COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan

Water Project Summary

Name of Applicant	Northern Water
Name of Water Project	Project-01865 Phase I of the Colorado Aerial Snowpack Measurement Study
Grant Request Amount	**$1,877,400.00**
Primary Category	$1,877,400.00
Water Storage & Supply	
Total Applicant Match	**$160,000.00**
Applicant Cash Match	$150,000.00
Applicant In-Kind Match	$10,000.00
Total Other Sources of Funding	**$774,860.00**
Other partner agency match funding for snow-on lidar (Denver Water, USGS, Lawrence B Natl Lab)	$549,860.00
Partner agency match funding for snow-free (St. Vrain & Left Hand Water, pending Dec board approval)	$50,000.00
Denver Water	$15,000.00
Northern Water (pending availability of snow-free data in Granby, Willow Creek basins)	$150,000.00
Northern Water	$10,000.00
Total Project Cost	**$2,812,260.00**

Applicant & Grantee Information

Name of Grantee: Northern Water
Mailing Address: 220 Water Avenue Berthoud CO 80513
FEIN: 846,000,204

Organization Contact: Emily Carbone
Position/Title:
Phone: 970-699-0759
Email: ecarbone@northernwater.org

Organization Contact - Alternate: Bradley Wind
Position/Title:
Phone: 970-622-2320
Email: bwind@northernwater.org

Grant Management Contact: Emily Carbone
Position/Title:
Phone: 970-699-0759
Email: ecarbone@northernwater.org

Description of Grantee/Applicant

Northern Water is a conservancy district that delivers water to municipal and agricultural entities, providing water to over a million people in northern Colorado. Northern Water jointly operates and maintains the Colorado-Big Thompson Project, a federally owned water project that delivers supplemental water to northeastern Colorado, with the Bureau of Reclamation. Northern Water also manages a variety of other water projects and infrastructure. In addition, Northern Water provides regional leadership through data collection and delivery (including water supply forecasts), water efficiency programs, source water protection and interagency cooperation.

Type of Eligible Entity

- ☐ Public (Government)
- ■ Public (District)
- ☐ Public (Municipality)
- ☐ Ditch Company
- ☐ Private Incorporated
- ☐ Private Individual, Partnership, or Sole Proprietor
- ☐ 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.
- ☐ 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	40.322247
Longitude	-105.075510
Lat Long Flag	Default/Proponent headquarters: If the location cannot be defined with flags above, use location of project proponent headquarters
Water Source	Our findings and development of a statewide ASO program will benefit the entire state. The flights included in this project are located in the Yampa, South Platte, Colorado, Arkansas, Gunnison, and Dolores basins.
Basins	
Counties	
Districts	

Water Project Overview

Major Water Use Type
Subcategory
Scheduled Start Date - Design
Scheduled Start Date - Construction
Description

Building on a legacy of Airborne Snow Observatories (ASO) flights (funded by CWCB and other partners), the Colorado Airborne Snow Observatories (CASO) workgroup (a WSRF-sponsored project) has identified 2022 as crucial for expansion and study of snow remote sensing flights in Colorado to establish the foundation for a sustained statewide ASO program. The proposed work will include snow remote sensing flights using the ASO methodology, workshops to study optimal data utilization amongst all stakeholder groups, conducting ASO-informed streamflow forecasting, comparing forecasting methods, and furthering the CASO program facilitation effort. Several flights are proposed in winter/spring providing decision-support data, and several are proposed for summer to establish baseline data supporting snow surveys in 2022-2023 and beyond. Data products from this project will be freely available to all stakeholders.

This project will also study the local-state-federal partnership model seen as critical to implementing a sustained statewide program. CASO will work with the CWCB to facilitate flight logistics and establish an ASO-coordinating body in Colorado.

Airborne Snow Observatories, Inc. remains the only provider for this unique combination of sensors, modeling, and processing – producing high-resolution, spatially-complete, and accurate snow depth, SWE, and albedo products. This product suite is referenced as “ASO” throughout this document.

Outcomes (Other):

Using the ASO lidar + spectrometer + camera sensor package to measure the basin-wide snow depth, SWE, and snow albedo, this study will explore the impacts of accurate, full-basin SWE accounting and albedo mapping on water supply forecasts and water management decision-making. The ASO remote sensing and data processing process are the most accurate method for estimating SWE at the watershed scale.

From these data products, the error in current SWE estimation methods can be quantified as well as how accurate basin SWE measurements may benefit all water stakeholders in Colorado. Winter/spring snow-on flights will provide these snow data products on operationally-relevant timetables, and summer/fall snow-free flights will lay the necessary groundwork to expand this analysis based on recommendations from the CASO Workgroup and WSRF Feasibility Study Recommendations. This study will also analyze differences in streamflow forecasting and data assimilation approaches between standard methods and NCAR’s WRF-Hydro platform that integrates the collected ASO SWE and albedo data, as well as study the options for integrating this data into other streamflow forecasting systems.

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

Water Project Justification

All aspects of water availability and security are driven by the ability to properly measure Colorado's water supply. Additionally, all Basin Implementation Plans identify the need to manage risk around water supply availability, both for in-basin M&I, recreational and environmental demands, Colorado River Compact administration and other goals.

In Chapter 10.3 of the Water Plan—Critical Goals and Actions—Critical Action #4 of the storage goal directly references data gaps. The importance of identifying and closing data gaps is essential for optimizing water supply and storage for all water users throughout the state of Colorado. Historically, accurately measuring basin-scale snowpack has been a persistent and high-impact data gap. Airborne Snow Observatories (ASO) measurements play a key role in filling that data gap.

At its core, the ASO snowpack measurements produce the only reliably accurate watershed-scale measurements of the snowpack of any existing technologies. Through its widespread implementation, there are multiple benefits that come at that scale:

• More precise and better-trusted seasonal runoff estimates for the April-July runoff season
• A better understanding of the uncertainty in current snowpack measurement methods
• Quantitative understanding of the impacts of climate change on Colorado's water supply

We have widespread interest in this study from stakeholders across many sectors and all major Colorado river basins. The evidence of this is the 36 letters of support we have received (including letters from 7 Basin Roundtables) to conduct this project and continue to study and grow the CASO program into the future.

The following agencies have provided letters of support for this project as well as matching funding:
• Northern Colorado Water Conservancy District
• Denver Water
• United States Geological Survey (USGS)
• Lawrence Berkeley National Laboratory
• St. Vrain and Left Hand Water Conservancy District

The following agencies have provided general letters of support:
• Southwest Basin Roundtable
• Metro Basin Roundtable
• Gunnison Basin Roundtable
• Colorado Basin Roundtable
• South Platte Basin Roundtable
• Yampa/White/Green Basin Roundtable
• Arkansas Basin Roundtable
• Colorado Division of Water Resources

• Colorado River Water Conservation District
• Colorado Springs Utilities
• Southwest Water Conservancy District
• Colorado Basin River Forecast Center (CBRFC)
• United States Bureau of Reclamation (USBR)
• United States Bureau of Reclamation Western Colorado Area Office
• Grand Valley Water Users Association
• Ute Water Conservancy District
• Colorado Water Trust
• Colorado State University
• City of Thornton
• City of Aspen
• Upper Yampa Water Conservancy District
• Colorado Snow and Avalanche Center
• City of Greeley
• Dolores Water Conservancy District
• City of Westminster
• City of Boulder
• Aurora Water
• Yampa Valley Sustainability Council
• City of Fort Collins
• Boulder County
• Pitkin County Healthy Rivers and Streams Board
• Town of Cedaredge

Below are specific goals within the Water Plan that would see direct benefit due to improved snowpack measurements using ASO technology. Goals within the Basin Implementation Plans are included in a separate document attached to this application.

Section 6.2: Meeting Colorado's Water Gaps
• Comply with and manage the risk associated with interstate compacts and agreements:
More precise measurement of snowpack will allow for better planning and understanding of Colorado's available supply and prevent overallocation (or under-allocation) of water within Colorado. ASO data can provide Colorado water managers with more confidence in making water allocation decisions within Colorado while also ensuring that downstream compact obligations are met.
• Develop multipurpose storage and projects/Balance all needs and reduce conflict:
ASO flights cover key headwater basins and provide multi-sectoral benefits. Storage projects specifically see direct benefit from ASO. Nearly every major reservoir in Colorado operates within a multi-objective framework, balancing inflows, releases, flood control, contracted supplies, and compliance. More accurate knowledge about remaining runoff will allow reservoir operators to balance those multiple objectives in a defensible way.

Meeting M&I Water Needs Throughout Colorado
• Meet community water needs during periods of drought:
Accurate measurement of snowpack and remaining runoff during key times will provide municipalities with information to make better decisions. If municipalities can make more informed decisions around drought declaration, watering restrictions, and other operational aspects, they will operate at lower risk of municipal shortages.

Meeting Colorado's Agricultural Needs
• More accurate measurement of the snowpack and ASO-integrated streamflow forecasting will allow contracted water providers to develop more appropriate contracts based on water availability. This will reduce unplanned agricultural shortages or cost increases that could be caused by the overestimation of water availability.

