx Pass.

Spring snowmelt period
● Apparent snowmelt (SWE decrease) Apr-May.
● Soil moisture upticks across depths.
● Rapid streamflow and reservoir storage increases.
Station Installation Status - 2023

**USDA-NRCS: SNOTEL**

- Rabbit Ears SNOTEL - soil stack installed June 2023
- Additional soil stacks added at SNOTELs next summer.

**CW3E/YVSC/CMC Sites**

- One-two stations installed this coming week (Nov 2023)
- 6-7 stations to be installed summer 2024 – scouting with USFS complete
Summary – Next Steps

Installation and Data Utility
• One station available in NRT on CW3E website, MesoWest, NOAA PSL, MADIS
• Continuing analysis for the upcoming water year

Coordination with other networks
• Dashboards -> including one in prep with Upper Yampa
• iRON (AGCI), SNOTEL (USDA-NRCS)
• Explore connections via other events in the region

CW3E scientists prepare to launch a radiosonde at the Yampa Youth Water Festival in 2023

Community members at a field trip to Mt Werner Water during the Yampa Basin Rendezvous in 2023