COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Last Updated: May 2021

Colorado Water Conservation Board

Water Plan Grant Application

Instructions

To receive funding for a Water Plan Grant, applicant must demonstrate how the project, activity, or process (collectively referred to as "project") funded by the CWCB will help meet the measurable objectives and critical actions in the Water Plan. Grant guidelines are available on the CWCB website.

If you have questions, please contact CWCB at (303) 866-3441 or email the following staff to assist you with applications in the following areas:

Water Storage & Supply Projects	Matthew.Stearns@state.co.us
Conservation, Land Use Planning	Kevin.Reidy@state.co.us
Engagement & Innovation Activities	Ben.Wade@state.co.us
Agricultural Projects	Alexander.Funk@state.co.us
Water Sharing & ATM Projects	Alexander.Funk@state.co.us
Environmental & Recreation Projects	Chris.Sturm@state.co.us

FINAL SUBMISSION: Submit all application materials in one email to *waterplan.grants@state.co.us* in the original file formats [Application (word); Statement of Work (word); Budget/Schedule (excel)]. Please do not combine documents. In the subject line, please include the funding category and name of the project.

Water Project Summary

Name of Applicant	Upper Yampa Water Conservancy District
Name of Water Project	Evaluating the Observation Network and Enhancing Soil Moisture Observations to Support Decision Making and to Monitor Potential Impacts of Climate Change in the Upper Yampa Basin – Phase 1, Period 1 (Tasks 1.1 -1.3).
CWP Grant Request Amount	$24,944.50
Other Funding Sources _____	$
Other Funding Sources _____	$
Other Funding Sources _____	$
Applicant Funding Contribution	$24,944.50
Total Project Cost	$49,889 (Phase 1, Period 1 Tasks)

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Applicant & Grantee Information
Name of Grantee(s) Upper Yampa Water Conservancy District
Mailing Address **PO Box 775529, Steamboat Springs, CO 80477**
FEIN
Organization Contact **Andy Rossi**
Position/Title **General Manager**
Email **arossi@upperyampawater.com**
Phone **970-819-3002**
Grant Management Contact **Andy Rossi**
Position/Title **same as above**
Email **same as above**
Phone **same as above**
Name of Applicant (if different than grantee)
Mailing Address
Position/Title
Email
Phone

Description of Grantee/Applicant
Provide a brief description of the grantee's organization (100 words or less).
The Upper Yampa Water Conservancy District (UYWCD) was formed in 1966 to provide legal authority to plan and construct water conservation projects in the Yampa Valley. Yamcolo and Stagecoach Reservoirs represent two major water conservation projects constructed by the UYWCD. The UYWCD includes most of Routt County and a portion of Moffat County. The UYWCD is governed by a board of nine directors. Upon instigation and certification as a district, the UYWCD was able to collect a levy on general taxes from both Routt and Moffat County. The UYWCD maintains its status as the guardian of critical water rights in the Yampa Valley through on-going efforts to benefit the residents and wildlife in the Yampa River Basin.

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Type of Eligible Entity (check one)	
	Public (Government): Municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
X	**Public (Districts):** Authorities, Title 32/special districts (conservancy, conservation, and irrigation districts), and water activity enterprises.
	Private Incorporated: Mutual ditch companies, homeowners associations, corporations.
	Private Individuals, Partnerships, and Sole Proprietors: Private parties may be eligible for funding.
	Non-governmental organizations (NGO): Organization that is not part of the government and is non-profit in nature.
	Covered Entity: As defined in Section 37-60-126 Colorado Revised Statutes.

Type of Water Project (check all that apply)	
X	Study
	Construction
	Other

Category of Water Project (check the primary category that applies and include relevant tasks)		
	Water Storage & Supply - Projects that facilitate the development of additional storage, artificial aquifer recharge, and dredging existing reservoirs to restore the reservoirs' full decreed capacity, multi-beneficial projects, water sharing agreements, Alternative Transfer Methods, and those projects identified in basin implementation plans to address the water supply and demand gap. *Applicable Exhibit A Task(s):* ***Note:*** *For Water Sharing Agreements or ATM Projects - please include the supplemental application available on the CWCB's website.*	
X	Conservation and Land Use Planning - Activities and projects that implement long-term strategies for conservation, land use, water efficiency, and drought planning. *Applicable Exhibit A Task(s):* ***All Tasks***	
	Engagement & Innovation - Activities and projects that support water education, outreach, and innovation efforts. *Applicable Exhibit A Task(s):*	
X	Agricultural - Projects that provide technical assistance and improve agricultural efficiency. *Applicable Exhibit A Task(s):* ***All Tasks***	
X	Environmental & Recreation - Projects that promote watershed health, environmental health, and recreation. *Applicable Exhibit A Task(s):* ***All Tasks***	
	Other	Explain:

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Location of Water Project	
Please provide the general county and coordinates of the proposed project below in **decimal degrees**. The Applicant shall also provide, in Exhibit C, a site map if applicable.	
County/Counties	Routt, Moffat
Latitude	The entire contributing watershed of the Upper Yampa River (above Craig)
Longitude	

Water Project Overview
Please provide a summary of the proposed water project (200 words or less). Include a description of the project and what the CWP Grant funding will be used for specifically (e.g., studies, permitting process, construction). Provide a description of the water supply source to be utilized or the water body affected by the project, where applicable. Include details such as acres under irrigation, types of crops irrigated, number of residential and commercial taps, length of ditch improvements, length of pipe installed, and area of habitat improvements, where applicable. If this project addresses multiple purposes or spans multiple basins, please explain. The Applicant shall also provide, in Exhibit A, a detailed Statement of Work, Budget, Other Funding Sources/Amounts and Schedule.
The Center for Western Weather and Water Extremes (CW3E), Colorado Mountain College (CMC), Yampa Valley Sustainability Council (YVSC), and the Upper Yampa Water Conservancy District (UYWCD) propose to install a soil moisture monitoring network of stations in the Upper Yampa Basin in order to connect relevant climate change science with local and regional water managers' goals to better align decision-making capacity, water use practices, and water supply in a changing future. Phase I, Period 1 of developing the soil moisture monitoring network is to conduct a basin-wide analysis of the Upper Yampa basin to identify where soil moisture monitoring stations should be located in order to most effectively meet decision maker needs. Phase I, Period 2 also includes the installation of a pilot soil moisture monitoring station, and initial demonstrations of utility in the context of the existing observing network in the Upper Yampa, including snowpack and stream observations. Phase 1 provides the needed foundation from which to launch Phase 2 of the project, which includes locating and installing additional stations in the network, as well as capturing, storing, disseminating, and interpreting the data in ways that provide decision-support services to water managers and users in the Basin. **Soil Moisture Monitoring Network Program Principal Goals**: ● Provide new observations in locations of highest scientific and operational value. ● Provide situational awareness on antecedent watershed conditions to operational partners. ● Provide decision-support tools to operational partners to connect watershed conditions to water user/manager needs. ● Provide a continuous record of changing landscape conditions with a changing climate. ● Improve forecasts of the hydrologic impacts of large storms through better understanding of physical processes such as runoff efficiency.

- Inform hydrologic modeling efforts leading to more accurate and reliable spring snowmelt volume forecasts.