Meeting Colorado's Environmental and Recreational Needs
• The environment (i.e. rivers/river-dependent ecosystems) sees benefit when water is managed as efficiently as possible so that more water can be shared/released as instream flows. ASO contributes to efficient water management through providing accurate measurements of watershed scale snowpack, which provides water users the confidence to make water management decisions, including for the environment and recreational needs. In the words of a staff member from the Colorado Water Trust in relation to the value of ASO: "[Water] sharing works best with as much certainty as possible." ASO helps provide that certainty.

Section 6.3: Water Conservation and Reuse
• Support water management activities for all water providers:
Similar to the above, ASO provides water managers confidence in knowing to a high degree of accuracy the amount of water that will eventually run off above their points of diversion. This improved understanding will allow for more informed decisions on reservoir operations, watering restrictions, drought declarations, and conservation practices.

Section 6.5: Municipal, Industrial and Agricultural Infrastructure Projects and Methods
• Collaborative Management Solutions
The proposed ASO flights, now and in future years, are planned with equity in mind. The design of these flights is to provide timely information to benefit multiple stakeholders and sectors. Notably, the members of the Colorado ASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

Section 6.5.3: Storage
• Storage vessels can meet a variety of needs beyond water conservation, including but not limited to: Compact Compliance, Drought Mitigation, others
Improved snowpack measurement will allow water providers to make more informed decisions around water use and savings, to stave off drought, and mitigate risk of compact non-compliance.

Water Plan Identified No-and-Low-Regrets Actions that would benefit from ASO
• Identify and Prioritize Multipurpose Storage and Infrastructure Opportunities
• Manage and improve storage, infrastructure, and reservoir operations to benefit environmental and recreational values
• Support basin roundtables in identifying feasible multipurpose projects
• Prioritize implementation of multipurpose projects that meet values of the Colorado Water Plan

An expanded Colorado ASO program will be a multi-sectoral effort by design. These flights will be planned both in space and time around providing the maximum decision-making benefit for the largest number of Colorado stakeholders.

(Goals within the Basin Implementation Plans are included in a separate document attached to this application.)

Related Studies

ASO snowpack measurements have been conducted across Colorado since 2013, with numerous science, applied science, and operations support efforts. The following list details ASO activity in CO to-date and planned, along with funding source and application:
• Uncompahgre River above Ridgway Reservoir; 1-4 flights per year 2013-2017
NASA Terrestrial Hydrology Program, Science support
• Grand Mesa; 2013, 2017, 2020, 2021
NASA Terrestrial Hydrology Program, Science support
• Rio Grande and Conejos Rivers; 1-2 flights per year 2015-2016, 2 flights in Conejos 2021
CWCB Rio Grande Forecast Improvement Project; CWCB Project funds; Applied science support
• Upper Gunnison River (East and Taylor Rivers); 1-2 flights per year 2016, 2018-2019, 2 flights planned 2022
Dept. of Energy East River Watershed Function Scientific Focus Area, Science support
CWCB Project funds, Applied science
• Blue River above Dillon Reservoir, 2 flights 2019 and 2021, 2 flights planned 2022
Denver Water

Taxpayer Bill of Rights

N/A

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.

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: (1) Summarizes the project and how the project was completed. (2) Describes any obstacles encountered, and how these obstacles were overcome. (3) Confirms that all matching commitments have been fulfilled. (4) 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 the Budget & Schedule Exhibit B. 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.

All the benefits of ASO data described in the Water Project Justification are further reflected in various Basin Implementation Plans:

Roundtable	Basin Implementation Plan Goal	Related Action
Colorado River	3. Secure Safe Drinking Water	Raise awareness of current obstacles and efforts facing water providers
	6. Assure Dependable Basin Administration	Protect and defend maximum mainstem calls at Shoshone Hydroelectric Plant and senior Grand Valley irrigation diversions
Southwest	C. Meet Municipal and Industrial Water Needs	C3 Promote wise and efficient water use through implementation of municipal conservation strategies to reduce overall future water needs.
	G. Comply with CO River Compact and Manage Risk	G1. Plan and preserve water supply options for all existing and new uses and values.
Gunnison	Goal 1: Protect existing water uses in the Gunnison Basin	Detail the projected effects of climate change that may require additional water development to protect existing uses. Water development includes measures taken to use existing supplies more efficiently or effectively, as well as seeking additional water.
	Goal 8: Restore, maintain, and modernize critical water infrastructure, including hydropower Hydrology and Water Management	Process to Achieve Goals: Implement at least one project every year in the Gunnison Basin focusing on the restoration, maintenance, and modernization of existing water infrastructure
Arkansas	1.6.1 Storage Goals: Support multiple uses at existing and new storage facilities	Action: Support rehabilitation efforts with Water Supply Reserve Account (WSRA) funds if the project includes environmental and recreational attributes
	1.6.2 Consumptive Goals: Develop collaborative solutions between municipal and agricultural users of water, particularly in drought conditions	Action: Support with WSRA grant/loan funding in collaboration with CWCB.
South Platte/Metro	1.9.2 Municipal Water Conservation, Reuse and Efficiency Goal: Continue the South Platte River Basin's leadership in wise water use.	MO#2 – Distribute and encourage adoption of "best management practices" as "guidelines" (not standards) for M&I water suppliers to consider in their "provider-controlled" programs recognizing the

		significant differences in climates, cultures and economic conditions throughout the South Platte River Basin.
	1.9.4 South Platte Storage and Other Infrastructure Goal: To the extent possible, develop multipurpose storage, conveyance, system interconnections and other infrastructure projects to take advantage of limited remaining South Platte supplies and enhance water use efficiencies and supply reliability.	MO#1 – Explore opportunities to maximize yield from additional South Platte Basin strategic and multipurpose storage and other infrastructure including collaborative inter-connections between water supply systems and including both above ground and groundwater (e.g. ASR and alluvial recharge) storage

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Last Updated: May 2021

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)
X	Letters of Matching and/or Pending 3rd Party Commitments(1)
X	Map (if applicable)(1)
X	Photos/Drawings/Reports
X	Letters of Support (Optional)
	Certificate of Insurance (General, Auto, & Workers' Comp.) (2)
	Certificate of Good Standing with Colorado Secretary of State(2)
X	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.

Colorado Water Conservation Board
Water Plan Grant - Exhibit A

Statement Of Work	
Date:	**11/15/2021**
Name of Grantee:	**Northern Colorado Water Conservancy District (NCWCD)**
Name of Water Project:	**Phase I of the Colorado Aerial Snowpack Measurement Study**
Funding Source:	**State funds plus matching funding from USGS, Lawrence Berkeley National Laboratory, Northern Water (pending availability of adequate snow-free data in the Granby and Willow Creek basins), Denver Water, St. Vrain and Left Hand Water Conservancy District (Pending Board approval in December)**
Water Project Overview:	

These grant funds will be used to answer key questions identified in the Colorado Airborne Snow Observatories (CASO) planning effort. Over the past year, the CASO team has been conducting a Water Supply Reserve Fund (WSRF) project to develop a plan for establishing a sustainable and equitable statewide program to conduct Airborne Snow Observatories (ASO) snowpack measurements. Before the CASO program can be fully implemented statewide, there are aspects of the overall program vision that must be tested and confirmed, including those pertaining to Funding, Governance, Hydroclimate science, Water management and decision support, as well as the feasibility of deploying ASO flights at the statewide scale.

The proposed technology uses paired airborne lidar and imaging spectrometer sensors coupled with a snow dynamics model to measure snow depth and albedo and determine Snow Water Equivalent (SWE, the liquid depth of water stored in the snowpack) and snow albedo (snow reflectivity, which controls snowmelt rate) across large river basins at a high spatial resolution and low degree of uncertainty (Figure 1). The resulting data provides watershed-scale snowpack measurements with detail, accuracy, and decision-support value unprecedented in water management. Ultimately, ASO snowpack measurements provide an accurate, spatially complete measurement of the volume of water (in acre-feet) remaining in the snowpack for a given watershed at the time of flight, which can then be used to more accurately forecast streamflow and seasonal runoff.

