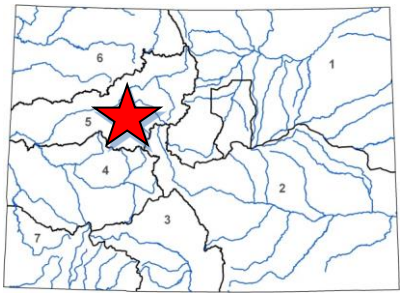
COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Aspen Global Change Institute, Inc.
Roaring Fork Watershed-Evaluation of Soil Moisture for Water Planning

Water Plan Grant Application

September 2022 Board Meeting



LOCATION	
County/Counties:	Pitkin, Eagle, Garfield
Drainage Basin:	Colorado Basins

DETAILS	
Total Project Cost:	$200,976
Water Plan Grant Request:	$140,683
Recommended Amount:	$140,683
Other CWCB Funding:	$0
Other Funding Amount:	$60,293
Applicant Match:	$
*Project Type(s): Planning/*Study	
Project Category(Categories): Conservation and Land Use Planning	
Measurable Result: Impact 111,000 Coloradans	

In the Colorado River Basin in 2021, a winter snowpack of around 80% of average translated into only 30% of average streamflow, contributing to severe deficits in the water supply and creating challenges for water managers. Soil moisture was indicated as one potential contributor to the gap in anticipated vs. realized streamflow. As climate change leads to regional warming, it is anticipated that evapotranspiration (loss of water from the soil) will increase, meaning that monitoring soil moisture may likewise be increasingly critical to water planning and management.

Following the 2021 event, local water managers and hydrologic researchers in the Upper Colorado, including in the Roaring Fork Watershed, showed accelerated interest in expanding soil moisture observations and incorporating soil moisture data into drought forecasts. Likewise, the Colorado Basin Implementation Plan specifically identifies drying soils as a cross-sector challenge, stating: “The effects of drought and climate change impact water supply availability, ecosystems, industry, and agriculture. There are concerns with dry soil moisture conditions, earlier runoff, and aridification” (CBIP, p.8). However, interaction between soil moisture values and streamflow has not been thoroughly investigated for the Roaring Fork Watershed and other mountain snowpack-driven Colorado watersheds.

The Evaluation of Soil Moisture for Water Planning project responds to a community need to better understand how soil moisture data can support drought-ready, climate-adaptive water management.

This project will strategically leverage existing observation networks in the Roaring Fork Watershed to:
- Expand stakeholder engagement around soil moisture data and its interpretation
- Augment current instrumentation to increase sites with co-located snow and soil moisture equipment
- Conduct a water cycle analysis using data to interpret snow, soil moisture, and streamflow relationships
- Produce a Guidebook for Stakeholders to communicate key findings and context
- Create a user-friendly Data Portal for access to local soil moisture conditions

Throughout the project they will closely engage with stakeholders including: water managers, city and county planners, agricultural interests, conservation organizations, and others to ensure that the approach matches the challenges they face. Using the Roaring Fork Watershed as a case-study, this project will provide a basis for identifying opportunities and considerations in utilizing soil moisture data to support decision making in the Upper Colorado River Basin. As the climate continues to warm, driving increased evaporation, this project will provide a necessary foundation for approaching in what ways soil moisture data can be applied to support effective drought planning.

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Water Plan

Water Project Summary

Name of Applicant	Aspen Global Change Institute Inc
Name of Water Project	Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning
Grant Request Amount	**$140,683.00**
Primary Category	$140,683.00
Conservation & Land Use Planning	
Total Applicant Match	**$0.00**
Applicant Cash Match	$0.00
Applicant In-Kind Match	$0.00
Total Other Sources of Funding	**$60,293.00**
Colorado River District	$60,293.00
Total Project Cost	**$200,976.00**

Applicant & Grantee Information

Name of Grantee: Aspen Global Change Institute Inc
Mailing Address: 104 Midland Ave. Suite. 205 Basalt CO 81621
FEIN: 841,305,687

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Grant Management Contact - Alternate: Elise Osenga
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Phone: 9709257376
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Description of Grantee/Applicant

Aspen Global Change Institute (AGCI) is a 501c3 non-profit dedicated to advancing global change science and solutions. We work closely to connect researchers across disciplines and to connect resource managers with the latest science to address key societal challenges.

Type of Eligible Entity

- [ ] Public (Government)
- [ ] Public (District)
- [ ] Public (Municipality)
- [ ] Ditch Company
- [ ] Private Incorporated
- [ ] Private Individual, Partnership, or Sole Proprietor
- [x] Non-governmental Organization
- [ ] Covered Entity
- [ ] Other

Category of Water Project

- [ ] Agricultural Projects
  Developing communications materials that specifically work with and educate the agricultural community on headwater restoration, identifying the state of the science of this type of work to assist agricultural users among others.
- [x] Conservation & Land Use Planning
  Activities and projects that implement long-term strategies for conservation, land use, and drought planning.
- [ ] Engagement & Innovation Activities
  Activities and projects that support water education, outreach, and innovation efforts. Please fill out the Supplemental Application on the website.
- [ ] Watershed Restoration & Recreation
  Projects that promote watershed health, environmental health, and recreation.
- [ ] 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 and Multi-beneficial projects and those projects identified in basin implementation plans to address the water supply and demand gap.

Location of Water Project

Latitude	39.367882
Longitude	-107.033440
Lat Long Flag	Default/Proponent headquarters: If the location cannot be defined with flags above, use location of project proponent headquarters
Water Source	Roaring Fork River, Ruedi Reservoir, Frying Pan River, other tributaries
Basins	Colorado
Counties	Eagle; Pitkin; Garfield
Districts	

Water Project Overview

Major Water Use Type	
Type of Water Project	Planning (e.g. watershed)
Scheduled Start Date - Design	10/1/2022
Scheduled Start Date - Construction	

Description

The Evaluation of Soil Moisture for Water Planning project responds to a community need to better understand how soil moisture data can support drought-ready, climate-adaptive water management.

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Measurable Results

New Storage Created (acre-feet)
New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive
Existing Storage Preserved or Enhanced (acre-feet)
New Storage Created (acre-feet)
Length of Stream Restored or Protected (linear feet)
Efficiency Savings (dollars/year)
Efficiency Savings (acre-feet/year)
Area of Restored or Preserved Habitat (acres)
Quantity of Water Shared through Alternative Transfer Mechanisms or water sharing agreement (acre-feet)
Number of Coloradans Impacted by Incorporating Water-Saving Actions into Land Use Planning
Number of Coloradans Impacted by Engagement Activity

Other

This project will support water planning for the Roaring Fork Watershed and downstream communities in Western Colorado that rely on the Roaring Fork for a portion of their water supply, a total of over *111,000 Coloradans*. Front Range communities, including Denver, that rely on diverted Roaring Fork water supplies would also benefit from the research conducted by this project. Additionally, findings from this project will likely be transferable to other regions. Relevant findings will be shared with other headwater watersheds in Colorado, further expanding the number of Colorado residents that will benefit from this project.