The goals of Phase 1 of the project are to:

- Identify key observation gaps in the Upper Yampa River Basin and where existing instrumentation exists (e.g. USGS gages, SNOTEL sites, etc.) in order to develop a strategic plan and set of ideal sites to install soil moisture monitoring stations. (Period 1, 2021)
- Install a pilot soil moisture monitoring station. (Period 2, 2022)
- Develop basic data dissemination methods to make Site 1 data readily and openly accessible to water managers and users. (Period 2, 2022)
- Demonstrate station utility in context of other observations being collected in the basin.

Measurable Results		
To catalog measurable results achieved with the CWP Grant funds, please provide any of the following values as applicable:		
	New Storage Created (acre-feet)	
	New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive	
	Existing Storage Preserved or Enhanced (acre-feet)	
	Length of Stream Restored or Protected (linear feet)	
	Efficiency Savings (indicate acre-feet/year OR dollars/year)	
	Area of Restored or Preserved Habitat (acres)	
	Quantity of Water Shared through Alternative Transfer Mechanisms or water sharing agreement	
	Number of Coloradans Impacted by Incorporating Water-Saving Actions into Land Use Planning	
All water users in the Upper Yampa Basin	Number of Coloradans Impacted by Engagement Activity	
	Other	Explain:

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Water Project Justification
Provide a description of how this water project supports the goals of Colorado's Water Plan, the Analysis and Technical Update to the Water Plan, and the applicable Roundtable Basin Implementation Plan and Education Action Plan. The Applicant is required to reference specific needs, goals, themes, or Identified Projects and Processes (IPPs), including citations (e.g. document, chapters, sections, or page numbers). The proposed water project shall be evaluated based upon how well the proposal conforms to Colorado's Water Plan Framework for State of Colorado Support for a Water Project (CWP, Section 9.4, pp. 9-43 to 9-44;)

The water landscape in the west is drying. The average flow of the Colorado River has declined nearly 20 percent over the past century, half of which is due to warming temperatures. According to a recent Washington Post study, Routt and Moffat Counties – along with several other western slope counties – are global warming "hot spots" because they have warmed over 2 degrees Celsius in the past century, double the global average (Eilperin 2020). Spanning over 30,000 square miles, this region is the largest 2C hot spot in the Lower 48 (ibid.). Though numerous factors influence why global warming occurs unevenly across the globe, on the Colorado Western Slope, a feedback loop between drying soils and increased temperatures is an evident contributor: increased temperatures lead to drier soils, which lead to further increases in temperature due to reduced amounts of evaporative cooling.

Increased temperature and dry soils reduce ground flows in the Upper Yampa River basin because dry soils absorb the water that would otherwise be flowing to the Yampa River via spring melt. In Colorado, we have long relied on our snowpack to supply 80% of our water but earlier spring melt, drier soils, and increased evaporative loss are underlining the need for more real-time observations of snowpack, streamflow, soil moisture, and other variables needed to forecast future supply and allocate water resources appropriately in the Upper Colorado River basin (Lukas and Payton 2020).

Currently, soil moisture data are recorded at only three SNOTEL sites in the Yampa River watershed.[1] Capturing soil moisture measurements throughout the watershed will enable water users and managers to better evaluate the relationship between precipitation and runoff[2] and related thresholds. For example, research in locations such as the Russian River in northern

[1] SNOTEL/soil moisture sites in the Yampa basin include: Lost Dog (Zirkels), Dry Lake (base of Buffalo Pass, Steamboat side), and Lynx Pass SNOTEL sites.

[2] Measuring soil moisture at different depths below the ground surface is useful for determining runoff efficiency (i.e., the fraction of precipitation that turns into runoff) for a given amount of predicted precipitation. Runoff efficiency depends largely on soil moisture saturation preceding a precipitation event, with dry soils acting as a buffer to runoff generation. Antecedent soil moisture conditions can thus significantly alter the hydrologic impacts of large storms, in addition to causing variability in the spatiotemporal distribution of rain and snow in individual extreme events impacting the Yampa River watershed.

California has demonstrated a clear threshold-based relationship between soil moisture and runoff. When antecedent soil moisture was lower than 80 percent of the maximum observed for the period of record, runoff efficiency remained below 10 percent. However, for precipitation events with antecedent soil moisture content in excess of 80 percent of the climatological maximum, runoff efficiency rapidly increased (Sumargo et al. 2020).

One of the stated goals of the **Colorado Water Plan** (CWP) is: "The State will continue to strengthen water outreach, education, and public engagement to equip Coloradans with the necessary information to make informed water choices" (CWP Exec. Summary). The development of a technically sound, professionally operated soil moisture sensor network in the Yampa River Basin will provide water users and managers necessary information required to make informed decisions about the operation of existing water resources and provide technical inputs for the consideration of future water resources.

Furthermore, **Colorado's Water Plan** considers a range of possible future conditions. Through public engagement and sound science, the plan develops a practical, adaptive, and balanced path forward for meeting Colorado's future water needs. One of the new features of the **Analysis and Technical Update** to the CWP is the inclusion of a consideration of climate change in the planning scenarios analyzed: Three of the five planning scenarios include assumptions related to a hotter and drier future climate (Analysis and Technical Update Page VIII). Projections of future climate conditions were not a part of SWSI 2010 and can have a significant influence on hydrology, water use, and estimated gaps. The ability to monitor environmental drivers to determine which scenario Colorado will most likely face, the State of Colorado will need to work with partners, to monitor the critical drivers of water supply, demand, and the level of "green" versus "full-resource use" values through future SWSI updates and other technical work (CWP page 6-14). The proposed soil moisture monitoring network will provide publicly available data that may be used as a direct input in this monitoring process.

The proposed soil moisture sensor network aligns with the **Yampa-White-Green Roundtable's Basin Implementation Plan's** goal to develop an integrated system of water use, storage, administration, and delivery to reduce water shortages and meet environmental and recreational needs. Again, the data collected from the proposed soil moisture sensor network will aid in the integrated management and monitoring of the Yampa River Basin's water resource.

Related Studies

Please provide a list of any related studies, including if the water project is complementary to or assists in the implementation of other CWCB programs.

Previous CWCB Grants, Loans or Other Funding
List all previous or current CWCB grants (including WSRF) awarded to both the Applicant and Grantee. Include: 1) Applicant name; 2) Water activity name; 3) Approving RT(s); 4) CWCB board meeting date; 5) Contract number or purchase order; 6) Percentage of other CWCB funding for your overall project.
The UYWCD is the recipient of CWCB grant funds for other projects. No other CWCB funds have been awarded for this project.

Taxpayer Bill of Rights
The Taxpayer Bill of Rights (TABOR) may limit the amount of grant money an entity can receive. Please describe any relevant TABOR issues that may affect your application.

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Submittal Checklist	
X	I acknowledge the Grantee will be able to contract with CWCB using the Standard Contract.
X	Statement of Work(1)
X	Budget & Schedule(1)
	Engineer's statement of probable cost (projects over $100,000)
	Letters of Matching and/or Pending 3rd Party Commitments(1)
X	Map (if applicable)(1)
	Photos/Drawings/Reports
	Letters of Support (Optional)
	Certificate of Insurance (General, Auto, & Workers' Comp.) (2)
	Certificate of Good Standing with Colorado Secretary of State(2)
	W-9(2)
	Independent Contractor Form(2) (If applicant is individual, not company/organization)
Water Sharing Agreements and Alternative Transfer Methods ONLY	
	Water Sharing Agreements and Alternative Transfer Methods Supplemental Application(1)

(1) Required with application.
(2) Required for contracting. While optional at the time of this application, submission can expedite contracting upon CWCB Board approval.