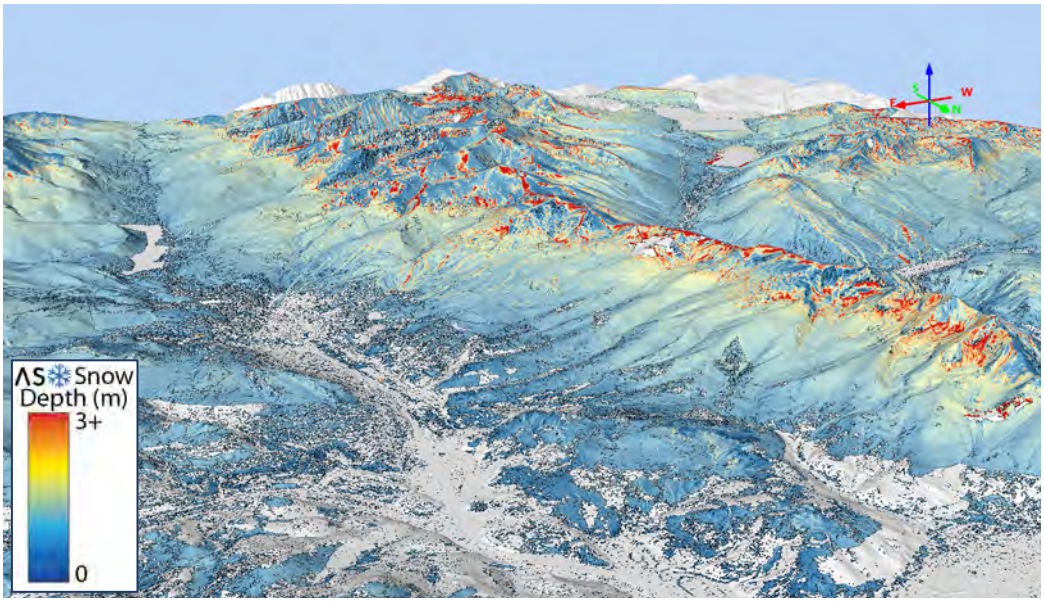

Figure 1: 3 meter resolution snow depth of the Blue River watershed above Dillon Reservoir, April 2021

Through the WSRF planning project, the CASO team has assembled a workgroup of over 100 water stakeholders throughout Colorado representing local, regional, state, federal, and non-profit entities. This diverse workgroup has demonstrated strong interest in expanding ASO snow measurements throughout Colorado and applying this technology to improve water management decision support. Momentum is building to develop a sustained statewide ASO snow measurement program, but there's still work to be done to get there.

The CASO team recognizes that 2022 will be a crucial year to build upon the established momentum from the WSRF Feasibility Study by expanding ASO flight coverage and studying the different aspects of implementing a statewide program. Additional flights across Colorado will:

1) Help determine how aerial lidar snowpack measurements can enhance stakeholder decision making throughout the state, especially in locations where these measurements have not been conducted previously.

2) Build upon a growing list of case studies that prove the value of ASO snow measurements to Colorado water management.
3) Test how the new aerial lidar partnerships in the state could lay the foundation for a sustained ASO program that would ultimately benefit statewide water supply and storage interests.
4) Allow for more in-depth study of Colorado's snowpack, which includes understanding the factors that allow for improvement in runoff forecasting.

This grant application leverages committed 2022 ASO funding from Denver Water, Northern Water, USGS, Lawrence Berkeley National Laboratory, and St. Vrain & Lefthand Water Conservancy District to request Water Plan Grant funds to do the following:

1) Conduct additional exploratory wintertime and summertime ASO flight coverage throughout Colorado in 2022, while studying the value of these data to all water stakeholders as well as the best methods for collaboratively implementing flights at a larger scale
2) Utilize the WRF-Hydro streamflow forecasting model to produce near real-time ASO-integrated streamflow forecasts wherever wintertime ASO data is available
3) Evaluate the feasibility and effectiveness of integrating ASO data into a range of streamflow forecasting models
4) Organize CASO stakeholder workgroup meetings and data distribution workshops to widely disseminate the data and help a wide range of water stakeholders apply the data to improve their decision making, as well as gather feedback on how to improve upon the data moving forward.
5) To continue work with state, federal, and local partners to study the feasibility setting up a sustained, long-term ASO program for the State of Colorado

The flight plan for 2022 is shown below in Figure 2, which distinguishes between winter/springtime flights (snow-on flights that provide snow depth, SWE, and albedo estimates) and summertime flights (snow-off flights which set the foundation to fly snow-on flights in future years). The map also indicates which flights are either partially or fully funded by the match-funding organizations.

For all winter/springtime flights (shaded in blue and green on the map), funds from this water plan grant would also be dedicated toward producing WRF-Hydro streamflow forecasts that directly integrate the data from these ASO flights into the forecasting process. Integrating ASO snowpack data products with streamflow forecasting has been flagged by the CASO stakeholder workgroup as especially important for ensuring the data is most useful for water management. WRF-Hydro is currently the only operational and deployable streamflow forecasting product that can integrate ASO SWE and albedo measurements at this time, though the project team will study several other forecast and data assimilation methods as part of this grant effort.

Last Updated: May 2021

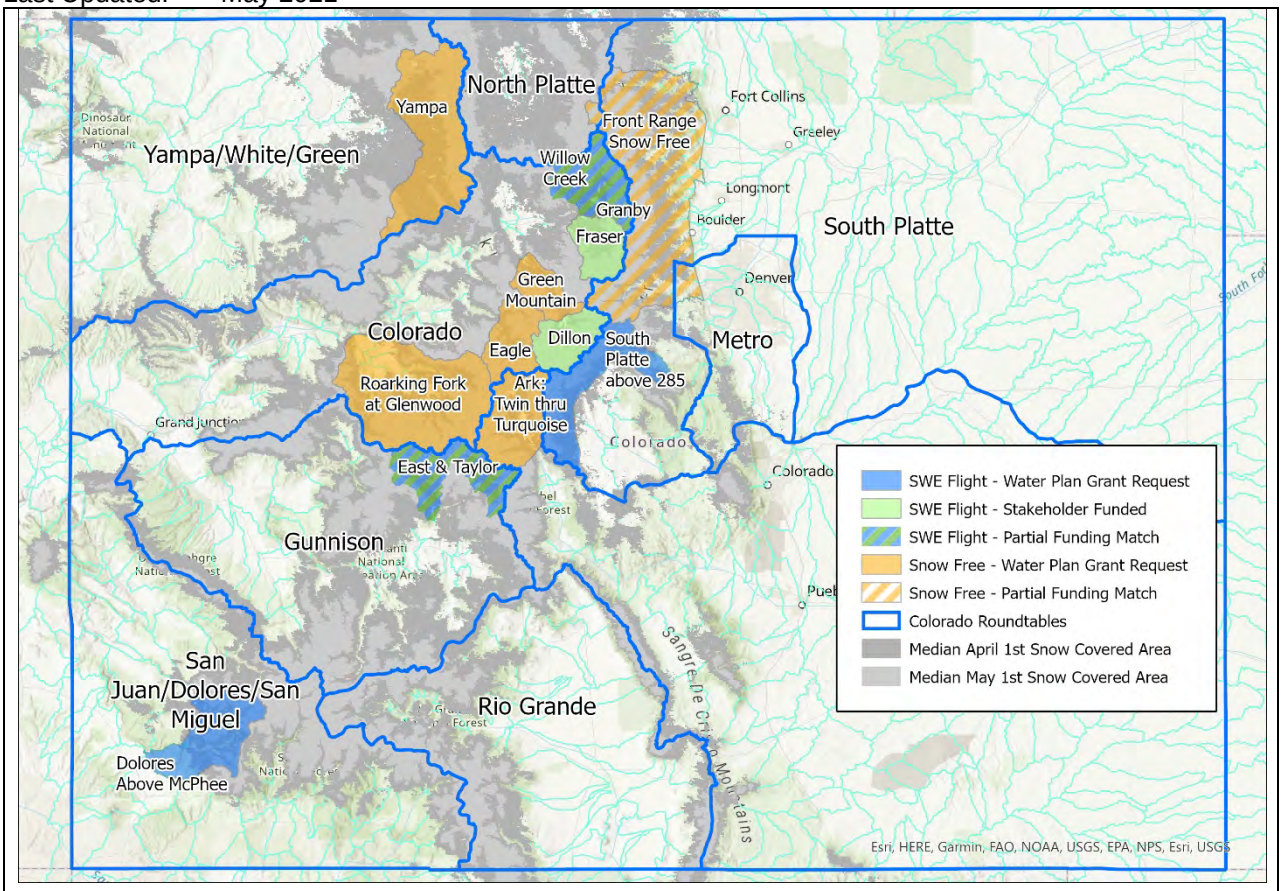

Figure 2: Proposed ASO flights for 2022

It is important to note that the 2022 summertime flights (shaded orange on the map) and additional processing of previously existing snow-free lidar data are essential for establishing a watershed baseline that is necessary to fly snow measurement flights in future years. Before aerial lidar snowpack measurements can be conducted for any basin, that basin must have a set of snow free data that meets ASO's quality standards. Lidar data from other programs like USGS 3DEP or the CWCB Lidar program can sometimes be sufficient, but it is not guaranteed that those data meet the standards required for ASO flights (see Figure 3 below, a case where existing snow-free lidar data was not sufficient for use with ASO snow-on flights). The summertime, snow-free ASO flights and advanced 3DEP data processing proposed in this grant are especially difficult to get funded by local stakeholders and thus would benefit greatly from Water Plan Grant funding.