Water Project Justification

The Colorado State Water Plan (CWP) and Basin Implementation Plans (BIP) center around ensuring that Colorado will have adequate water to meet agricultural, municipal, industrial, ecological, and compact needs for decades to come. Understanding how climate change will impact different dynamics of the hydrologic cycle, such as soil moisture, can help support near and long term planning to avoid gaps in the water supply. This project in the Roaring Fork Watershed (a watershed covered by the Colorado Basin Implementation Plan) will support adaptive water management locally and will more broadly advance understanding of potential climate change impacts to water supplies for this and other mountain watersheds with snowpack-driven hydrology.

The Colorado Water Plan acknowledges that “because of climate change, previous assumptions used for planning purposes are no longer sufficient” (CWP, p. 4-11). The Colorado Basin Implementation Plan lists “plan for uncertainty in water supply” as a Key Strategy (CBIP, p.3). Climate change impacts on the relationship between snowpack, soil moisture, and runoff to streamflow is one area where a more nuanced understanding

could help support drought preparedness and bolster understanding of potential climate change impacts.

In the Colorado River Basin in 2021, a winter snowpack of around 80% of average translated into only 30% of average streamflow, contributing to severe deficits in the water supply and creating challenges for water managers. Soil moisture was indicated as one potential contributor to the gap in anticipated vs. realized streamflow. As climate change leads to regional warming, it is anticipated that evapotranspiration (loss of water from the soil) will increase, meaning that monitoring soil moisture may likewise be increasingly critical to water planning and management. Following the 2021 event, local water managers and hydrologic researchers in the Upper Colorado, including in the Roaring Fork Watershed, showed accelerated interest in expanding soil moisture observations and incorporating soil moisture data into drought forecasts. Likewise, the Colorado Basin Implementation Plan specifically identifies drying soils as a cross-sector challenge, stating: “The effects of drought and climate change impact water supply availability, ecosystems, industry, and agriculture. There are concerns with dry soil moisture conditions, earlier runoff, and aridification” (CBIP, p.8). However, interaction between soil moisture values and streamflow has not been thoroughly investigated for the Roaring Fork Watershed and other mountain snowpack-driven Colorado watersheds.

This project proposes creating a case study to forward understanding of the correlation between in-situ soil moisture measurements, snowmelt, and streamflow through:

- Augmentation of existing in-situ soil moisture and meteorological instrumentation
- Water cycle analysis through data comparison of in-situ soil moisture data and SNOTEL USGS, and satellite-derived soil moisture
- Generation of a Guidebook for Stakeholders
- Expansion and update of a soil moisture Data Access Portal

Facilitated engagement between the research and water operations communities will be interwoven throughout each of these activities.

This case study will be based in the Roaring Fork Watershed, a headwaters for the Colorado River, (contributing ~6% of total river flows annually), and a key contributor of diversions for Front Range water supplies (~47,000 acre-feet diverted annually).

The Action Plan of the CWP specifically includes a step to “support innovative and collaborative science… [that will] lead to accurate quantification of the snowpack and runoff, regardless of the scenario.” (CWP, Ch. 6.1, p. 6-14). Changes in timing of melt and volume of snowpack are already apparent in Colorado mountain watersheds, and the CWP acknowledges the potential of these changes to impact water storage, diversions, and reservoir management (CWP, Table 4.1). Less well documented is how summer and fall or multi-year drought contribute to percent of snow that translates to streamflow runoff, with consequences for accuracy in seasonal streamflow forecasting. As the climate of Western Colorado continues to warm, driving increased water loss through evaporation and evapotranspiration, understanding the role of soil moisture in snow-to-streamflow dynamics may help to improve forecast skill [Koster et al, 2010; Mahanama et al., 2012].

ENGAGEMENT AND OUTREACH

The research from this project will serve a dual purpose: primarily to support informed planning and decision making around drought for stakeholders and secondarily to advance understanding of mountain hydrology in the research community. Objective H: Education, Outreach, and Innovation of the Colorado Water Plan includes a recommendation to “expand outreach and education efforts that engage the public to promote well-informed community discourse and decision making regarding balanced water solutions” (CWP, Ch. 10.3, p. 10-14).

As is underlined by the ongoing, severe drought in the Colorado River Basin, the challenges for meeting Colorado water supply needs are likely to grow under continued climate change. Partnerships such as this, across research and management communities, will be critical to helping meet this challenge and creating adaptive water management approaches for the future.

Engagement with varied stakeholders will be woven throughout all aspects of this project. This project will take a cooperative approach, working across boundaries of research and operations to engage feedback and input from stakeholders across multiple sectors, including water managers, utilities, conservation organizations, and agricultural communities. This project will elevate stakeholder input and highlight user needs within the research community, and it will make relevant scientific research directly accessible to the local community through direct interactions with AGCI staff carrying out the locally-relevant soil moisture research. This collaborative approach supports the Colorado Basin Implementation Plan Roundtable PEPO Goal to: “Encourage awareness and development of holistic, locally driven collaborative solutions supported by best available hydrologic and watershed data” (CBIP, p.46). As a boundary organization with over 30 years of experience connecting stakeholders, decision makers, communicators, and researchers AGCI is well suited to act as a conduit for this two-directional exchange.

Both the updated Data Access Portal and the Guidebook produced by the project will help to meet the CWP and CBIP goals of increasing understanding of the water cycle and potential climate impacts to this vital resource.

GUIDEBOOK FOR STAKEHOLDERS

The Guidebook for Stakeholders will be a written document that provides an overview of findings from the project’s water cycle analysis, with these findings packaged in an accessible format that includes context for the data analysis, descriptions of relationships between findings and climate projections, and considerations for water planning.

DATA ACCESS PORTAL:

The Data Access Portal will provide a timely update to AGCI’s existing data sharing platform to make it more robust and user-friendly to stakeholders outside the research community. The portal will offer access to archived and near-live data from all AGCI soil moisture stations in the Roaring Fork Watershed. To support the CWP and CBIP goals of education and data-informed decision making, access to data and metadata will be provided in a way that is clear and easily navigable for stakeholders–as informed by input from the stakeholders themselves.

The Data Access Portal and Guidebook for Stakeholders will be publicly available through the Aspen Global Change Institute website (agci.org) and will be guided by the questions: How could climate change impact local water supplies? And how might in-situ soil moisture data inform climate-adaptive planning around snowmelt driven runoff?