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ENGAGEMENT & INNOVATION GRANT FUND SUPPLEMENTAL APPLICATION

Introduction & Purpose

Colorado's Water Plan calls for an outreach, education, public engagement, and innovation grant fund in Chapter 9.5.

The overall goal of the Engagement & Innovation Grant Fund is to enhance Colorado's water communication, outreach, education, and public engagement efforts; advance Colorado's water supply planning process; and support a statewide water innovation ecosystem.

The grant fund aims to engage the public to promote well-informed community discourse regarding balanced water solutions statewide. The grant fund aims to support water innovation in Colorado. The grant fund prioritizes measuring and evaluating the success of programs, projects, and initiatives. The grant fund prioritizes efforts designed using research, data, and best practices. The grant fund prioritizes a commitment to collaboration and community engagement. The grant fund will support local and statewide efforts.

The grant fund is divided into two tracks: engagement and innovation. The Engagement Track supports education, outreach, communication, and public participation efforts related to water. The Innovation Track supports efforts that advance the water innovation ecosystem in Colorado.

Application Questions

*The grant fund request is referred to as "project" in this application.

Overview (answer for both tracks)
In a few sentences, what is the overall goal of this project? How does it achieve the stated purpose of this grant fund (above)?
Who is/are the target audience(s)? How will you reach them? How will you involve the community?
Describe how the project is collaborative or engages a diverse group of stakeholders. Who are the partners in the project? Do you have other funding partners or sources?

Describe how you plan to measure and evaluate the success and impact of the project?
What research, evidence, and data support your project?
Describe potential short- and long-term challenges with this project.

Please fill out the applicable questions for either the Engagement Track or Innovation Track, unless your project contains elements in both tracks. If a question does not relate to your project, just leave it blank. Please answer each question that relates to your project. Please reference the relevant documents and use chapters and page numbers (Colorado's Water Plan, Basin Implementation Plan, PEPO Education Action Plan, etc.).

Engagement Track
Describe how the project achieves the education, outreach, and public engagement measurable objective set forth in Colorado's Water Plan to "significantly improve the level of public awareness and engagement regarding water issues statewide by 2020, as determined by water awareness surveys."
Describe how the project achieves the other measurable objectives and critical goals and actions laid out in Colorado's Water Plan around the supply and demand gap; conservation; land use; agriculture; storage; watershed health, environment, and recreation; funding; and additional.
Describe how the project achieves the education, outreach, and public engagement goals set forth in the applicable Basin Implementation Plan(s).

Describe how the project achieves the basin roundtable's PEPO Education Action Plans.

Innovation Track
Describe how the project enhances water innovation efforts and supports a water innovation ecosystem in Colorado.
Describe how the project engages/leverages Colorado's innovation community to help solve our state's water challenges.
Describe how the project helps advance or develop a solution to a water need identified through TAP-IN and other water innovation challenges. What is the problem/need/challenge?
Describe how this project impacts current or emerging trends; technologies; clusters, sectors, or groups in water innovation.

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Colorado Water Conservation Board
Water Plan Grant - Exhibit A

Statement Of Work	
Date:	**06/28/21**
Name of Grantee:	**Upper Yampa Water Conservancy District (UYWCD)**
Name of Water Project:	
Funding Source:	**Water Plan Grant, UYWCD**

Water Project Overview:

The Center for Western Weather and Water Extremes (CW3E), Colorado Mountain College (CMC), Yampa Valley Sustainability Council (YVSC), and the Upper Yampa Water Conservancy District (UYWCD) propose to install a soil moisture monitoring network of stations in the Upper Yampa Basin in order to connect relevant climate change science with local and regional water managers' goals to better align decision-making capacity, water use practices, and water supply in a changing future.

Phase I, Period 1 (2021) of developing the soil moisture monitoring network is to conduct a basin-wide analysis of the Upper Yampa basin to identify where soil moisture monitoring stations should be located in order to most effectively meet decision maker needs. Phase I, Period 2 (2022) also includes the installation of a pilot soil moisture monitoring station, and initial demonstrations of utility in the context of the existing observing network in the Upper Yampa, including snowpack and stream observations. Phase 1 provides the needed foundation from which to launch Phase 2 of the project, which includes locating and installing additional stations in the network, as well as capturing, storing, disseminating and interpreting the data in ways that provide decision-support services to water managers and users in the Basin.

This grant application is for financial assistance in support of Phase 1, Period 1 (2021) project activities only.

Project Objectives:

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Soil Moisture Monitoring Network Program Principal Goals:

- Provide new observations in locations of highest scientific and operational value.
- Provide situational awareness on antecedent watershed conditions to operational partners.
- Provide decision-support tools to operational partners to connect watershed conditions to water user/manager needs.
- Provide a continuous record of changing landscape conditions with a changing climate.
- Improve forecasts of the hydrologic impacts of large storms through better understanding of physical processes such as runoff efficiency.
- Inform hydrologic modeling efforts leading to more accurate and reliable spring snowmelt volume forecasts.

The goals of Phase 1 of the project are to:

- Identify key observation gaps in the Upper Yampa River Basin and where existing instrumentation exists (e.g. USGS gages, SNOTEL sites, etc.) in order to develop a strategic plan and set of ideal sites to install soil moisture monitoring stations. (Period 1, 2021)
- Install a pilot soil moisture monitoring station. (Period 2, 2022)
- Develop basic data dissemination methods to make Site 1 data readily and openly accessible to water managers and users. (Period 2, 2022)
- Demonstrate station utility in context of other observations being collected in the basin.

Tasks
Task 1: Basin Analysis Description
Description of Task:
Using geospatial analysis software, statistical and physical analysis, and site visits, the project team will conduct a basin-scale analysis to determine where observations of soil conditions would best be able to meet stakeholder and decision-maker needs in the Upper Yampa River basin.
Method/Procedure:

Task 1.1: Develop analysis framework.

The project's major focus is to collect observations that will support decision-making in water resources and hazard management, and a careful assessment is needed in order to maximize the benefits of new observations. This analysis will investigate the basin as a whole, including a range of elevations and subbasins (Map 1, see attached reference documentation). The first step is to develop a robust and replicable process for identifying where soil measurements will be most critical for effective monitoring. In particular, this basin analysis will identify water producing zones, where variation in soil moisture is likely to have the greatest impact on snowmelt runoff. This framework will be documented and provided to the sponsor in a report, and if desired, a presentation.

Task 1.2: Integrate partners and stakeholders.

The project team will hold virtual or in person (if possible) meetings with stakeholders and partners to include the Colorado Basin River Forecast Center, National Weather Service Western Region, and others identified by local water managers. The outcome of this meeting or series of meetings will be input on forecast needs. At least three meetings will be held throughout the course of the project: 1) to present the basin analysis framework and get feedback, 2) to present proposed sites after the analysis is conducted and ensure all relevant data dissemination pathways are being followed and 3) to demonstrate station data collection and usability and revisit network priorities in context of the new data streams.

Task 1.3: Conduct analysis. The project team will integrate input solicited from partners mentioned in Task 1.2 into the final basin analysis deliverable.