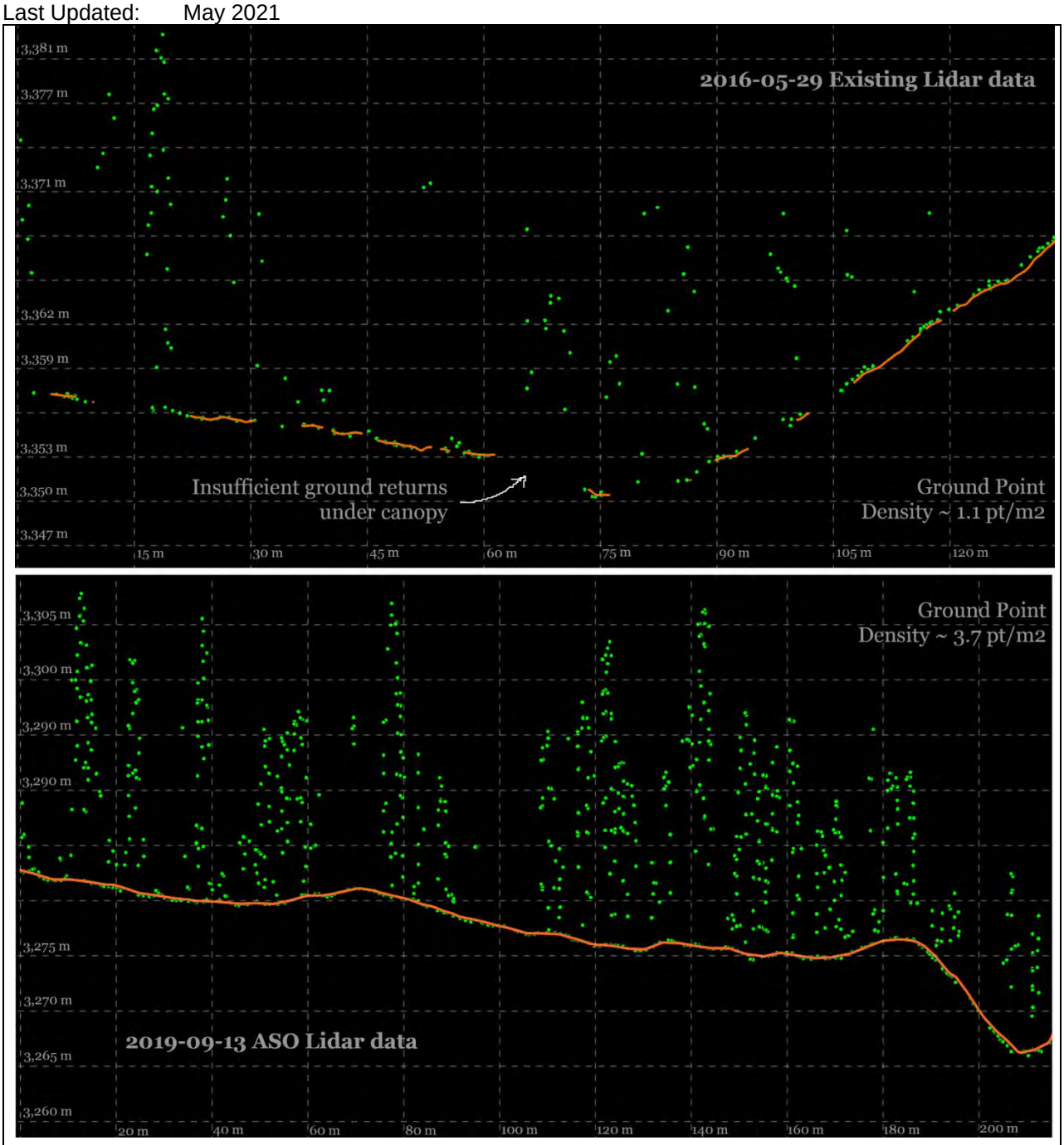

Figure 3: Many existing lidar data sets have insufficient lidar point density in forested areas (top), prohibiting reliable snow depth and SWE measurement. ASO-standard data (bottom) allows complete coverage under the forest canopy, enabling accurate snow-on measurements in these important areas.

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The table below details the timing of planned snow-on and snow-free flight activities.

Basin	Flights	External Funding Source	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22
Snowpack Measurement Flights										
Dillon Reservoir	2	Denver Water								
Granby, Willow Creek, Windy Gap Reservoirs	2	Northern Water (pending availability of adequate snow-free data in the Granby and Willow Creek basins)								
Fraser River above Tabernash	2	USGS								
East and Taylor Rivers	4	US Department of Energy								
South Platte River West of US-285	2									
Dolores above McPhee Reservoir	2									
Snow free flights and/or 3DEP data work										
Roaring Fork at Glenwood Springs	1 + 3DEP									
Upper Arkansas at Granite	1 + 3DEP									
Green Mountain Reservoir Basin	1 + 3DEP									
Eagle River Basin	1 + 3DEP									
Yampa River Headwaters	3DEP only									
Front Range, Clear Creek through Poudre River	1 + 3DEP	St Vrain/Lefthand (pending December Board approval)								

Finally, below we have included some ASO testimonials from water managers in Colorado and California that highlight ASO's value to the water community. These testimonials are also complementary to the large number of letters of support the CASO team has gotten from the stakeholder workgroup:

"ASO provides detailed information into the snowpack like we have never seen before. The information gained from ASO flights allows for a finer level of water management and provides more opportunity to benefit more users and get the maximum benefit out of every drop."

- Nathan Elder, Raw Water Operations Manager, Denver Water

"*What you've done is created new reservoir space and water supply without any impacts to the current physical or environmental paradigms."*

- Wes Monier, Chief Hydrologist, Turlock Irrigation District

"ASO provides invaluable information that is not otherwise available, most importantly information about the rate of melt that provides a real opportunity to optimize reservoir operations for water supply, flood control, and instream requirements."

- Steve Haugen, Watermaster, Kings River Water Association

"Having used this technology, it is hard to imagine a future without it."

- Dave Rizzardo, Chief of Snow Surveys and Water Supply Forecasting, CA DWR

Project Objectives:

As an overarching objective, this Water Plan Grant project is designed to work towards the CASO vision. The CASO vision was developed as part of the 2021 WSRF project and is composed of four components:

Vision 1: Funding – "While local partners should demonstrate their interest and engagement through matching funding, widespread ASO flights benefit many stakeholders and should be funded on a regional level through State and Federal funding sources."

Vision 2: Governance and Structure – "To be both effective and equitable, CASO should be facilitated by the CWCB with local stakeholders making decisions on flight timing and location. Ultimately, the program would benefit from engaging in a state-federal partnership."

Vision 3: Hydroclimate Science – "A fully developed ASO program will have accurate, accessible snowpack measurements and improved water supply forecasts across the high-elevation, snow-covered areas of Colorado."

Vision 4: Water Management and Decision-Support Applications – "Through the delivery of improved measurements and water supply forecasts, local and regional water managers will be empowered to make better short term (annual) and long term (decadal) decisions. These improvements will be measurable."

The tasks for this grant are all connected back to the CASO program vision statements (each associated vision statement will be listed as V1, V2, V3, or V4). Related to these identified visions, this study will aim to answer the following questions:

V1 (Funding):

- How can local, state, and federal stakeholders partner to fund a statewide ASO snow measurement program?
- How can we calculate and communicate the net return on investment from improvement snowpack measurements and streamflow forecasts?

- How does expanding snow-free flight coverage lower funding barriers and thus increase accessibility to future snow-on flights?

V2 (Governance and Structure):

- Is the program governance structure laid out by the CASO workgroup effective, manageable, and equitable in terms of planning flights and delivering timely results?
- How can the State effectively manage the decision-making process around flight coverage, timing and logistics?

V3 (Hydroclimate Science):

- What improvements in snowpack measurements and streamflow forecasting are made available by expanded ASO flight coverage?
- How do accurate, spatially-complete snowpack measurements improve our overall understanding of Colorado's snowpack and runoff dynamics?

V4 (Water Management and Decision-Support Applications):

- How can all water stakeholders effectively use the results of this program to improve their decision making?
- What are some examples of measurable savings in water or money as a result of ASO-informed decision making?

Tasks

Task 1 – Flight Activities

Description of Task:

The core products proposed in this grant are high resolution, distributed snow depth, snow water equivalent (SWE), and snow albedo measurements produced using the Airborne Snow Observatories sensor package. During winter/spring 2022, we will conduct 14 snowpack measurement flights corresponding to the basins shown in the tables and figures above. All basins identified will receive at least 2 flights. These flights will be planned to provide local stakeholder agencies with measurements timed to be available before key water resources decisions.

For the basins identified in the map above as needing snow free data, the project team will conduct activities to create those datasets. Currently about 40% the project budget is requested for snow-free activities. By conducting these flights and data processing efforts now, all basins will be ready for snow measurement flights next winter as the CASO program continues to grow. If all activities are completed as expected, 16,000 km^2 of the typical April 1st snow covered area statewide will be ready for snow measurement flights in winter 2022-2023.

The project team is aware of ongoing efforts across Colorado to generate lidar-based digital elevation models (DEM) statewide. The Colorado Hazard Mapping program (https://coloradohazardmapping.com/lidar) shows coverage of existing and planned lidar activities. Unfortunately, while these efforts are useful, they often do not provide data of sufficient point density (particularly in forested regions) and overall resolution in areas key to ASO snowpack measurements. This is typically since areas with denser snow that are far from urban areas and highway corridors, where typical ASO missions focus their efforts.