AUGMENTATION OF INSTRUMENTATION:

The Additional Critical Actions and Goals of the CWP emphasizes the need to “Respond to, monitor, and prepare for climate change” (CWP, Ch. 10.2, p. 10-14). The Roaring Fork Watershed Plan (2012), the guiding document referenced in the Roaring Fork’s Basin Implementation Plan, likewise identifies as an Urgent Action “the need to assess and prepare for climate impacts on a local level” (FRWP, p.13).

The Roaring Fork Watershed provides an excellent opportunity to coalesce data from multiple variables and

across agencies to provide a baseline understanding of potential challenges and opportunities in leveraging in-situ soil moisture to generate more accurate streamflow forecasts in the context of a changing climate. AGCI manages a watershed-wide network in the Roaring Fork that is designed for long-term research on local climate change impacts. The 10 station in-situ soil moisture monitoring network spans 6,200 ft to 12,080 ft in elevation and represents multiple ecological zones. The Roaring Fork Watershed is additionally instrumented with 8 SNOTEL sites and 11 USGS stream gauges, as well as other additional weather and river monitoring stations.

This project will augment the existing value of the AGCI and SNOTEL networks by adding instrumentation to targeted sites (two SNOTEL sites, five AGCI sites), where the sub-catchment being monitored currently has either soil moisture sensors or snow depth sensors, but not yet both at the same station.

Adding additional sensors to already instrumented catchments in the Roaring Fork Watershed will build on the value of previous county, city, state, and federal investments by adding datasets that enhance the robustness of water cycle analysis for this project while simultaneously expanding the suite of long-term data available to support future climate change research in mountain headwaters.

Community partners at Ruedi Water and Power Authority and the Colorado River District have expressed interest particularly in the addition of soil moisture stations to the catchment above Ruedi Reservoir, and conversations are already underway with the Colorado NRCS USDA office to validate which SNOTEL stations are most appropriate for augmentation. After installation, these additional sensors will be incorporated into the project's data analysis, and all data from these sensors will be made publicly available for long-term access and application.

WATER CYCLE ANALYSIS:

The water cycle analysis, an evaluation to understand how water is moving through the watershed–e.g., from snow to soil moisture to streamflow–is central to this project working from SNOTEL (an NRCS managed network of snowpack and meteorological sensors), USGS stream gauges, satellite data, and AGCI's soil moisture and weather network, including newly installed sensors. The guiding intent of this analysis will be to improve understanding of the relationship between snow, soil moisture and streamflow.

The Colorado Basin Implementation Plan calls to "capitalize on science and data to understand gaps and risks and to inform priority setting and decision making for the basin" (CBIP, p. 44. Key Strategy 6).

Warming temperatures and alterations in precipitation timing and intensity associated with climate change have the potential to alter soil drying regimes. How changes in soil moisture may impact seasonal streamflow runoff (both timing and volume) and subsequently impact water supplies (both local and regional) is currently unclear. For this project we will conduct a comparative analysis of the new and existing datasets, helping to ground-truth satellite and regional model soil-moisture values. We will then assess the full water cycle over various time scales to better understand the relationship between snow, soil moisture and streamflow. Together these analyses will seek to answer the question: how can soil moisture data be best leveraged to improve planning and seasonal streamflow forecasts? Additionally, the development of a conceptual model describing the influence of soil moisture on runoff based on in situ measurements will provide a foundation for future planning and forecast modeling. The expansion of work regarding soil-moisture is especially critical in light of the fact that climate change is altering the water cycle in such ways that past conditions alone are no longer adequate predictors of likelihood or intensity of drought events in the future. Further research such as this is acknowledged in the Colorado Water Plan: "Many basins now recognize that, because of climate change, previous assumptions used for planning purposes are no longer sufficient" (CWP, p. 4-11)

Related Studies

“Bioclimatic and Soil Moisture Monitoring Across Elevation in a Mountain Watershed: Opportunities for Research and Resource Management.” 2018. Osenga, E.C., Arnott, J.C., Endlsey, A., Katzenberger, J. Water Resources Research, 55. DOI: https://doi.org/10.1029/2018WR023653

“Colorado River Basin Climate and Hydrology: State of the Science.”2020. Lead Authors: Lukas, J. and Payton, E. Publication of the Western Water Assessment. https://wwa.colorado.edu/sites/default/files/2021-06/ColoRiver_StateOfScience_WWA_2020_FullReport_hi-res.pdf

“Drought less predictable under declining future snowpack.” 2020. Livneh, B. and Badger, A.M. Nature Climate Change, 10 (2020). DOI: https://doi.org/10.1038/s41558-020-0754-8

“Skill in streamflow forecasts derived from large-scale estimates of soil moisture and snow.” 2010. Koster, R.D., Mahanama, S.P.P., Livneh, B., Lettenmaier, D.P., and Reichle, R.H. Nature Geoscience, 3 (2010). DOI: https://doi.org/10.1038/NGEO944

“Soil Moisture, Snow, and Seasonal Streamflow Forecasts in the United States.” 2012. Mahmanama, S., Livneh, B., Koster, R., Lettenmaier, D., Reichle, R. Hydrometeorology, 13(1). DOI: https://doi.org/10.1175/JHM-D-11-046.1

Taxpayer Bill of Rights

No known issues

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Last Updated: May 2021

Colorado Water Conservation Board
Water Plan Grant – Statement of Work – Exhibit A

Statement Of Work	
Date:	06 30 2022
Name of Grantee:	Aspen Global Change Institute (AGCI)
Name of Water Project:	Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning
Funding Source:	

Water Project Overview:

The *Colorado State Water Plan (CWP)* and multiple Basin Implementation Plans (BIP) center around ensuring that Colorado will have adequate water to meet agricultural, municipal, industrial, ecological, and compact needs for decades to come. Understanding how climate change will impact water cycles (e.g., snowpack to soil moisture to streamflow) and how these changes affect our water supply can help support near and long-term planning. Successful management to ensure that water supply is sufficient to meet demand relies on accurate representation of streamflow. By deepening our understandings of the relationship between soil moisture and streamflow in the Roaring Fork Watershed, this project will serve to (1) support adaptive water management locally and (2) advance understanding of climate change impacts to water supplies in a watershed that is a key contributor to Colorado River and Front Range water supplies and is emblematic of snowpack-driven hydrology in Colorado and beyond.

Soil moisture acts as an important integrator of hydrologic conditions across seasons and across years. In Colorado's snowy mountains, which serve as water towers for the western US, how wet the soil is in the fall influences how much snowmelt infiltrates into the ground or leaves the system in rivers in the spring. With warming climate conditions it is possible that whether and how the mountains retain water throughout the spring and summer will change (through changes in both snow and soil-drying regimes). Therefore, a better understanding of soil moisture has much potential to improve water management and help communities become drought-ready and better positioned to adapt to climate change. To achieve this, there needs to be (a) an increase in measurements of soil moisture, (b) analysis of how soil moisture observations correlate to other hydrologic variables such as snowpack and streamflow, (c) exploration of how single-point measurements can be used to strengthen modeled or satellite representations of soil moisture, and (d) broader awareness among stakeholders and other data users as to the role of soil moisture in the water cycle and in water resource planning.