Deliverable:

The final deliverable will be a comprehensive report describing the optimal Upper Yampa Basin soil moisture monitoring network design, specifying the recommended number and location of sites, the feasibility of site locations (permission and permitting required), and a recommendation for ancillary sensors that will best address information gaps (e.g., precipitation, temperature). This report will also be presented to partners.

Tasks
Task 2 – [Name]
Description of Task:

Method/Procedure:
Deliverable:

Repeat for Task 3, Task 4, Task 5, etc.

Budget and Schedule
This Statement of Work shall be accompanied by a combined Budget and Schedule that reflects the Tasks identified in the Statement of Work and shall be submitted to CWCB in excel format.

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Reporting Requirements

Progress Reports: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of issuance of a purchase order, or the execution of a contract. The progress report shall describe the status of the tasks identified in the statement of work, including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Report: At completion of the project, the applicant shall provide the CWCB a Final Report on the applicant's letterhead that:

- Summarizes the project and how the project was completed.
- Describes any obstacles encountered, and how these obstacles were overcome.
- Confirms that all matching commitments have been fulfilled.
- Includes photographs, summaries of meetings and engineering reports/designs.

The CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.

Payment

Payment will be made based on actual expenditures and must include invoices for all work completed. The request for payment must include a description of the work accomplished by task, an estimate of the percent completion for individual tasks and the entire Project in relation to the percentage of budget spent, identification of any major issues, and proposed or implemented corrective actions.

Costs incurred prior to the effective date of this contract are not reimbursable. The last 10% of the entire grant will be paid out when the final deliverable has been received. All products, data and information developed as a result of this contract must be provided to as part of the project documentation.

Performance Measures

Performance measures for this contract shall include the following:
(a) Performance standards and evaluation: Grantee will produce detailed deliverables for each task as specified. Grantee shall maintain receipts for all project expenses and documentation of the minimum in-kind contributions (if applicable) per the budget in Exhibit C. Per Water Plan Grant Guidelines, the CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.
(b) Accountability: Per Water Plan Grant Guidelines full documentation of project progress must be submitted with each invoice for reimbursement. Grantee must confirm that all grant conditions have been complied with on each invoice. In addition, per Water Plan Grant Guidelines, Progress Reports must be submitted at least once every 6 months. A Final Report must be submitted and approved before final project payment.
(c) Monitoring Requirements: Grantee is responsible for ongoing monitoring of project progress per Exhibit A. Progress shall be detailed in each invoice and in each Progress Report, as detailed above. Additional inspections or field consultations will be arranged as may be necessary.
(d) Noncompliance Resolution: Payment will be withheld if grantee is not current on all grant conditions. Flagrant disregard for grant conditions will result in a stop work order and cancellation of the Grant Agreement.

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Colorado Water Conservation Board

Water Plan Grant - Exhibit C
Budget and Schedule

Prepared Date: 06/28/21

Name of Applicant: Upper Yampa Water Conservancy District

Name of Water Project: Evaluating the Observation Network and Enhancing Soil Moisture Observations to Support Decision Making and to Monitor Potential Impacts of Climate Change in the Upper Yampa Basin

Project Start Date: July-August 2021

Nov-21

Task No.	Task Description	Task Start Date	Task End Date	Grant Funding Request	Match Funding	Total
1	**Basin Analysis Description**	July/August 2021	November 2021	24,944.50	24,944.50	$49,889
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
			Total	$24,945	$24,945	$49,889

Evaluating the Observation Network and Enhancing Soil Moisture Observations to Support Decision Making and to Monitor Potential Impacts of Climate Change in the Upper Yampa Basin

Prepared by: F. Martin Ralph, Ph.D.[1], Anna Wilson, PhD[1], Nathan Stewart, PhD[2], Michelle Stewart, PhD[3], Tim Sullivan, M.Sc.[3], Madison Muxworthy[3]

[1]*Center for Western Weather and Water Extremes,* [2]*Colorado Mountain College*, [3]*Yampa Valley Sustainability Council*

The Center for Western Weather and Water Extremes (CW3E), Colorado Mountain College (CMC) and Yampa Valley Sustainability Council (YVSC) propose to install a soil moisture monitoring network of stations in the Upper Yampa Basin in order to connect relevant climate change science with local and regional water managers' goals to better align decision-making capacity, water use practices, and water supply in a changing future.

This proposal covers Phase I of this project in detail. The first step in developing the soil moisture monitoring network is to conduct a basin-wide analysis of the Upper Yampa basin to identify where soil moisture monitoring stations should be located in order to most effectively meet decision maker needs. Phase I also includes the installation of a pilot soil moisture monitoring station, and initial demonstrations of utility in the context of the existing observing network in the Upper Yampa, including snowpack and stream observations. Phase 1 provides the needed foundation from which to launch Phase 2 of the project, which includes locating and installing additional stations in the network, as well as capturing, storing, disseminating and interpreting the data in ways that provide decision-support services to water managers and users in the Basin.

Soil Moisture Monitoring Network Program Principal Goals:

- Provide new observations in locations of highest scientific and operational value.
- Provide situational awareness on antecedent watershed conditions to operational partners.
- Provide decision-support tools to operational partners to connect watershed conditions to water user/manager needs.
- Provide a continuous record of changing landscape conditions with a changing climate.
- Improve forecasts of the hydrologic impacts of large storms through better understanding of physical processes such as runoff efficiency.

- Inform hydrologic modeling efforts leading to more accurate and reliable spring snowmelt volume forecasts.

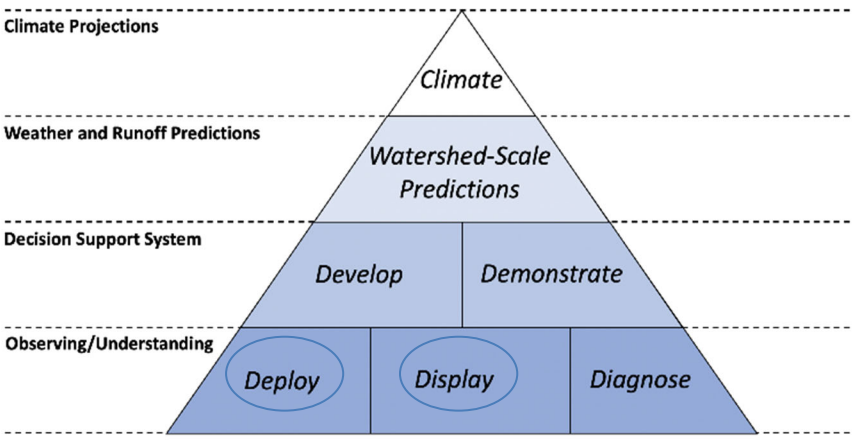


Figure 1: This proposal supports Phase 1 of the overarching soil moisture monitoring network, initiating the foundational deploy and display aspects of the program pyramid (see blue circles).

The goals of Phase 1 of the project are to:

- Identify key observation gaps in the Upper Yampa River Basin and where existing instrumentation exists (e.g. USGS gages, SNOTEL sites, etc.) in order to develop a strategic plan and set of ideal sites to install soil moisture monitoring stations.
- Install a pilot soil moisture monitoring station.
- Develop basic data dissemination methods to make Site 1 data readily and openly accessible to water managers and users.
- Demonstrate station utility in context of other observations being collected in the basin.