Method/Procedure:

Last Updated: May 2021

This task addresses the following aspect of the CASO Vision:

V3 - Hydroclimate Science

V4 – Water Management and Decision Support Applications

The project team will conduct ASO flights between March and June 2022 to develop precise snowpack measurements covering 7,000 km^2 of April 1st snow covered area. Once the flights are completed, the flight data will be post-processed to generate spatially-complete snow depth, SWE, and albedo data products. In the summer and fall of 2022, the project team will conduct the snow-free flights and 3DEP advanced data processing activities.

As part of CASO, a flight coordination committee was proposed, which would be overseen by the CWCB. The goals of this committee are to balance aircraft availability, weather, and the ideal timing that different stakeholders need measurements to use the resulting data in key water resources decisions. 14 flights are proposed across Colorado over a 3-month period, some of which are funded by external stakeholders. As shown in the table above, several of the flights are funded by CASO partner agencies including Denver Water, Northern Water, the USGS, and the US Department of Energy. The timing of the stakeholder funded flights will be decided by the respective stakeholders, and the remaining snow-on flights will be decided by testing a flight planning committee. The process to implement this flight coordination committee and develop a plan for optimal flight timing will serve as a pilot for future years, where there will hopefully be more flights across a larger area.

Deliverable:

For each of the snowpack measurement flights in the table above, the project team will provide the following:

- Flight Reports that include detailed snow measurement data
- Raster datasets of snow depth (3m resolution), SWE (50m resolution), and snow albedo (3m resolution)

For the snow-free activities, the project team will provide lidar datasets for all basins where snow free coverage must be flown or generated from advanced processing of existing data products.

Tasks

Task 2 – Ongoing Scientific and Program Support

Description of Task:

This task addresses these aspects of the CASO Vision:

V1 - Funding

V2 - Governance and Structure

V4 - Water Management and Decision Support

This task consists of activities to study and promote the use of these ASO snowpack measurements for water management and decision support. In the CASO workgroup, there is a good understanding of the qualitative use of these data products for runoff forecasting, but there is still an educational gap around how these data can be used quantitatively to inform forecasts and improve operations. The project team will work with the stakeholder group

to study and demonstrate the utility of the improved snowpack measurements as applied to a range of different agency types, as well as to use feedback from the listed stakeholder groups to explore the different use-types of the data:

- Municipal water providers
- Recreational interests (e.g. rafting and fishing communities)
- Environmental Interests
- Reservoir operators
- Agricultural producers
- Research scientists
- Public safety groups (e.g. avalanche control)
- Educators
- Skiing industry
- Other groups

To further study and promote the governance and structure of CASO, the project team will continue its stakeholder engagement activities. There are several proposed activities to study and improve the integration of ASO snowpack measurements into the decision-making processes of various water resources management agencies. These activities include:

- Ongoing facilitation of CASO workgroup activities including collaborative flight coordination, basin identification for future flights, decision-support workshops, and stakeholder feedback collection
- Presentation of snowpack measurement results for use in stakeholder-specific applications
- Hindcast comparison of several streamflow forecast model options to study the value to stakeholders of integrating ASO data with various streamflow forecasting methods

To build upon existing efforts, this project will fund integrated streamflow forecasting using the WRF-Hydro forecasting model. These forecasts will integrate the snow-on flight data to produce near real-time streamflow forecasts in the associated watersheds. Stakeholders from the CASO workgroup have identified that having streamflow forecasts constrained by ASO snowpack measurements is key to ensuring this data has the widest and most beneficial utility possible. WRF-Hydro has been set up to integrate ASO SWE and snow albedo measurements to inform its forecasts, so its deployment this runoff season will help emphasize the overall benefit of this program and study how these forecasts can benefit different stakeholder groups.

In addition to the WRF-hydro ASO-integrated streamflow forecasting as part of this project (a model that is already well set-up to integrate ASO snowpack measurements), the project team will work to compare different streamflow forecasting model options and their applicability to integrating ASO data. There are many streamflow forecast model frameworks that exist, though these models are not typically designed to rely on intermittent (1-2 per season) snowpack measurements. It is a significant area for improvement to assimilate ASO snowpack measurements into a forecast model and calibrate the model in such a way that it reflects the improved measurement accuracy. As part of this task, the team will conduct a post-runoff hindcast study that will compare several options for streamflow forecasting models that meet the goals of the CASO workgroup. This effort will include the identification of several model framework options, deployment of those options and a retrospective analysis of model performance with and without the improved ASO measurements.

Method/Procedure:

The CASO vision includes the development of a statewide flight coordination committee that will balance stakeholder needs and the logistical limitations of conducting ASO flights (e.g., weather, plane availability). The project team will facilitate the creation of this committee and its first meeting to coordinate exact flight timing and data set production.

The project team will also continue to facilitate stakeholder workshops/feedback sessions to discuss the utility of ASO snow measurements for stakeholders of various sectors and sizes. Through a series of stakeholder meetings and analysis, the project team will continue to work towards the CASO vision. These meetings will include decision support workshops that bring together diverse groups of stakeholders to discuss data results from each snow-on flight included in this project, as well as how to best plan for future flights with the newly collected snow-free data. This will also be a valuable time to collect feedback from stakeholders on different uses for the data and how to improve data collections operations to provide the maximum possible benefit.

The WRF-Hydro model will be run continuously throughout the snow season, and will be updated each time ASO snow-on flights are conducted to produce real-time streamflow forecasts using the most accurate snowpack data available. These real-time streamflow forecasts will be shared with all interested stakeholders and presented at various decision support workshops organized as part of this project.

The project team will calibrate and deploy, in a model testbed, several runoff forecasting models and data snow data assimilation methods that may be used for ASO-informed runoff forecasting. The project team will then conduct a benchmarking study identifying the challenges and opportunities of various streamflow forecast models and processes to assimilate ASO data to improve the forecasts. This study will include quantitative model performance results and ”as-if” runoff forecasts for all basins with ASO snowpack measurements this season.

Deliverable:

Throughout the project, the project team will facilitate multi-stakeholder flight planning meetings. These meetings will be well-documented and will serve as a template for flight planning activities in future years.

For each snow-on flight, the project team will host a stakeholder engagement decision-support event to discuss snow-on flight results, streamflow forecasts, and overall utility of the ASO data sets. These events will include pre-meeting conversations with relevant stakeholders so we can present examples of specific decision support improvements related to each flight.

For each snow-on flight, a WRF-hydro streamflow forecast will be produced that integrates the snow-on ASO data collected to-date.

The team will produce runoff hindcast model results for multiple runoff models at all sites with snow-on flights. These model results will be accompanied by a report describing the performance, challenges and opportunities presented by each approach.

Tasks

Task 3 – Summary Memo

Description of Task:

This task is to develop a summary memo and final presentation materials to synthesize all funded activities and make recommendations for advancing all aspects of the CASO vision:
V1 - Funding
V2 - Governance and Structure
V3 - Hydroclimate Science
V4 - Water Management and Decision Support

Method/Procedure:
The project team will develop a memo and presentation materials summarizing the activities, snow data results, and lessons learned from the 2022 activities. This memo will summarize the work done, the progress towards the CASO vision, and any recommendations for future efforts related to each aspect of the vision.
Deliverable:
This project will be summarized in a memo and will be accompanied by any relevant presentation materials generated over the course of the project.

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.

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.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Exhibit C
Budget and Schedule

Prepared Date: November 15, 2021

Name of Applicant: Northern Colorado Water Conservancy District (Northern Water)

Name of Water Project: Phase I of the Colorado Aerial Snowpack Measurement Study

Project Start Date: 2/1/2022

Project End Date: 9/30/2022

Task No.	Task Description	Task Start Date	Task End Date	Grant Funding Request	Match Funding	Total
1	Task 1 - Flight Activities	2/1/2022	9/30/2022	$ 1,579,000	$ 749,860	$2,328,860
2	Task 2 - Ongoing Scientific and Program Supp	2/1/2022	9/30/2022	$ 293,400	$ 25,000	$318,400
3	Task 3 - Summary Memo	8/1/2022	9/30/2022	$ 5,000		$5,000
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
						$0
			Total	$1,877,400	$774,860	$2,652,260

Northern Water
Northern Colorado Water Conservancy District
220 Water Avenue • Berthoud, Colorado 80513
800-369-7246 • www.northernwater.org

11/30/2021

To Whom It May Concern:

Northern Water would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. Additionally, we would like to commit $150,000 as matching funds to this project, which is the budget amount we have allocated toward conducting ASO flights in 2022*. We would also like to commit $10,000 of in-kind work hours toward workgroup contributions and fiscal agent responsibilities.

This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project). The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado. Therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

DocuSigned by:
Bradley D. Wind
FC0471B7832F49C...