In the Colorado River Basin, recent dry years have led to increased interest in installing additional soil moisture measurement stations and incorporating these data into seasonal drought planning. Close collaboration between decision makers seeking this data and researchers who may be collecting this data can

help ensure that data approaches and related communications are meaningful for water management and planning. Furthermore, effectively building capacity to incorporate soil moisture observations into seasonal drought forecasts will require assessment of the value-add of soil moisture data and how its application can be most complementary to other monitored hydrologic variables.

The Aspen Global Change Institute (AGCI) is ideally situated to make this happen. AGCI is a non-profit that has worked in the Roaring Fork Watershed for over 30 years. In carrying out our mission to *advance global change science and solutions*, we work with both researchers and stakeholders, often acting as a facilitator for flow of knowledge across these two communities. Within our own watershed, we have existing, trusted relationships with water-relevant entities including: City of Aspen Water Utility, Ruedi Water and Power Authority, Colorado River District, and Pitkin County Healthy Rivers. (Each of these entities has provided a letter of support for this proposal, which may be found in the supplemental materials of this application.) We also work actively across watershed boundaries in the Colorado River Basin, building networks for climate adaptive planning and supporting education and research efforts that parallel our own work. Consequently, lessons learned throughout this project in the Roaring Fork Watershed will be amplified across other Colorado headwaters watersheds.

AGCI is also well situated from the research perspective of studying soil moisture. We manage a community-supported network of stations that measure soil moisture and other variables in the Roaring Fork Watershed. We propose enhancing this network's data, alongside data from the US Geological Survey, National Resource Conservation Service, and others to assess how in-situ soil moisture can be leveraged to better understand seasonal streamflow. We will pair data analysis with close engagement of local stakeholders, including water managers, city and county planners, agricultural interests, and others.

Outcomes of this project will include:

(A) Identification and communication of lessons and opportunities for using soil moisture data to support planning and decision making in the Colorado River Basin
(B) Deepened understanding of stakeholder needs relative to science research opportunities
(C) A written Guidebook for Stakeholders covering project findings in the context of management needs and including graphs and other visual representations from the project's data analysis
(D) A user-friendly Data Access Portal to communicate local soil moisture conditions
(E) A project final report

Project Objectives:

Objective 1: Strengthen adaptive water management and planning in the Roaring Fork Watershed.

Objective 2: Improve understanding of the role of soil moisture in the water cycle in mountain regions relative to snowpack and seasonal streamflow.

Objective 3: Assess the value-add, opportunities and considerations, for utilizing in-situ soil moisture data to support long-term and seasonal water resource planning.

Objective 4: Provide facilitated, context-rich access to real-time in-situ soil moisture and meteorological data for water resource managers and other stakeholders.

Objective 5: Provide similarly located snowpack-driven mountain watersheds in Colorado and beyond insight into utilizing local soil moisture and snow measurements to help tracking and planning of drought and climate change.

Tasks

Task 1 – Engagement with Stakeholders

Description of Task:

Stakeholder engagement will be an important component throughout all stages of this project.

This task will include conducting meetings, interviews, email outreach, and information-sharing sessions to foster collaborative discussion between AGCI and key water-relevant stakeholders in the Roaring Fork Watershed. The purpose of this collaboration will be to ensure alignment between the needs of stakeholders and the project approach to research and communication.

Feedback and viewpoints gathered throughout engagement activities will be used to guide how findings from the Water Cycle Analysis are conveyed, the content of the Guidebook for Stakeholders, and supporting information and data access format on the Data Access Portal.

In addition to engaging with stakeholders local to the Roaring Fork Watershed, AGCI will additionally disseminate key findings and lessons-learned to partners in other Colorado watersheds including partners in City of Denver, the Yampa Watershed, the East River Watershed, and elsewhere.

Method/Procedure:

In Quarter 1 of the project, AGCI will host one-on-one or small group conversations with stakeholders from the agricultural, municipal, river conservation, and water management communities to identify needs and questions surrounding drought forecasting and planning, particularly as it relates to the relationship between snowpack, soil moisture, and streamflow. AGCI will additionally conduct outreach to groups such as the Colorado River Basin Forecast Center (CRBFC) to gather input on format, content, and location of comparable existing resources for stakeholders relating to hydrologic variables beyond soil moisture.

In Quarter 5 of the project, AGCI will reach out to stakeholders via email to gather feedback on desired content and format for the Guidebook for Stakeholders and data presentation methods for findings from the Water Cycle Analysis, identifying key areas of focus and preferred format of data presentation (e.g., maps, graphs, other). This input will be used to help guide format and content for the Guidebook and the Portal.

In Quarter 7 AGCI will host 2-3 presentations at which stakeholders will be invited to learn about and give feedback on sample materials from the Guidebook. Additionally, some stakeholders will be invited to explore a beta version of the Data Access Portal and provide input on ease of access and use.

In Quarter 8, AGCI will share the final Guidebook and Data Access Tool with stakeholders via email and provide them the opportunity to meet with AGCI staff to receive additional guidance or to provide feedback.

Deliverable:

- Summary of meeting highlights: A text document outlining key feedback and insight from stakeholder engagement throughout the project
- Presentation materials: A PowerPoint presentation or other visuals used to solicit feedback on the Guidebook for Stakeholders and Data Access Portal
- Dissemination Plan: A timeline and approach for engagement and dissemination of resources and lessons learned for watersheds beyond the Roaring Fork

Tasks
Task 2 – Augmentation of Existing Instrumentation
Description of Task:

Last Updated: May 2021

This project will install 5 additional snow depth sensors and two additional suites at three depths each of soil moisture sensors to complement existing AGCI and SNOTEL instrumentation in the Roaring Fork Watershed.

Building upon these existing monitoring networks will increase the number of stations in the Roaring Fork Watershed that represent both soil moisture and snow-depth at a shared station while bypassing the challenges of citing, permitting, and cost associated with the establishment of completely new stations. Soil moisture is variable across different elevations, ecosystems, and soil types. The AGCI and SNOTEL networks complement each other in providing coverage of different elevations and/or different catchments within the Roaring Fork region.

This task will support project Objective 2: *Improve understanding of the role of soil moisture in water partitioning,* by expanding data available for co-located soil moisture and snow depth measurements. All data from new instruments will be made publicly available to support project Objective 1: *Support adaptive water management and planning.*

Data provided by these new sensors will build upon city, county, private, and federal investments that have already been made to strengthen monitoring in the Roaring Fork Watershed. In addition to increasing the robustness of datasets for comparative analysis during this project, these additional sensors will support climate preparedness for a changing water supply by providing additional variables to ongoing monitoring and research on climate change in the Colorado River Headwaters.