Phase 2 (beyond the scope of this proposal) of this project will involve adding the needed additional stations to the network at sites prioritized through the basin analysis process; developing a more robust platform for data dissemination and visualization; and developing decision support tools and dashboards to respond to operational needs in the basin.

Phase 3 (beyond the scope of this proposal) of the project will focus on connecting soil moisture monitoring data with watershed-scale predictions and climate projections.

Background - Yampa River Basin Context

The water landscape in the west is drying. The average flow of the Colorado River has declined nearly 20 percent over the past century, half of which is due to warming temperatures. According to a recent *Washington Post* study, Routt and Moffat Counties – along with several other western slope counties – are global warming "hot spots" because they have warmed over 2 degrees Celsius in the past century, double the global average (Eilperin 2020). Spanning over 30,000

square miles, this region is the largest 2C hot spot in the Lower 48 (*ibid*.). Though numerous factors influence why global warming occurs unevenly across the globe, on the Colorado Western Slope, a feedback loop between drying soils and increased temperatures is an evident contributor: increased temperatures lead to drier soils, which lead to further increases in temperature due to reduced amounts of evaporative cooling.

Increased temperature and dry soils reduce ground flows in the Upper Yampa River basin because dry soils absorb the water that would otherwise be flowing to the Yampa River via spring melt. In Colorado, we have long relied on our snowpack to supply 80% of our water but earlier spring melt, drier soils, and increased evaporative loss are underlining the need for more real-time observations of snowpack, streamflow, soil moisture, and other variables needed to forecast future supply and allocate water resources appropriately in the Upper Colorado River basin (Lukas and Payton 2020).

The recent call on the Yampa River on August 26, 2020 was the second call in history in the last three years, suggesting that a new paradigm of water management may be needed for the Yampa River basin (Best 2021). The water restriction was issued because of low flows near Dinosaur National Monument and the fact that water users were not receiving their legally allotted shares. Importantly, the restriction came after an above average snowpack year during the 2019-2020 winter,[1] underlining the disruption in the relationship between snowpack accumulation and ground flows. The importance of interflow to groundwater recharge and its potential changes with a changing climate needs to be understood to effectively support water use and management.

As of March 2021, discussions about whether to formally designate the Yampa River as over-appropriated (Best 2021), and the start of new negotiations over operational guidelines for the Colorado River Basin in the face of future climatic conditions (Runyon 2021), underline the need for programs and data that quantify the variables influencing precipitation and runoff within the basin to support advanced water resource decision-making by reducing uncertainty. Accurate knowledge of antecedent watershed conditions is vital for understanding how incoming precipitation may affect the watershed.

Currently, soil moisture data are recorded at only three SNOTEL sites in the Yampa River watershed.[2] Capturing soil moisture measurements throughout the watershed will enable water users and managers to better evaluate the relationship between precipitation and runoff[3] and

[1] NRCS reported 104% as of April 11 2020.

[2] SNOTEL/soil moisture sites in the Yampa basin include: Lost Dog (Zirkels), Dry Lake (base of Buffalo Pass, Steamboat side), and Lynx Pass SNOTEL sites.

[3] Measuring soil moisture at different depths below the ground surface is useful for determining runoff efficiency (i.e., the fraction of precipitation that turns into runoff) for a given amount of predicted precipitation. Runoff efficiency depends largely on soil moisture saturation preceding a precipitation event, with dry soils acting as a

related thresholds. For example, research in locations such as the Russian River in northern California has demonstrated a clear threshold-based relationship between soil moisture and runoff. When antecedent soil moisture was lower than 80 percent of the maximum observed for the period of record, runoff efficiency remained below 10 percent. However, for precipitation events with antecedent soil moisture content in excess of 80 percent of the climatological maximum, runoff efficiency rapidly increased (Sumargo et al. 2020).

Phase 1 Scope of Work

Phase 1, the scope of work that will be supported with this proposal, will consist of three tasks: (1) a basin-scale analysis determining where observations of soil conditions would best be able to meet stakeholder and decision-maker needs in the Upper Yampa River basin; (2) installation of a pilot soil moisture monitoring station to be located in the Upper Yampa Basin; and (3) the development of basic data logging, provision of a dissemination platform, and demonstration of station utility in context of other observations.

Task 1: Basin Analysis Description

Using geospatial analysis software, statistical and physical analysis, and site visits, the project team will conduct a basin-scale analysis to determine where observations of soil conditions would best be able to meet stakeholder and decision-maker needs in the Upper Yampa River basin.

Task 1.1: Develop analysis framework.

The project's major focus is to collect observations that will support decision-making in water resources and hazard management, and a careful assessment is needed in order to maximize the benefits of new observations. This analysis will investigate the basin as a whole, including a range of elevations and subbasins (Map 1). The first step is to develop a robust and replicable process for identifying where soil measurements will be most critical for effective monitoring. In particular, this basin analysis will identify water producing zones, where variation in soil moisture is likely to have the greatest impact on snowmelt runoff. This framework will be documented and provided to the sponsor in a report, and if desired, a presentation.

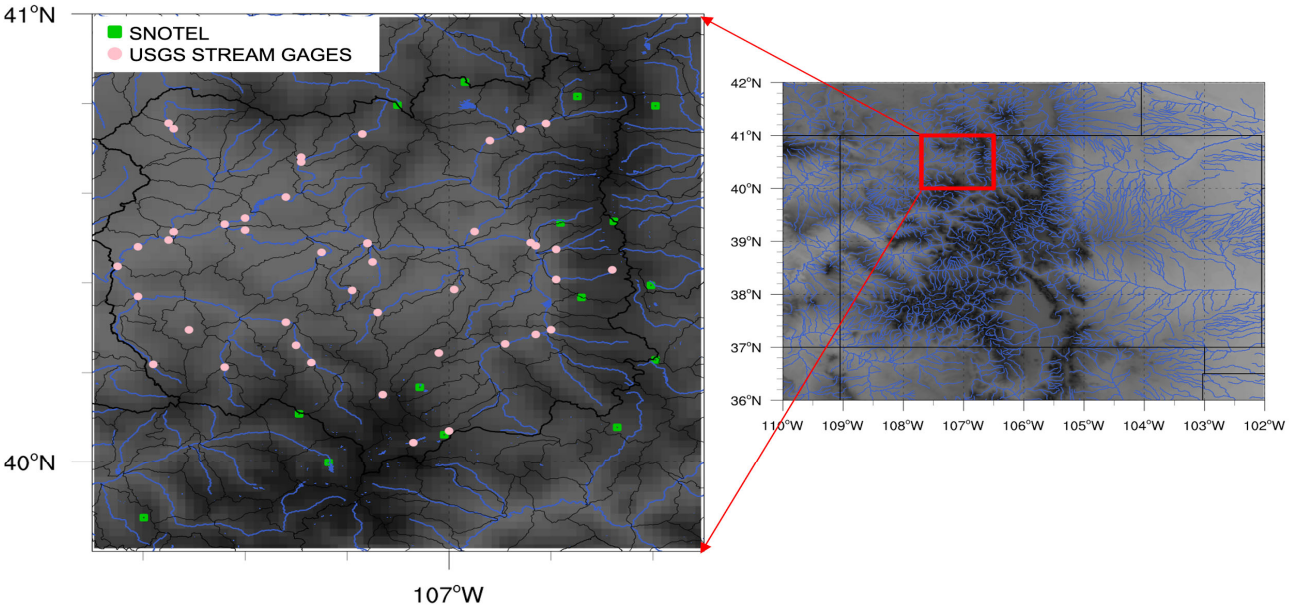
Task 1.2: Integrate partners and stakeholders. The project team will hold virtual or in person (if possible) meetings with stakeholders and partners to include the Colorado Basin River Forecast Center, National Weather Service Western Region, and others identified by local water managers. The outcome of this meeting or series of meetings will be input on forecast needs. At

buffer to runoff generation. Antecedent soil moisture conditions can thus significantly alter the hydrologic impacts of large storms, in addition to causing variability in the spatiotemporal distribution of rain and snow in individual extreme events impacting the Yampa River watershed.

least three meetings will be held throughout the course of the project: 1) to present the basin analysis framework and get feedback, 2) to present proposed sites after the analysis is conducted and ensure all relevant data dissemination pathways are being followed and 3) to demonstrate station data collection and usability and revisit network priorities in context of the new data streams.