Bradley D. Wind
General Manager, Northern Water

*These matching funds would be used toward flights in the Granby and/or Willow Creek basins and are pending availability of adequate snow-free data in those basins.

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
COLORADO WATER SCIENCE CENTER
Denver Federal Center
Lakewood, CO 80225

MEMORANDUM

To: Whom it may concern

From: David (Matt) Ely, Director
U.S. Geological Survey
Colorado Water Science Center

DAVID ELY Digitally signed by DAVID ELY
Date: 2021.11.30 16:48:18 -05'00'

Date: Tuesday, November 30, 2021

The U.S. Geological Survey (USGS) Colorado Water Science Center would like to express support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. Additionally, the USGS would like to commit $194,860 as matching funds to this project, which is the budget amount USGS has allocated toward conducting Airborne Snow Observatory flights in 2022.

This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a Colorado Water Conservation Board Water Supply Reserve Fund sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable tool to all water- sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. Real-time measurements mountain snowpack are instrumental to inform water-management decisions and scientific research related to water resources and climate change in Colorado. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and water- management decision making.

The CASO workgroup has identified this Water Plan grant proposal as crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the necessary funding for consistent year-to-year flights in Colorado; therefore, it is vital for the project to develop collaborations and long-term funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan grant proposal is the first major step of that process.

Expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders including water managers and scientific researchers in federal, state, municipal, environmental, recreational, agricultural, scientific, and industrial sectors. Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continued engagement with aerial snowpack measurement efforts in Colorado.

ST. VRAIN AND LEFT HAND WATER CONSERVANCY DISTRICT

1715 Iron Horse Drive, Suite 250 • Longmont, CO 80501 • 303-772-4060 • www.svlhwcd.org

November 10th, 2021

To Whom It May Concern:

The St. Vrain and Left Hand Water Conservancy District ("District") would like to express our enthusiastic support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. In support of this project, the District budgeted $50,000 as matching funds (pending approval from the District Board of Directors in December) toward conducting ASO flights in 2022.

This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

The District fully supports this project and look forward to continuing to remain engaged with ASO efforts in Colorado.

Sincerely,

Scott Griebling, Water Resources Engineer
St. Vrain and Left Hand Water Conservancy District

Lawrence Berkeley National Laboratory

Earth & Environmental Sciences Area

November 15, 2021

To Whom It May Concern:

The Senior Leadership of Berkeley Lab's Watershed Function Science Focus Area, of which I am a member, would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. Additionally, we would like to commit $200,000 as matching funds to this project, which is the budget amount we have allocated toward conducting ASO flights in 2022.

This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process
We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.
Sincerely,

Kenneth H. Williams, PhD
Senior Scientist
Program Lead, Environmental Remediation and Water Resources
Deputy Lead and Chief Field Scientist, Watershed Function Science Focus Area
Climate and Ecosystem Science Division

Lawrence Berkeley National Laboratory

One Cyclotron Road / MS: 74R316C / Berkeley, California 94720 / **phone** 510-701-1089 / **fax** 510-486-5686 / **email** khwilliams@lbl.gov

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

11/15/2021

To Whom It May Concern:

Denver Water would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. Additionally, we would like to commit $155,000 as matching funds to this project, which is the budget amount we have allocated toward conducting ASO flights in 2022. Additionally, we will contribute $15,000 of in-kind services toward project facilitation.

This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Nathan Elder

Manager of Raw Water Supply

Denver Water

THE COLORADO BASIN ROUNDTABLE
C/O 201 CENTENNIAL STREET, SUITE 200
GLENWOOD SPRINGS, COLORADO 81601

November 30, 2021

Colorado Water Conservation Board
c/o Chris Sturm
1313 Sherman Street, Room 721
Denver, Colorado 80203

Dear Chris,

The Colorado Basin Roundtable would like to express its unanimous support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Regards,

Jason V. Turner, Chair
Colorado Basin Roundtable

Metro Basin Roundtable

November 30, 2021

Ben Wade
Colorado Water Conservation Board
1313 Sherman, Room 710
Denver, Colorado 80203

At its November meeting, the Metro Roundtable voted unanimously to support the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

The Metro Roundtable supports this project and looks forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Barbara Biggs, Chairperson

Garrett Varra, South Platte Basin Roundtable Chair

11/30/2021

Kevin Reidy
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

Dear Kevin,

At the November 9, 2021 meeting of the South Platte Basin Roundtable the membership unanimously voted to support the Phase I of the Colorado Aerial Snowpack Measurement Study. A quorum of the membership was present at the meeting.

The South Platte Bain Roundtable would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Garrett Varra, South Platte Basin Roundtable Chair

SOUTHWEST BASINS ROUNDTABLE
C/O La Plata Archuleta Water District
PO Box 1377
Ignacio, Colorado 81137

November 16, 2021

To Whom It May Concern:

The Southwest Basins Roundtable would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Edward Tolen
Southwest Basins Roundtable Chair

Arkansas Basin Roundtable

November 16, 2021

Via Electronic Mail: ben.wade@state.co.us

Mr. Ben Wade
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

Re: Colorado Water Plan Grant Application: *Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion*

Dear Ben:

At its November 10, 2021 meeting, the Arkansas Basin Roundtable (ABRT) approved support of the Colorado Airborne Snow Observatories (CASO) request for $1,799,000 in Water Plan Grant funds for the Optimizing statewide aerial snow measurement program. The applicant is providing $714,000 in matching funds.

The project: Phase I of the Colorado Aerial Snowpack Measurement Study. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. Expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Mark Shea, Chair

Cc: Applicant, Needs Assessment Committee Chair

Yampa-White-Green Basin Roundtable

November 23, 2021

To Whom It May Concern:

The Yampa White Green Basin Round Table (YWG BRT) would like to express our support for the following project: *Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

ASO's innovative snow measurement technologies and data products provide a valuable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users, planners, and stewards. As the YWG BRT has learned, ASO provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making uniquely aligning with several of our BRT goals. The YWG BRT believes the us of this technology will continue to advance becoming a greater water management tool for the benefit of the continued drought-stricken NW and Western Colorado Region.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into large diverse funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding ASO flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from ASO.

The YWG BRT supports this project and anticipates staying well informed with ASO efforts in Colorado.

Sincerely,

Alden Vanden Brink

Alden Vanden Brink, Chairperson
Yampa White Green Basin Round

COLORADO
Division of Water Resources
Department of Natural Resources

November 9, 2021

Subject: **Letter of Support for Colorado Aerial Snowpack Measurement Study**

Dear Colorado Water Conservation Board and Staff:

The Colorado Division of Water Resources (DWR) would like to express its support for the "*Phase 1 of the Colorado Aerial Snowpack Measurement Study.*" This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted in 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

ASO's innovative snow measurement technologies and data products provide a valuable new tool to all water sector stakeholders for making decisions in the complex water landscape of Colorado. The better real-time understanding we have of mountain snowpack, the better decisions we can make as water administrators. ASO provides one of the most accurate real-time measurements of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making. Colorado is facing ever increasing complexity in water administration and pressure to beneficially use every available drop of water. The need for more accurate snowpack information and streamflow forecasting is a critical component in our ability to deal with these issues.

DWR has been involved in the CASO workgroup since its inception. The program involves a broad range of Colorado water entities for both input in the design and as users of the information. We note that, due to the broad range of Colorado stakeholder involvement, the workgroup believes that a request for funding from the state is appropriate.

Colorado has benefited in the past from the few initial ASO flights that have occurred within Colorado's watersheds. However, in order to fully realize the potential of this program, a larger scale project is being developed. Expanding ASO flights in Colorado will have benefits for better water administration in all of our Water Divisions, as well as multiple benefits to Colorado from better compact administration.

We support this project and look forward to continuing to remain engaged with ASO efforts in Colorado.

Sincerely,

Kevin G. Rein, P.E.
Director, State Engineer

COLORADO RIVER DISTRICT
PROTECTING WESTERN COLORADO WATER SINCE 1937

November 23, 2021

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

Dear Colorado Water Conservation Board Directors:

The Colorado River Water Conservation District (River District) would like to express our support for the following project: Phase I of the Colorado Aerial Snowpack Measurement Study. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project). The River District staff has actively participated as part of the CASO workgroup since its inception.