This task is in direct response to interest from the Ruedi Water and Power Authority and the Colorado River District in expanding in-situ soil moisture monitoring above Ruedi Reservoir and in other key areas of the Roaring Fork Watershed.

Method/Procedure:

AGCI's current, watershed-wide network (described in the paper: *A community-supported weather and soil moisture monitoring database of the Roaring Fork catchment of the Colorado River Headwaters* https://doi.org/10.1002/hyp.14081) consists of 10 stations that record soil moisture and meteorological observations across an elevational span of 6,200 ft to 12,080 ft, representing a variety of ecosystems and soil types. All stations measure soil moisture at 2 in, 8 in, and 20 in depths and soil temperature at an 8 in depth. Nine sites measure air temperature, relative humidity, and rain. Three of these stations are already equipped with snow depth sensors, two additionally include wind speed/direction, and one has upward/downward radiation as well. These stations have been installed over multiple years, with the longest standing station having a 10-year period of record as of this summer.

SNOTEL is a National Resources Conservation Service (NRCS) managed network of stations that measure snowpack (either depth, snow water equivalent, or both) and relevant weather conditions (such as wind speed, air temperature, and rain). SNOTEL has eight existing stations within the Roaring Fork, only one of which includes soil moisture observations (Schofield Pass, at the edge of the watershed). Conversations are already underway with the NRCS, the Colorado River Basin Forecast Center, and the Colorado River District regarding which SNOTEL sites in the region are most relevant to existing water models and seasonal forecasts.

The locations of AGCI and SNOTEL stations do not overlap, with each network representing different catchments within the Roaring Fork Watershed.

Task 2 will augment these existing networks by adding snow depth sensors to five AGCI stations that do not yet include snow depth measurements and adding soil moisture sensors at three depths (2-4 in, 8 in, and 20 in) to two SNOTEL stations in the Ruedi catchment. Local stakeholders, including the Ruedi Water and Power Authority (RWAPA) have already reached out to AGCI to inquire about the potential of adding soil moisture sensors to the catchment above Ruedi Reservoir to help improve planning and reservoir management.

Step one of this task will be to verify that the selected SNOTEL sites would most benefit water managers by augmentation. AGCI is already in discussion with Ruedi Water and Power Authority (RWAPA), the Colorado River District (CRD), NRCS, and Colorado River Basin Forecast Center (CRBFC) staff about potential benefits of extended soil moisture and snow depth instrumentation in the Roaring Fork Watershed. As an initial implementation step for this project, AGCI will move forward in discussion with these partners to confirm that the proposed sensor locations address current gaps in monitoring equipment and that selected SNOTEL sites above Ruedi Reservoir align with sites weighted most heavily in forecasting models.

Additional snow depth and soil moisture sensors will be ordered upon receipt of funding. The purchase list will be as follows: 5 Judd Snow Depth sensors, 5 analog converters for Onset RX3000 logger boxes, 6 soil moisture sensors (as compatible with existing SNOTEL station equipment) to be installed in suites of three at 2-4 in, 8 in, and 20 in depths, and related hardware (e.g., bolts, crossarms, analog converters etc.).

AGCI will conduct in-office tests to verify accuracy for snow depth sensors and to calibrate soil moisture sensors for accuracy relative to soil type for the location at which they will be installed. Sensors will be installed at their respective AGCI network or SNOTEL sites as soon as weather conditions and access permissions allow. All instrumentation will be in place before summer of 2023.

Following installation, AGCI will maintain and manage data collection from the snow sensors added to the AGCI network. AGCI will work with NRCS SNOTEL personnel to develop a data management plan and a maintenance and repair plan for the sensors added to SNOTEL stations.

As a final step in this task all data collected from both networks will be made publicly available.

Deliverable:

- Successful installation: New equipment is established at all designated stations and is reporting reasonable values.
- Data Archived: First season of data from new sensors is archived alongside existing data on AGCI's updated Data Access Portal, in hard drive back-up files, on the National Science Foundation's CUAHSI Hydro-share data access portal, and on the International Soil Moisture Network website.
- Data Management Plan: a collaborative plan for sharing data moving forward as generated by AGCI and NRCS SNOTEL staff

Last Updated: May 2021

Tasks
Task 3 – Water Cycle Analysis (Data Analysis)
Description of Task:
Funding for this task will be used to improve understanding of the role of soil moisture in the water cycle, using the Roaring Fork Watershed as a case-study of relevance to other Colorado watersheds with snowpack-driven hydrology. The case-study is an assessment of snow- soil moisture -streamflow correlation. This task will support project Objective 2: *Improve understanding of the role of soil moisture in water partitioning,* Objective 3: *Assess the value-add, of utilizing in-situ soil moisture data to support water resource planning*, and Objective 5: *Provide other snowpack-driven mountain watersheds insight into application of soil moisture and snow measurements*. This project will utilize comparative data analysis to assess the relationship between in-situ soil moisture, seasonal streamflow, peak and total seasonal snowpack, and remotely-sensed soil moisture data. This analysis along with further correlation and other statistical analyses will pioneer quantitative reporting on the largely unexplored soil-moisture/streamflow relationship in the Roaring Fork Watershed.
Method/Procedure:
AGCI will conduct a review of existing research on soil moisture/snowpack/streamflow relationships for North American watersheds with snowpack-driven hydrology. AGCI will assemble data from: - AGCI's soil moisture monitoring network: ten stations; elevational spread 6,200 ft to12,080ft ; data available– soil moisture at 2, 8, and 20 in; soil temperature at 8in, rain, air temperature, relative humidity, snow depth [in Year 2 including data from newly expanded instrument suites] - SNOTEL sites located within the Roaring Fork Watershed: eight stations, elevational spread: 8,730ft to 10,650 ft; datasets intended for use in this project– snow depth, snow water equivalent, air temperature, relative humidity, rain, [newly added as of Year 2] soil moisture at 2-4, 8, and 20-in depths - USGS stream gauge data– timing and volume of streamflow (utilizing 8 of the 13 stations located in the Roaring Fork Watershed) - NASA SMAP gridded soil moisture data - Other data sets as relevant These data will be used to conduct an analysis of the new and existing datasets to quantify correlation between soil moisture and: snowpack, streamflow, and satellite derived soil moisture data. Following this comparative analysis, AGCI will assess the full water cycle over various time scales to better understand the relationship between these key variables. These analyses will generate visual elements to represent key findings, such as graphs and tables, designed to enable clearer comprehension and enhance the Guidebook described below in Task 4.
Deliverables:

- Text summaries: Explanations and discussion of key findings from data analysis
- Graphs: Representations of different water cycle components and relationship to soil moisture
- Infographics: Visuals representing soil moisture's role in the water cycle in relation to snowpack and streamflow

AGCI will present findings at local roundtables (such as the Future Forest Roundtable), regional scientific gatherings (such as the Yampa Basin Rendezvous or gatherings of the Colorado Watershed Assembly), and broader scientific gatherings (such as National Soil Moisture Workshop) or conferences held by the American Geophysical Union professional society.