Task 1.3: Conduct analysis. The project team will integrate input solicited from partners mentioned in Task 1.2 into the final basin analysis deliverable. The final deliverable will be a comprehensive report describing the optimal Upper Yampa Basin soil moisture monitoring network design, specifying the recommended number and location of sites, the feasibility of site locations (permission and permitting required), and a recommendation for ancillary sensors that will best address information gaps (e.g., precipitation, temperature). This report will also be presented to partners.

Upper Yampa River Basin: Existing SNOTEL and USGS Stream Gage Locations



Map 1: Using geospatial analysis software and interactive discussion with key partners, Phase 1 of the project will develop a basin analysis and recommendations for network design and locations. This analysis will be an important first step towards launching a Soil Moisture Monitoring Network Program in the Upper Yampa River basin. CW3E, YVSC, and CMC staff will collaborate with Upper Yampa River basin partners and water managers to identify the monitoring locations and assess the feasibility of site locations (permission and permitting), as well as to identify which sensors are best suited to data needs.

Task 2: Pilot Site/Site 1 of the Soil Moisture Monitoring Network

The second component of Phase 1 will be the implementation of a pilot site to initiate the launch of the Upper Yampa Basin Soil Moisture Monitoring Network Program.

Task 2.1

The location of the pilot site will be determined from the basin analysis described above. All final siting, permitting, and landowner/agency interaction will be covered by this statement of work. Comprehensive site documentation will be provided as station metadata and made available publicly along with the dataset collected at the station.

Task 2.2

The ***surface meteorology and soil moisture site*** (see Appendix I, Figures 2 and 3) will include meteorological sensors for temperature, relative humidity, pressure, wind speed and direction, solar radiation, and precipitation (the current design does not include the ability to monitor frozen precipitation, but could be added if needed, with associated cost increment), and soil moisture and temperature at 6 depths beneath the ground (5, 10, 15, 20, 50, and 100 cm). Temperature, relative humidity, and solar radiation data provide information on moisture content, potential drying, and other atmospheric conditions along with a clearer picture of event evolution; precipitation data captures the amount of water available to enter into the soil; and wind speed, direction and pressure capture local circulations. Including these meteorological measurements along with the soil measurements is key to understanding the evolution of soil moisture before, during, and after precipitation events.

Task 2.3 Partner and stakeholder meeting

A stakeholder and partner briefing will be held to present details on the new station and information on how observations will be collected. Feedback will be requested and integrated into plans for Task 3.

Task 3: Development of data collection and transmission processes and scoping needs

Task 3.1 Data dissemination

After the pilot station is installed, CW3E will develop a process to collect and disseminate the data freely to water managers and users. Data will be collected remotely via cell modem or satellite and will be made available to program partners through delivery via multiple avenues including MADIS (MesoWest), NOAA's Hydrometeorology Testbed, CW3E's website, and others as requested by partners. Data resolution is two minutes and updates will be provided hourly.

Task 3.2 Scoping and demonstrating data utility

One of CW3E's strengths in their operations in other basins is their strategy to connect soil moisture data with water basin manager needs. Using the newly deployed pilot soil moisture station, in conjunction with other observations available in the watershed (e.g., SNOTEL, USGS stream gauges, multi-network precipitation gauges), the project team will scope opportunities to connect the soil moisture data with monitoring needs for immediate operational decisions and prediction support as well as longer-term climate scale monitoring needs. The project team will

identify areas where usability of existing data collection could be improved; integrate partner perspectives from forecasters to decision-makers; and make recommendations for decision-support improvement and enhancement based on defined partner goals, e.g. preparedness for extreme events; climate resiliency; among others.

Task 3.3 Partner and stakeholder meeting

A final stakeholder and partner briefing will be held to present findings and get feedback on data usability via current dissemination avenues. A demonstration will be conducted making use of data from the new station in the context of existing datasets, with an acknowledgement that the new dataset will become more valuable with increasing length in the period of record after sampling a range of different seasons and storms with different strengths and durations.

Phase 2: Additional Stations and Decision-support Services

Phase 2 of this soil moisture monitoring network program, which is beyond the scope of this request, will add the remainder of recommended stations to the network and develop a robust, interactive decision-support platform. In other watersheds, CW3E has developed an array of data products and dashboards that are iteratively and collaboratively produced by partners to maximize learning, data value, and use for decision-support needs (see Appendix I, Figure 4 for a simple visualization example).

Potential Operational Benefits

With these new observations as important context and potential input into models, end-users will be able to increase confidence in their decision-making based upon forecasts of precipitation impacts and potential streamflow at a variety of timescales. In addition, operations may directly benefit from a comprehensive observation network analysis of existing use of collected data and recommendations to both 1) increase operational benefits of existing data and 2) suggest potentially useful additional data collection strategies.

Some potential uses of improved predictive capability for runoff include:

1) Adjusting reservoir operations in the Upper Yampa River Basin to optimize storage capacity and timing of releases.
2) Better advanced notice of potential water shortages for water managers and individual users.
3) Better data for planning seasonal operations for water users in the Basin.
4) Better communication to the public about water issues and impacts on uses including recreation.
5) Providing agency to water users – like ranchers and homeowners – to make informed decisions on how much water they use and apply to their land.

Phase 1 Deliverables: Basin Analysis, Pilot Site and Data Dissemination

Deliverable		Time
1	***Basin Analysis - 2 reports/presentations; organization and facilitation of meetings***	**Year 1**
1.1	**Documentation of Basin Analysis Framework**	**Year 1**
1.2	**Meeting with Stakeholders and Partners**	**Year 1**
1.3	**Final Report identifying Upper Yampa Basin Soil Moisture Monitoring Network locations: include recommended number of sites, recommended instruments, and permits/permissions needs. Context will include leveraging existing observational networks.**	**Year 1**
2	*Install first soil moisture station*	Year 1-2
2.1	Siting of pilot station, including permitting	Year 1-2
2.2	Installation of pilot station	Year 1-2
2.3	Meeting with Stakeholders and Partners	Year 1-2
3	*Data dissemination and usability demonstration*	Year 2
3.1	Near real-time (hourly) data dissemination through pathways including at minimum: CW3E website, MesoWest, NOAA HMT. May add others as indicated during partner meetings.	Year 2
3.2	Report and presentation demonstrating new station data utility in context of existing observational networks. Includes recommendations for increasing usability of existing observations.	Year 2
3.3	Meeting with Stakeholders and Partners	Year 2

*Detailed descriptions of Deliverables are above.