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

The River District exists to protect West Slope water, serving water users across the Colorado River watershed, which includes the Yampa, White, Gunnison, Uncompahgre, the mainstem of the Colorado and all associated tributaries. Airborne lidar flights addresses one of our strategic goals to understand to the highest degree possible patterns of snowpack accumulation and forecasted runoff now and through time to better understand changing climate patterns. This leads to better resource management on the West Slope and supports all water users – agriculture, municipal, environmental, recreational, and industrial sectors. In particular, the River District

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

supports additional data in the upper Yampa, Eagle, and Roaring Fork basins where baseline snow-free data will allow for accurate future snow flights as well as continued snowpack monitoring in the Gunnison Basin.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Andrew A. Mueller, General Manager

Colorado Springs Utilities

It's how we're all connected

November 12, 2021

To Whom It May Concern:

Colorado Springs Utilities would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Earl Wilkinson
Chief Water, Compliance & Innovation Officer

1521 South Hancock Expressway
P.O. Box 1103, Mail Code 1825
Colorado Springs, CO 80947-1825

Phone 719.448.8888
www@csu.org

THE SOUTHWESTERN WATER CONSERVATION DISTRICT
Developing and Conserving the Waters of the
SAN JUAN AND DOLORES RIVERS AND THEIR TRIBUTARIES
IN SOUTHWESTERN COLORADO
West Building – 841 East Second Avenue
DURANGO, COLORADO 81301
(970) 247-1302

November 16, 2021

To Whom It May Concern:

On behalf of the Board of Directors of the Southwestern Water Conservation District (SWCD), I would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

As the Colorado Water Conservation Board (CWCB) knows, exceptional drought in southwestern Colorado continues to have myriad impacts on local water uses and watershed health. As aridification alters the timing of runoff, affects soil moisture, and reduces total snowpack, improved runoff forecasting is more essential than ever for southwest Colorado. We saw that airborne lidar can also help us better understand low-elevation snowpack, which we have few opportunities to predict and measure during the winter season.

SWCD is grateful that the CWCB supported 2020-2021 flights in the Animas and Dolores basins to demonstrate the value of aerial snow measurement. However, given the price tag, local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights here; that's why SWCD is supportive of this Water Plan Grant application as a test of the method at a statewide scale.

Beyond its benefits for southwest Colorado, SWCD believes statewide aerial snow measurement in Colorado will have benefits for all major water sectors and stakeholders — municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

SWCD fully supports this plan, will remain engaged in aerial snow measurement efforts in Colorado, and encourages the CWCB to give full and favorable consideration to this Water Plan Grant application.

Sincerely,

Steve Wolff, General Manager
Southwestern Water Conservation District

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Colorado Basin River Forecast Center
2242 West North Temple
Salt Lake City, Utah 84116-2919

Oct 28, 2021

To Whom It May Concern:

The Colorado Basin River Forecast Center supports *Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

The additional snow depth measurements that airborne LiDar surveys provide will help us determine the extent to which that data may improve our streamflow forecasts. Preliminary studies suggest these data have potential to improve our water supply forecast products. In addition, we see value in the distributed snow depth and accompanying data as we move toward developing gridded and physically based snow modeling in the Upper Colorado River Basin.

We support this project and look forward to continuing to remain engaged with ASO efforts in the Colorado River Basin.

Sincerely,

Michelle Stokes, Hydrologist in Charge

Colorado Basin River Forecast Center, NOAA

United States Department of the Interior
BUREAU OF RECLAMATION
P.O. Box 25007
Denver, CO 80225-0007

IN REPLY REFER TO:
86-69100
2.4.1.05

VIA ELECTRONIC MAIL ONLY

November 22, 2021

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

Subject: CASO (Colorado Airborne Snow Observatories) Water Plan Grant Application

To Whom It May Concern:

This letter is in reference to the CASO team's proposal *Phase I of the Colorado Aerial Snowpack Measurement Study*. If the proposal is selected for funding, Reclamation is interested to engage with the CASO team as they purse this project to better understand and quantify how the work may enhance water supply forecasts and water management.

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Central to that mission is operation of Reclamation's 491 dams and 338 reservoirs. As many of these facilities are in snowmelt dominated regions, Reclamation has considerable interest in snow monitoring and water supply forecasting. If the CASO team's proposal is selected, we will provide discussion and feedback of its analysis, providing insight from our operations and research experience related to this topic.

Sincerely,

Kenneth C Nowak

Kenneth C Nowak, PhD
Water Availability Research Coordinator
Bureau of Reclamation

United States Department of the Interior

BUREAU OF RECLAMATION
Durango Field Division
185 Suttle Street, Suite 2
Durango, CO 81303-7911

IN REPLY REFER TO:

WCD-SBehery
2.4.1.05

VIA ELECTRONIC MAIL ONLY

Colorado Water Conservation Board
1313 Sherman Street
Room 718
Denver, CO 80203
taylor.winchell@denverwater.org

Subject: CASO (Colorado Airborne Snow Observatories) Water Plan Grant Application, Project Dolores, McPhee Reservoir, Colorado

Dear Grant Application Reviewer:

This letter is in reference to the CASO team's proposal *Phase I of the Colorado Aerial Snowpack Measurement Study*. If the proposal is selected for funding, the Bureau of Reclamation (Reclamation) is interested to engage with the CASO team as they purse this project to better understand and quantify how the work may enhance water supply forecasts and water management.

Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. Central to that mission is operation of Reclamation's 491 dams and 338 reservoirs. As many of these facilities are in snowmelt dominated regions, Reclamation has considerable interest in snow monitoring and water supply forecasting. If the CASO team's proposal is selected, we will provide discussion and feedback of its analysis, providing insight from our operations and research experience related to this topic.

Should you have any questions, please contact Susan Behery at (970) 385-6560 or email sbehery@usbr.gov. For the hearing impaired please call the Federal Relay System at (800) 877-8339 (TTY).

Sincerely,

SUSAN BEHERY

Digitally signed by SUSAN BEHERY
Date: 2021.11.23 12:29:59 -07'00'

Susan Behery
Hydraulic Engineer

Grand Valley Water Users Association
Grand Valley Project
1147 24 Road, Grand Junction, CO 81505
Phone: 970-242-5065 Fax: 970-243-4871
www.gvwua.com

November 15, 2021

To Whom It May Concern:

Grand Valley Water Users Association would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Mark Harris
General Manager
Grand Valley Water Users Association

P.O. Box 460 (81502)
2190 H 1/4 Road
Grand Junction, CO 81505

WATER
Conservancy District

Office: (970)242-7491
Fax: (970) 242-9189
www.utewater.org

November 16, 2021

To Whom It May Concern:

Ute Water Conservancy District (District) would like to express our support for *Phase I of the Colorado Aerial Snowpack Measurement Study*. The benefits of this study to all types of water users, both large and small and in all corners of the state, are essential and will continue to be necessary as we navigate the intricate water issues in Colorado with those reliant on its water sources.

We recognize the value of real-time snowpack measurements that allows for efficient and effective management and planning. In combination with the multifaceted approaches and tools in use today, increasing the accuracy of snowpack measurements will continue to enhance the information available to stakeholders and their ability to respond.

Continued development and implementation of this innovative tool through the use of a Water Plan Grant demonstrates a great example of what the Colorado Water Plan's purpose set out to accomplish in addressing water challenges. The collaboration and value in a project that municipal, industrial, agricultural, recreational, and environmental users in all the major basins of Colorado can benefit from should not be ignored.

On behalf of the Ute Water Conservancy District, we support the efforts of all those involved with this grant request. We urge you to award this grant to enable those involved to continue to build upon the beneficial aerial snowpack measurement efforts that have been performed on the behalf of all Colorado water users.

Respectfully,

Greg Williams
Assistant Manager
Ute Water Conservancy District

COLORADO WATER TRUST

11-15-21

To Whom It May Concern:

The Colorado Water Trust would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides a valuable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Andy Schultheiss,

Executive Director

COLORADO STATE UNIVERSITY

Dept. of Ecosystem Science and Sustainability - Watershed Science Program
voice 001.970. 491.5454; fax 001.970.491.1965
Natural and Environmental Sciences Bldg B260
Fort Collins, Colorado 80523-1476 USA
email: <*steven.fassnacht@colostate.edu*>
URL: <*https://sites.warnercnr.colostate.edu/srf*>

November 10th, 2021

To Whom It May Concern:

I am a Snow Hydrology researcher at Colorado State University, and express my support for the *Phase I of the Colorado Aerial Snowpack Measurement Study* project. It will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

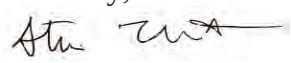
The infrastructure of the ASO program provides innovative snow measurement and data products that are an invaluable new tool for all water sector stakeholders across Colorado and the western U.S. Improved real-time information about the mountain snowpack will help in better decision-making across this increasingly complex water landscape. Currently, ASO provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making. Further, these data can be used by researchers to better understand the dynamic spatio-temporal complexity of the snowpack.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding ASO flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from ASO. Researchers will also use these data to further assist stakeholders with their water management and related decisions.

I fully support this project and look forward to continuing to remain engaged with ASO efforts in Colorado. Feel free to contact me if you have any further questions.

Sincerely,



Steven R. Fassnacht, PhD, PEng
Professor of Snow Hydrology
Fellow, Cooperative Institute for Research in the Atmosphere
Senior Research Scientist, Natural Resources Ecology Laboratory

City of Thornton

Thornton City Hall
12450 Washington Street
Thornton, CO 80241
www.thorntonco.gov

Infrastructure Department
Water Resources Division
PH 720-977-6600
FAX 720-977-6202

November 16, 2021

To Whom It May Concern:

City of Thornton would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Emily Hunt, Deputy Director - Infrastructure

CITY OF ASPEN

November 16, 2021

To Whom It May Concern:

The City of Aspen Water Department would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Steve Hunter, PE, PH
Utility Resource Manager
City of Aspen Utilities

November 29, 2021

To Whom It May Concern:

The Upper Yampa Water Conservancy District would like to express our enthusiastic support for the following project: *Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

ASO's innovative snow measurement technologies and data products provide an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, ASO provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding ASO flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from ASO.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We fully support this project and look forward to continuing to remain engaged with ASO efforts in Colorado.