Tasks

Task 4 –Create a Guidebook for Stakeholders

Description of Task:

Clear, informative communication of key findings from the water cycle analysis will be essential to meeting project Objective 1: *Support adaptive water management and planning,* Objective 2: *Improve understanding of the role of soil moisture in water partitioning*, and Objective 5: *Provide other snowpack-driven mountain watersheds insight into application of soil moisture and snow measurements*.

AGCI will use stakeholder input on key questions and drought planning needs to inform the writing of the Guidebook for Stakeholders. This written document will cover key findings from the project in the form of text explanations, graphs, maps, and infographics. This output will provide a resource to help water managers and other decision makers in the Roaring Fork Watershed better understand the regional relationship between soil moisture, snowpack, and streamflow in the context of climate change. The Guidebook will also describe considerations and opportunities for utilizing in-situ soil moisture data to improve spring seasonal streamflow forecasts and will address the questions: How might climate change impact local water supplies? How might in-situ soil moisture data inform climate-adaptive planning around snowmelt driven streamflow?

Method/Procedure:

This task will be carried out in collaboration with key stakeholders as an iterative process throughout the project.

During Quarter 1, AGCI will engage with stakeholders to understand what information is most needed for water planning and management. Relative to the Guidebook for Stakeholders, feedback will be recorded in relation to: type of information desired, pertinent topics of related context, and preferred method of visual delivery of information.

As soon as results are available from the water cycle analysis, these data and findings will be used to generate a baseline description of the role of soil moisture in the water cycle of the Roaring Fork Watershed, relative to snowpack and streamflow.

Drafting of the Guidebook for Stakeholders will begin at the start of the second year of the project (Quarter 5). The Guidebook will be a written document, approximately 20 pages in length and including graphs and other visual data representations. This Guidebook will utilize the project's assessment of the water cycle to discuss the quantitative and qualitative relationship between in-situ soil moisture measurements and in-situ snow depth and streamflow values in the Roaring Fork Watershed. However, the document will move beyond simply providing graphs and statements of findings to include context in which this research was carried out, observations on the role of soil moisture in the water cycle broadly, and considerations for how in-situ data may best be leveraged to improve seasonal water forecasting: opportunities and considerations.

During Quarter 5 and 6, AGCI will generate beta-versions of graphs, infographics, and example sections of text to communicate findings from project data analysis. These beta materials will be shared via email with project partners for feedback on efficacy in communicating concepts, visual clarity, and intuitiveness.

In Quarter 7, AGCI will make revisions to final outputs before completion of the project. As needed, individual meetings will be set with stakeholders to answer questions and gather additional information about response to the Guidebook draft and visualizations.

In Quarter 7 AGCI's communication manager will provide edits for clarity and ease of comprehension to the Guidebook for Stakeholders, and AGCI will engage with a graphic designer to ensure clarity and visual appeal of the final product.

In Quarter 8, AGCI will share the Guidebook with Roaring Fork stakeholders through individual or small group meetings, as well as at group presentations. This outreach will serve a dual purpose of providing an additional opportunity for stakeholder response to the final Guidebook and allowing AGCI to offer explanation and guidance on use of the Guidebook.

This document will be made available as a PDF on AGCI's website, will be provided directly to stakeholders who provided feedback throughout the project, will be announced on AGCI's social media platforms, and will be shared with research and community partners in other watersheds in Colorado.

Deliverable:

- Guidebook for Stakeholders document: PDF and printed versions of the Guidebook for Stakeholders
- Digital Access: Public, online access to the Guidebook for Stakeholders on agci.org
- Presentation of Guidebook: In-person presentation to present stakeholders with an introduction to the Guidebook and other key findings from the project
- Cross-Watershed Outreach: Dissemination of Guidebook to partners in City of Denver, the Yampa Watershed, the East River Watershed, and others

Tasks

Task 5 – Upgrade Soil Moisture Data Access Portal

Description of Task:

This project will upgrade AGCI's existing data platform to create a more user-friendly soil moisture data access tool. The revamped platform will allow stakeholders to not only access near real-time soil moisture and meteorological data, it will additionally provide context around collection of data, field sites, and the role of soil moisture in drought and water planning; links to other relevant research networks; and data visualizations.

This task will support project Objective 4: *Develop a tool for data-sharing,* and Objective 1: *Support adaptive water management and planning*.

Methods:

Data from AGCI's soil moisture network are currently available on an annual basis on the Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) Hydro-share , account access only data portal. Additionally, AGCI currently manages an Application Programming Interface (API) which automates data collection across eight of the network's sites for near-real time downloads. The existing interface is not designed for users outside of the research community and does not provide visualizations or contextual information about the data available.

Beginning in Quarter 2 of the project, AGCI will carry-out phone or in-person conversations with stakeholders from the water management, water education, and water conservation communities to understand their current avenues for and barriers to data access.

Following these conversations, AGCI will work with an expert in web design and data management to update AGCI's existing API to be a dependable, easily accessible, user-friendly data access portal that includes data from all ten of AGCI's soil moisture stations. The webpage will (a) provide a more robust system of data collation; (b) apply basic QA/QC flags to the data and apply calibrations to soil moisture data, (c) provide "readme" files to accompany data downloads that offer site metadata, (d) and provide other contextual information about the dataset. The platform will also include a basic explanation of the role of soil moisture in the water cycle.

Work on the Data Access Portal, in terms of discussing approach, how data should be represented, and data management approaches will begin in Quarter 3 of the project. A basic beta platform for the access tool will be developed in Quarter 5 and tested both internally and with feedback from key stakeholders in the following months.

An operational portal will be available by the end of Quarter 8 of the project.

Deliverable:

- Downloadable Data: Streamlined access to data from AGCI's pre-existing and newly augmented instrumentation
- Data Context: An online portal that provides access to and context for soil moisture and other hydrologic data local in the Roaring Fork Watershed
- Visualizations: graphs and other example representations of soil moisture values

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.

Last Updated: May 2021

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 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 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 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 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.