Budget

Item	2021	2022
Equipment** (1 station)		$15,000
Station Installation and Maintenance**		$20,000
Analysis and Reports (2021: Deliverables 1.1-1.3; 2022: Deliverable 3.2-3.3)	**$50,000**	$35,000
Data dissemination and scope for decision-support opportunities relative to existing and potential data (2022: Deliverable 3.1-3.2)		$10,000
Total by Year	**$50,000**	**$80,000**
TOTAL		**$130,000**

** Budget assumes handling liquid precipitation only; significant assistance with siting, installation, and maintenance from local partners.

Phase 2 Deliverables: Additional Stations in Network and Development of Data Dissemination and Visualization Platform to support manager/user needs

Deliverable	Time
Add additional soil moisture monitoring stations to the network (2-8)	2022-2023
Data dissemination and visualization	2022-2023
Decision support dashboards	2022-2023

Budget

Item	2022	2023
Equipment** (4 stations/year)	80,000	$80,000
Station Installation	60,000	$60,000
Station Maintenance	20,000	20,000
Labor	35,000	35,000
Data dissemination and visualization and scope for decision-support opportunities relative to existing and potential data	65,000	65,000
Total by Year	**$260,000**	**$260,000**
TOTAL		**$520,000**

** Budget assumes handling liquid precipitation only; significant assistance with siting, installation, and maintenance from local partners.

Partnerships

Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Scripps Institution of Oceanography's Center for Western Weather and Water Extremes (CW3E) will purchase equipment and site and deploy instrumentation in collaboration with local partners. CW3E director F. Martin Ralph and his team have extensive experience designing and deploying observation networks to serve local and regional needs throughout the western United States. CW3E has set up data dissemination through various different avenues used by California stakeholders (NOAA HMT, CW3E website, California Data Exchange Center, Mesowest and MADIS) and looks forward to doing the same in Colorado. CW3E also has experience leading development of decision support tools and iterating with partners to maximize their usability and effectiveness. CW3E has been partnering for several years with CMC and YVSC (among other organizations) on the Yampa Basin Rendezvous and looks forward to expanding these partnerships with this project. This partnership will support CW3E's mission to: "Provide 21st Century water cycle science, technology and outreach to support effective policies and practices that address the impacts of extreme weather and water events on the environment, people and the economy of Western North America."

COLORADO MOUNTAIN COLLEGE

Colorado Mountain College Steamboat Springs will serve as a local academic partner to CW3E and provide workforce support to YVSC through an accredited student internship program. Under the mentorship of N. Stewart, Assoc. Professor of Sustainability Studies, bachelor's students seeking career pathways in *weather, water and climate science* will enroll in a meteorological technician certification program designed to train and employ student technicians in support of soil moisture monitoring network (SAMPA) operations and maintenance. CMC's engagement in SAMPA aligns with the institution's mission to "Match academic and training pathways to local and regional labor market demands by innovating and integrating with industry partners" and to "Seek out and promote joint-use partnerships for current and new facilities that address resource needs of both the college and mountain communities" (Pillars C.1 and C.5, Reaching Greater Heights, Colorado Mountain College Strategic Plan 2019-2023). The return on investment in CMC engagement in SAMPA will be measured by post-graduate student placement in the field, including local, state and federal natural resource agencies.

YAMPA VALLEY SUSTAINABILITY COUNCIL

Yampa Valley Sustainability Council will provide on the ground support for the network with staff and interns, working closely with CW3E and CMC, while also serving as the community based non-profit connecting and making the data accessible for community members, local and regional partners through education and outreach. This proposed network and related YVSC activities sit within YVSC's Soil Moisture, Water and Snow Program, which strives to support the community in adapting to a warmer and drier climate in the Yampa Valley and connect relevant research and data with decision-making needs. Other program activities include work relating to the Climate Action Collaborative (charged with implementing the Routt County Climate Action Plan), wildfire-watershed initiatives, snowpack, drought, and water conservation. For YVSC, this proposed network fills data gaps and provides water users and managers with resources and tools that stand to increase their adaptive capacity to the changes ahead.

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Lukas, J. and L. Payton. 2020. *Colorado River Basin Current Understanding of Processes, Patterns and Variability*, September 29, 2020. Webinar in the Colorado River Basin Climate and Hydrology: State of the Science report webinar series.

Runyon, L. (Host). (2021, March 22). Colorado River water negotiation showdown looms [KUNC]. https://cronkitenews.azpbs.org/2021/03/22/a-colorado-river-showdown-is-looming-let-the-posturing-begin/.

Sumargo, E., **A.M. Wilson**, **F.M. Ralph**, R. Weihs, A. White, J. Jasperse, M.A. Lamjiri, S. Turnbull, C. Downer, and L. Delle Monache, 2020: The Hydrometeorological Observation Network in California's Russian River Watershed: Development, Characteristics and Key Findings from 1997 to 2019. *Bulletin of American Meteorological Society*, 101(10): E1781–E1800.

Appendix I

Surface meteorology and soil moisture instrument array examples

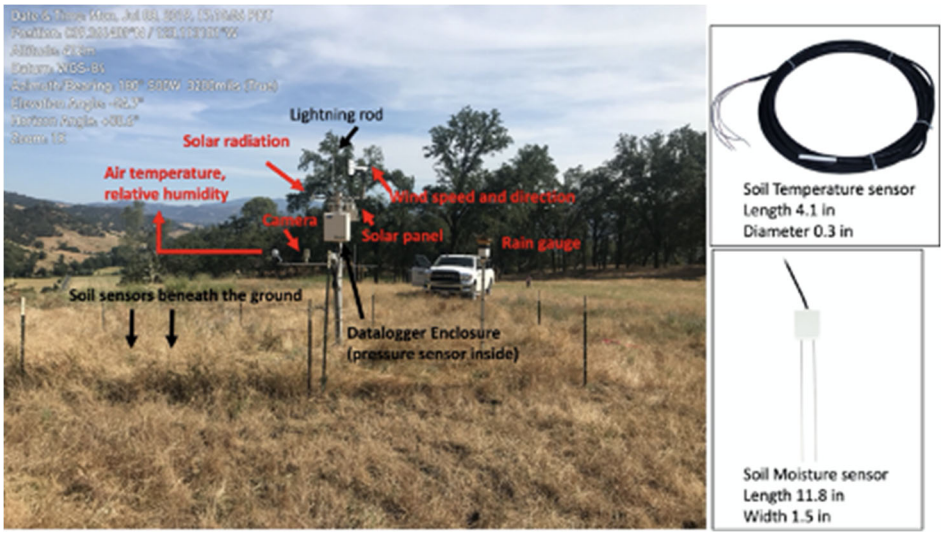

Figure 2. Surface meteorology and soil moisture instrument array example from the Potter Valley North station, showing post (installed with concrete), meteorology and soil moisture instruments and data logger. This installation is shown with a barbed wire fence since the area has cattle and wild hogs. The barbed wire fence is not necessary for all installations.