Sincerely,

Ken Brenner
Ken Brenner (Nov 29, 2021 10:41 MST)

Ken Brenner, Board President
Upper Yampa Water Conservancy District

CENTER FOR
SNOW & AVALANCHE
STUDIES

November 10, 2021

To Whom It May Concern:

Center for Snow and Avalanche Studies would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Jeff Derry

Jeff Derry – Executive Director
Center for Snow and Avalanche Studies

Jeff Derry
Executive Director

Mail:
P.O. Box 190
Silverton, CO
USA 81433

Center:
1428 Greene Street
Suite 103
Silverton, CO

Telephone:
Office: (970) 387-5080
Cell: (970) 231-6595

Website:
www.snowstudies.org

Email:
jderry@snowstudies.org

City of Greeley Colorado

November 15, 2021

To Whom It May Concern:

The City of Greeley would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Sean Chambers
Director, Water and Sewer Department
City of Greeley

Dolores Water Conservancy District

60 S. Cactus St. P.O. Box 1150 Cortez, CO 81321
Phone: 970-565-7562 Fax: 970-565-0870
Email: dwcd@frontier.net

November 16, 2021

Dear CWCB:

Dolores Water Conservancy District, DWCD, would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar. DWCD was fortunate to have your support with two surveys on the Dolores Basin that showed value in improving annual runoff forecasts during an extremely dry year in southwestern Colorado.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

DWCD General Manager / CASO Stakeholder

WESTMINSTER

November 10, 2021

To Whom It May Concern:

City of Westminster would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process. We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.
We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Bob Krugmire
Water Resources Engineer
City of Westminster

CITY OF WESTMINSTER
Department of Public Works and Utilities
6575 West 88th Avenue
Westminster, Colorado 80031
P 303-658-2176
F 303-706-3927
www.cityofwestminster.us

City of Boulder
Public Works

1739 Broadway
Boulder, Colorado 80302
(303) 441-3200

November 3, 2021

To Whom It May Concern:

The City of Boulder would like to express its support for the following project: *Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a WSRF sponsored project).

Over the last couple of years, the City of Boulder has been investigating tools and methodologies that can improve upon the city's ability to forecast and manage its water supplies. ASO provides accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making. However, the costs involved in ASO flights and data processing are high.

The CASO workgroup has identified this Water Plan Grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado. Therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

Expanding ASO flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from ASO.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We fully support this project and look forward to continuing to remain engaged with ASO efforts in Colorado.

Sincerely,

Kim Hutton
Water Resources Manager
City of Boulder – Public Works Utilities Department

AURORA WATER

City of Aurora

Water Administration
15151 E. Alameda Parkway, Suite 3600
Aurora, Colorado 80012
303.739.7370

Worth Discovering • auroragov.org

Colorado Water Congress Board
Attn: Colorado Water Plan Grant
1313 Sherman Street, Room 718
Denver, CO 80203

October 29, 2021

Dear CWCB Board Members,

Aurora Water would like to express our support for the "Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion" project. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide ASO program (a CWCB Water Supply Reserve Fund sponsored project). Aurora Water is an active participant in the CASO workgroup and supports continued efforts to develop an ASO program in Colorado.

ASO's innovative snow measurement technologies and data products provide an invaluable new tool to all water sector stakeholders, including Aurora Water, for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, ASO provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies and municipalities, such as Aurora Water, are not able to provide the amount of funding on their own that is necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we utilize larger funding sources to test the program on a larger scale to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding ASO flights in Colorado will have benefits not only to Aurora Water and other municipalities, but also to other major water sectors and stakeholders, including environmental, recreational, agricultural, and industrial sectors. All of Colorado's water sectors will see value from the added accuracy of snowpack measurement from ASO. Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

Aurora Water fully supports this project and looks forward to continuing to remain engaged with ASO efforts in Colorado.

Sincerely,

Marshall P. Brown
General Manager
Aurora Water

Wednesday, November 10, 2021

YAMPA VALLEY SUSTAINABILITY COUNCIL

Dear, CWCB Water Plan Grant Review Committee,

Yampa Valley Sustainability Council would like to express our support for the following project: ***Phase I of the Colorado Aerial Snowpack Measurement Study***. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Madison Muxworthy
Soil Moisture, Water and Snow Program Manager
Yampa Valley Sustainability Council

Utilities
electric · stormwater · wastewater · water
PO Box 580
Fort Collins, CO 80522

970.212.2900
V/TDD: 711
utilities@fcgov.com
fcgov.com/utilities

November 5, 2021

To Whom It May Concern:

The City of Fort Collins, Water Resources Division, would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Donnie Dustin

Donnie Dustin, P.E.
Fort Collins Utilities, Water Resources Manager

Parks & Open Space
5201 St. Vrain Road • Longmont, CO 80503
303-678-6200 • POSinfo@bouldercounty.org
www.BoulderCountyOpenSpace.org

November 15, 2021

To Whom It May Concern:

Boulder County would like to express our support for the following project: *Phase I of the Colorado Aerial Snowpack Measurement Study*. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,
Therese Glowacki

Therese Glowacki, Director
Boulder County Parks & Open Space

Pitkin County Healthy Rivers
530 East Main Street Suite 301
Aspen Colorado 81611
970 920 5191 office
970 379 865 cell
pitkincountyrivers.com

November 9, 2021

To Whom It May Concern:

On behalf of Pitkin County's Healthy Rivers Program and Board, I write to convey our full support for Phase I of the Colorado Aerial Snowpack Measurement Study, specifically in the Roaring Fork Watershed. This project will build upon the work that the Colorado Airborne Snow Observatories (CASO) workgroup has conducted throughout 2021 to develop a plan for establishing a statewide aerial snow measurement program (a WSRF sponsored project).

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

The innovative snow measurement technology of airborne lidar provides an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, airborne lidar provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual aerial snow measurement program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado; therefore, it is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process.

We emphasize that expanding airborne lidar flights in Colorado will have benefits for all major water sectors and stakeholders—municipal, environmental, recreational, agricultural, and industrial sectors will all see value from the added accuracy of snowpack measurement from airborne lidar.

Notably, the members of the CASO workgroup represent all major Colorado River basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We support this project with emphasis on our local Roaring Fork Watershed and look forward to continuing to remain engaged with aerial snowpack measurement efforts in Colorado.

Sincerely,

Chris Lemons
Chairman

Town of Cedaredge Colorado

235 W Main Street | PO Box 398
Cedaredge, Co 81413
970-856-3123
wwwCedaredgeColorado.com

November 19, 2021

Colorado Water Conservation Board
Rebecca Mitchell, Director

Dear Ms. Mitchell and Members of the Colorado Water Conservation Board Grant Committee,

The Town of Cedaredge confirms our support for the successful grant award of the Northern Colorado Water Conservation District (NCWCD) for the Optimizing Colorado Water Supplies Through Airborne Snow Observatories (ASO) Flight Expansion project. This program has demonstrated the ability to provide an accurate, spatially complete measurement of the volume of water in the snowpack for a given watershed, which will accurately forecast streamflow and seasonal runoff. Application of this technology to the Gunnison Basin and to the Grand Mesa in particular will help the Town better monitor and regulate water supplies, so we can effectively manage the water resources for our community.

Water is life, especially in an agricultural valley like ours. As a member of the Gunnison Basin Roundtable, a member of the NCWCD, we have a deeply vested interest in supporting the continued work to manage the ever-increasingly sparse water resources in our state. ASO's innovative snow measurement technologies and data products provide an invaluable new tool to all water sector stakeholders for making decisions in the increasingly complex water landscape of Colorado and the western U.S. The better real-time understanding we have of mountain snowpack, the better decisions we can all make as water users and stewards. Of existing technologies, ASO provides the most accurate real-time measurement of mountain snowpack across entire watersheds, supporting runoff forecast improvements and management decision-making.

The CASO workgroup has identified this water plan grant effort as being crucial for establishing the foundation of an annual ASO program in Colorado. Local agencies alone will not be able to provide the amount of funding necessary for consistent year-to-year flights in Colorado. It is vital that we start tapping into larger funding sources to test the program on a larger scale and to better understand the many benefits of implementing this technology. This Water Plan Grant is the first major step of that process. Notably, the members of the CASO workgroup represent all major Colorado river basins, which demonstrates that this project will continue to contribute to statewide relationship building. This type of project aligns with Colorado's tradition of being an internationally recognized leader in water management.

We thank you in advance for your support of the Northern Colorado Water Conservation District grant application.

Raymond F. Hanson

Raymond F. Hanson, Mayor
Town of Cedaredge