Last Updated: May 2021

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Exhibit C
Budget and Schedule

Prepared Date:

Name of Applicant:

Name of Water Project:

Project Start Date:

Project End Date:

Task No.	Task Description	Task Start Date	Task End Date	Grant Funding	Match Funding	Total
1	Engagement with Stakeholders	Oct 2022	Oct 2024	$20,160	$8,640	$28,800
2	Augmentation of Existing Instrumentation	Oct 2022	May 2023	$23,538	$10,088	$33,625
3	Water Cycle Anaysis	Oct 2022	Jun 2024	$39,410	$16,890	$56,300
4	Create a Guidebook for Stakeholders	Oct 2023	Oct 2024	$28,560	$12,240	$40,800
5	Soil Moisture Data Access Portal Upgrade	July 2023	Oct 2024	$29,015	$12,435	$41,450
			Total	$140,683	$60,293	$200,975

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Detailed Budget Estimate
Fair and Reasonable Estimate

Prepared Date: 06 30 22
Name of Applicant: Aspen Global Change Institute
Name of Water Project: Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning

Detail: Roaring Fork Watershed--Evaluation of Soil Moisture for Water Planning

	Staff				Contracts, Equipment, Supplies							
Sub-task	Community Science Manager	Senior Staff, Research Director	Research Scientist	Subtotal	Field Technician Stipend	Research Intern Stipend	Sub-Contracts	Other (Itemized expenses)	Subtotal	Project Total	**CWCB Funds**	**Matching Funds**
	$75	$150	$85		Lump sum	Lump sum	Lump sum	Lump sum				
Task 1 - Engagement with Stakeholders	Estimated Hours											
Project Initiation / Stakeholder identification	30	5	20	$ 4,700					**$ -**	$4,700	$3,290	$1,410
Intial outreach and interviews	40	10	20	$ 6,200					**$ -**	$6,200	$4,340	$1,860
Mid-project feedback and beta testing	20	5	20	$ 3,950					**$ -**	$3,950	$2,765	$1,185
Final Reporting/Hosted Presentations	30	10	30	$ 6,300					**$ -**	$6,300	$4,410	$1,890
Project Management	20			$ 1,500					**$ -**	$1,500	$1,050	$450
Other Direct Costs -- Meeting Refreshments, Travel expenses (itemized below)								$ 6,150	**$ 6,150**	$6,150	$4,305	$1,845
Task 2 - Augmentation of Existing Instrumentation												
Ordering Equipment	10		5	$ 1,175					**$ -**	$1,175	$823	$353
Instrument Calibration	30		20	$ 3,950	$ 1,000				**$ 1,000**	$4,950	$3,465	$1,485
Planning and permitting	30		20	$ 3,950					**$ -**	$3,950	$2,765	$1,185
Instrument Installation	80			$ 6,000	$ 3,200				**$ 3,200**	$9,200	$6,440	$2,760
Data integration			40	$ 3,400					**$ -**	$3,400	$2,380	$1,020
Project Management	20			$ 1,500					**$ -**	$1,500	$1,050	$450
Other Direct Costs--Snow and soil moisture sensors (itemized below)								$ 9,450	**$ 9,450**	$9,450	$6,615	$2,835
Task 3 - Water Cycle Analysis												
Data Analysis		80	220	$ 30,700		$4,000			**$ 4,000**	$34,700	$24,290	$10,410
Data Access/Management		10	80	$ 8,300					**$ -**	$8,300	$5,810	$2,490
Generation of Visualizations	20	10	80	$ 9,800			$2,000		**$ 2,000**	$11,800	$8,260	$3,540
Project Management	20			$ 1,500					**$ -**	$1,500	$1,050	$450
									$ -			
Task 4 - Create a Guidebook for Stakeholders												
Assessment and design for stakeholder initial input	20	20	20	$ 6,200		$4,000			**$ 4,000**	$10,200	$7,140	$3,060
Generation of visuals and text	20	20	80	$ 11,300					**$ -**	$11,300	$7,910	$3,390
Revisions and final draft	20	20	80	$ 11,300					**$ -**	$11,300	$7,910	$3,390
Graphic design							$6,000		**$ 6,000**	$6,000	$4,200	$1,800
Project Management	20			$ 1,500					**$ -**	$1,500	$1,050	$450
Other Direct Costs--Printed Copies				$ -				$500	**$ 500**	$500	$350	$150
Task 5 - Soil Moisture Data Access Portal Upgrade												
Planning/Integration of Stakeholder input	20	10	20	$ 4,700					**$ -**	$4,700	$3,290	$1,410
Platform web design and data automation	10	10	80	$ 9,050		$2,000	$8,000		**$ 10,000**	$19,050	$13,335	$5,715
Development of visual elements	30	20	80	$ 12,050					**$ -**	$12,050	$8,435	$3,615
Data management	10		40	$ 4,150					**$ -**	$4,150	$2,905	$1,245
Project Management	20			$ 1,500					**$ -**	$1,500	$1,050	$450
				$ -					**$ -**			
TOTALS	520	230	955		$4,200	$10,000	$16,000	$16,100		**$200,975**	**$140,683**	**$60,293**

Itemized expenses (included in "Other Direct Costs"rows above)

Item:	Units	Unit Cost	Total
Meeting Refreshments	3	$50	$150
Travel Expenses	3	$2,000	$6,000
Snow Sensor: Judd Snow Depth Sensors ($1100), crossarms ($200), hardware ($100), shipping ($100)	5	$1,500	$7,500
Soil moisture sensor (Campbell soil moisture/temp sensor) ($250), shipping ($25), hardware ($50)	6	$325	$1,950
Printed Copies of Guidebook for Stakeholders	25	$20	$500
Total Cost:			**$16,100**

CITY OF ASPEN

Attn: Kevin Reidy, Conservation and Land Use Planning
Colorado Water Conservation Board
1313 Sherman St.
Denver, CO 80203

Subject: Colorado Water Plan Grant Program

Dear Colorado Water Conservation Board,

On behalf of the City of Aspen Water Department, I would like to submit a letter in support of Aspen Global Change Institute's (AGCI) Colorado Water Plan grant application: Roaring Fork Watershed-Evaluation of Soil Moisture for Water Planning.

The City of Aspen is committed to providing a safe and resilient water supply for our residents and visitors. Efficient and climate-adaptive management of water resources is reliant on accurate understanding of the factors influencing seasonal streamflow. AGCI's Soil Moisture Evaluation project proposes to conduct an assessment of the relationship between soil moisture and streamflow that would help improve understanding of water supplies in the Roaring Fork Watershed, where the City of Aspen is located. This work would support our water management goals by helping to provide a clearer understanding of how soil moisture relates to snowpack and predictions of spring runoff. Additionally, this project includes the creation of a data-communication tool that would improve ease of access to and visual representations of data from AGCI's existing soil moisture research stations. Such a tool would help improve ease of access to information of high interest to the City.