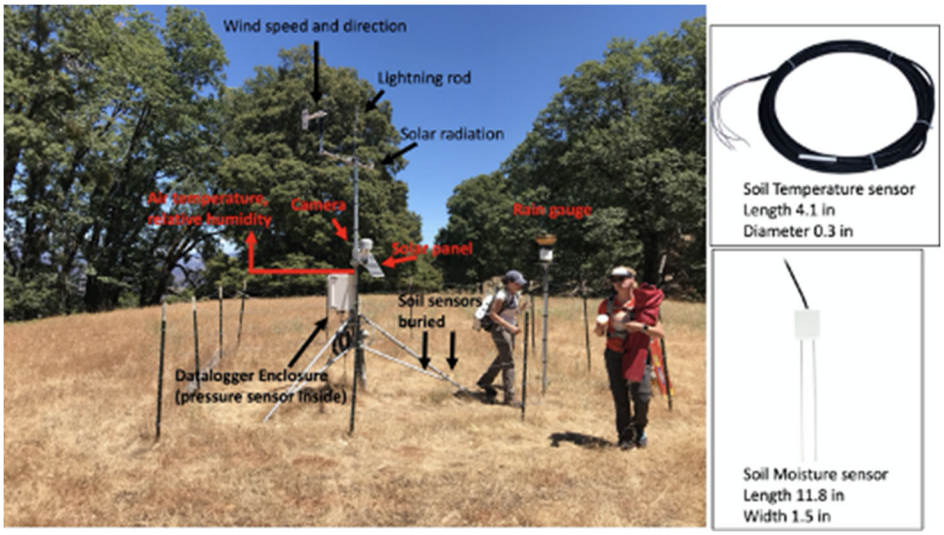

Figure 3. Same as previous, except showing install with a tripod at North Cow Mountain site in the Russian River, CA (see example data output in Figure 2).

Soil Moisture Monitoring Network Data Visualization Example

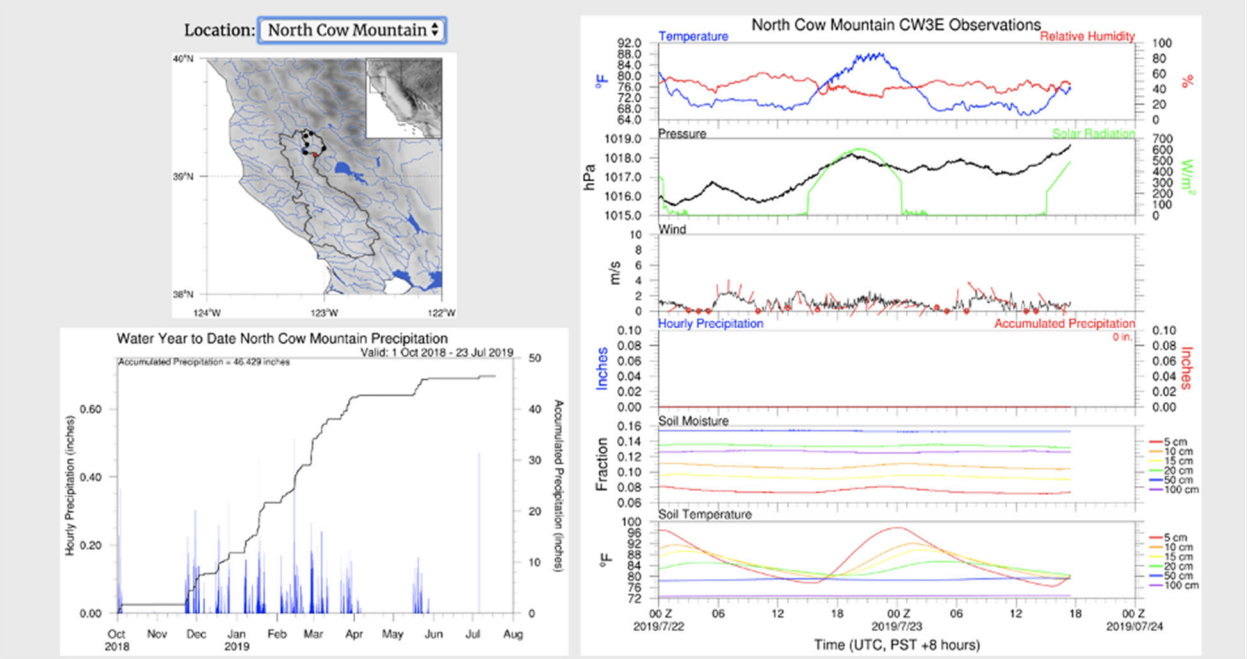

Figure 4. Example of data output from the North Cow Mountain site in the Russian River, CA (see Fig 4 for image of that site). (Website: http://cw3e.ucsd.edu/cw3e-surface-meteorology-observations/)

UCSD # 35591-2021

Evaluating the Observation Network and Enhancing Soil Moisture Observations to Support Decision Making and to Monitor Potential Impacts of Climate Change in the Upper Yampa Basin

Period 1: 07/01/21 through 12/31/21

A. SALARIES & BENEFITS	FY Rates Beginnin	Monthly Direct	No. Months	% Salary or Effort	Person Mos.	Salary Subtotal	Fringe Benefits %	Fringe Benefits Amount	TOTAL
F.M. (Marty) Ralph Researcher	7/21	20,732	6.00	1.65%	0.10	2,057	35.20%	724	2,781
Anna Wilson Research Grant Program Officer	7/21	8,320	6.00	4.00%	0.24	1,999	43.00%	860	2,859
TBN Postdoctoral Scholar	7/21	5,281	6.00	16.67%	1.00	5,282	21.80%	1,151	6,433
TBN Research Data Analyst	7/21	6,716	6.00	16.67%	1.00	6,717	43.00%	2,888	9,605
TBN Field Researcher	7/21	5,019	6.00	10.34%	0.62	3,114	43.00%	1,339	4,453
				Total person months	2.96				
					DIRECT SALARIES TOTAL	19,169			
							BENEFITS TOTAL	6,962	
								SALARIES AND BENEFITS TOTAL	**26,131**

F. CONTRACTUAL

Service Contract - Yampa Valley Sustainability Council	5,000	
SERVICE CONTRACT TOTAL		**5,000**

H. OTHER

Project Specific Communications, Mailing/FedEx, and Network Costs	444	
OTHER EXPENSES TOTAL		**444**

I. TOTAL DIRECT COSTS **31,575**

J. INDIRECT COSTS (less equipment, tuition remission, subcontract costs in excess of $25K)

		Base	OH Rate	
Tuition:	*0*			
Equipment:	*0*	31,575	58.0%	18,314
UC Campus:	*0*			
Excluded from Indirect:	*0*			

TOTAL INDIRECT COST **18,314**

K. TOTAL AMOUNT REQUESTED **49,889**

Evaluating the Observation Network and Enhancing Soil Moisture Observations to Support Decision Making and to Monitor Potential Impacts of Climate Change in the Upper Yampa Basin

	Period 1	Period 2	TOTAL PROJECT
A. Salaries	19,169	11,512	**30,681**
B. Fringe Benefits	6,962	5,083	**12,045**
C. Travel	0	12,038	**12,038**
D. Equipment	0	18,112	**18,112**
E. Supplies	0	2,400	**2,400**
F. Contractual			
Service Contracts	5,000	8,000	**13,000**
H. Other Expenses	444	219	**663**
I. Total Direct Costs	**31,575**	**57,364**	**88,939**
J. Indirect Cost	18,314	22,766	**41,080**
K. Total Amount Requested	**49,889**	**80,130**	**130,019**