City of Aspen has a long history of working in close partnership with AGCI to learn about local climate impacts to our community. We have also helped fund some of the stations in the existing AGCI soil moisture monitoring network. Our relationship is one of trusted partnership around using the best available science to support smart planning and community needs.

For these reasons, we strongly support AGCI's Colorado Water Plan Grant application: Roaring Fork Watershed-- Evaluation of Soil Moisture for Water Planning.

If you have any further questions, please feel free to contact me at 970.309.5657 or steve.hunter@aspen.gov

Sincerely,

Steve Hunter

Steve Hunter PE, PH. Utility Resource Manager/City of Aspen

COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

June 29, 2022

Via electronic mail
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

RE: Colorado Water Plan Support Letter: Aspen Global Change Institute

Dear CWCB Board of Directors:

The Colorado River Water Conservation District ("River District") is pleased to support the Aspen Global Change Institute's application to the Water Plan Grant Program for the Roaring Fork Watershed-Evaluation of Soil Moisture for Water Planning Project.

Colorado's Western Slope and the entire Colorado River Basin continue to suffer from the effects of multi-decadal drought and increasing temperatures. The impacts of these hotter, drier temperatures on water supplies are real and meaningful. For every 1-degree Fahrenheit rise in average temperature, we see streamflow reductions between 3% and 9%, with most recent studies leaning heavily on the 9% end of the spectrum. Soil aridification significantly compounds streamflow issues. As temperatures rise, moisture evaporates from our plants and soils, creating a massive water debt due when snows melt, drawing water away from rivers and streams. Never has this issue been clearer than in 2021, when our headwaters snowpack averaged at 89% while inflows to Lake Powell reached only 32%.

Since 2012, the Aspen Global Change Institute (AGCI) has been at the forefront of measuring soil moisture with an established, local network across the Roaring Fork Basin. We support their efforts to identify opportunities and considerations in utilizing soil moisture data to support planning and decision making by multiple entities in the Upper Colorado River Basin. As hydrologic uncertainty persists, we must support efforts aimed at understanding climate change and how it may affect water supplies.

Thank you for your consideration.

Sincerely,

Andrew A. Mueller
General Manager

970.945.8522
201 Centennial Street | Suite 200
Glenwood Springs, CO 81601
ColoradoRiverDistrict.org

Pitkin County Healthy Rivers
530 East Main Street Suite 301
Aspen Colorado 81611
970 920 5191 office
970 309 2139 cell
pitkincountyrivers.com

June 24, 2022

Kevin Reidy, Conservation and Land Use Planning
Colorado Water Conservation Board
1313 Sherman St.
Denver, CO 80203

AGCI Grant Proposal: Colorado Water Plan Grant Program

Dear Mr. Reidy,

On behalf of the Pitkin County Healthy Rivers Program and Board ("HRSB"), I would like to write to support the Aspen Global Change Institute's proposal to the Colorado Water Plan Grant Program for the project "Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning."

In 2008, Pitkin County voters authorized a dedicated sales tax to establish a healthy rivers and streams fund. The Pitkin County HRSB assists our local representatives and citizens in administering the fund program and in furthering the objectives of the program. Objectives for the fund include maintaining and improving water quantity and quality within the Roaring Fork Watershed as well as working with other entities to ensure ecological health, recreational opportunities, and wildlife and riparian habitat.

The health of our rivers and streams in the Roaring Fork Watershed is impacted by both natural conditions as well as a myriad of water management related decisions. In all cases understanding the water-cycle, especially it's impacts related to climate warming, can mean the difference between a smart decision and a regretful one. In order to better strategize in protecting the quantity and quality of flows throughout our watershed, Pitkin County's Healthy Rivers Program would be particularly interested in how the Soil Moisture project proposed by AGCI would help advance local understanding of how soil conditions in a drought year impact our streamflow's.

Advancing understanding of how soil moisture translates to snow-to-streamflow dynamics is proving to be critically important to understand in order to inform adaptive water management. AGCI's goals of collecting this more refined type of information improves planning around water resources especially for municipalities, agricultural diverters, reservoir operations, in-stream flow protections, coordination with trans-basin diverters, and obligations to the Colorado River's 15-mile reach.

The Pitkin County Healthy Rivers Board and program has supported AGCI's long-term research on soil moisture at their local research stations multiple times in the past. AGCI is well respected, effective

Pitkin County Healthy Rivers
530 East Main Street Suite 301
Aspen Colorado 81611
970 920 5191 office
970 309 2139 cell
pitkincountyrivers.com

communicators, as well as a reliable source of locally collected data and scientific information in-general regarding our warming climate.

We feel the Pitkin County Healthy Rivers Program and the Roaring Fork Watershed would benefit from the "Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning." We strongly urge the Colorado Water Plan Grant Program approve this request for funding.

Sincerely,

Chris Lemons
Chair

RWAPA
Ruedi Water & Power Authority

Ms. Jaclyn Brown
Colorado Water Conservation Board
1313 Sherman St.
Denver, CO 80203

Subject: AGCI Grant Proposal: Colorado Water Plan Grant Program

Dear Ms. Brown, Directors, and Staff of the CWCB,

I am writing to express Ruedi Water and Power Authority's (RWAPA) full support in favor of funding the Aspen Global Change Institute's proposal: Roaring Fork Watershed–Evaluation of Soil Moisture for Water Planning.

RWAPA is a regional water agency in the Roaring Fork Watershed, directed by a Board with an elected official from each local government within the watershed – City of Aspen, Town of Snowmass Village, Town of Basalt, Town of Carbondale, City of Glenwood Springs, Pitkin County and Eagle County. Our mission is to mobilize resources and influence to protect and enhance the waters and communities of the Roaring Fork Watershed. We foster, facilitate, and support policies, programs, and projects that span jurisdictional boundaries and are more beneficial or efficient when implemented watershed wide. This project, and the data to be collected from it, most certainly is of interest and benefit to all of our jurisdictions.

With ongoing drought in the Roaring Fork Watershed, understanding the role of soil moisture is more important than ever. The data analysis carried out by this project would provide important insight into the snow-soil moisture-streamflow relationship, allowing for better forecasting of annual water availability and streamflow expectations. The Summary for Stakeholders developed by this project would be useful for drought planning and adaptive water management. The data access tool product would offer easy access to information and context for interpreting local soil moisture data. Additionally, this project proposes to add soil moisture sensors to two existing SNOTEL sites in the Ruedi Reservoir catchment. This would directly benefit us by adding an additional, critical variable to the datasets used to inform operations of this reservoir.

RWAPA would benefit from this project and strongly supports AGCI's proposal to the Colorado Water Plan Grant Program.

If you have any further questions, please feel free to contact me at 970-901-6082 or april@rwapa.org.

Sincerely,

April B. Long
Executive Director, Ruedi Water and Power Authority

P.O. Box 565
Basalt, CO 81621