STATE OF COLORADO
INTERAGENCY AGREEMENT
SHORT FORM

Paying State Agency Department of Natural Resources Colorado Water Conservation Board, ("CWCB")	**Contract Number** CMS Number: 185370 Encumbrance Number: CTGG1 PDAA 2024*2159
Performing State Agency Regents of the University of Colorado	**Agreement Performance Beginning Date** The later of the Effective Date or August 15, 2023
Contract Maximum Amount Entire Contract term for all applicable fiscal years: $173,326.00	**Agreement Effective Date** Upon approval by the State Controller or an authorized delegate
	Agreement Expiration Date August 15, 2028
	Terms Payment is due 30 days upon receipt of a valid invoice. Disputes are governed by Fiscal Rule 3-5, Section 4.2. Agencies shall report any outstanding balance on Exhibit AR_AP at Fiscal Year end.

Agreement Purpose and Obligations of the Parties

The purpose of this project is to quantify the effects of developing centralized rainwater harvesting on streamflow in the Denver metro area using statistical modeling, hydrologic modeling, and watershed-scale monitoring. Specifically, this work seeks to quantify the differences in streamflow in an undeveloped watershed vs. a traditionally developed watershed vs. a watershed developed with centralized rainwater harvesting.

Exhibits and Attachments

The following Exhibit(s) and/or Attachment(s) are included with this Agreement:

1. Exhibit A – Statement of Work and Budget.

Principal Representatives

For the Paying State Agency:

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Exhibit A

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

Statement Of Work	
Date:	May 23, 2023
Name of Grantee:	The Regents of the University of Colorado
Name of Water Project:	Modeling and analysis of the effects of centralized rainwater harvesting on streamflow
Funding Source:	Conservation and Land Use Planning

Water Project Overview:

Water scarcity driven by population growth and climate change are a major challenge to water security in Colorado and in the Metro and South Platte River Basins. Municipal water efficiency, reuse, and rainwater harvesting can serve to bolster water supplies in growing urban areas. Rainwater harvesting captures increased runoff from new development that senior water rights have not historically diverted as part of their supply. Following HB09-1129, Sterling Ranch has been the first pilot centralized rainwater harvesting project in Colorado. There are some barriers to expanded rainwater harvesting. The Grantee seeks to better quantify the effects of developing centralized rainwater harvesting on streamflow in the Denver metro area using statistical modeling, hydrologic modeling, and watershed-scale monitoring. Specifically, the Grantee seeks to quantify the differences in streamflow in an undeveloped watershed vs. a traditionally developed watershed vs. a watershed developed with centralized rainwater harvesting.

Project Objectives:

1. The Grantee will determine what most affects the streamflow change from an undeveloped watershed to a traditionally developed watershed.
2. The Grantee will determine what most affects the streamflow change from an undeveloped watershed to a watershed developed with centralized rainwater harvesting.
3. The Grantee will determine what most affects the streamflow change from a traditionally developed watershed to a watershed developed with centralized rainwater harvesting.

Tasks
Task 1 – Data analysis of the effects of urban development and centralized rainwater harvesting on streamflow
Description of Task:
The grantee will examine streamflow change from an undeveloped to a developed watershed, without and with rainwater harvesting.
Method/Procedure:

The Grantee has previously analyzed 21 watersheds in the Denver metro area across a gradient of urban development and found changes in streamflow such as decreased dry time with urban development. The School of Mines has also modeled the effect of re-development in Denver on additional stormwater runoff produced in the Berkeley neighborhood and compared this with the water use in the neighborhood. The Grantee has also estimated the lawn irrigation return flow in some of these watersheds (Fillo et al., 2021) and the grantee's ongoing work is expanding to more watersheds. The Grantee will build on this work to develop predictive models (i.e., regression and machine learning) for changes in streamflow (mean flow, and other quantiles of streamflow) with impervious surface cover, urban land use, lawn irrigation return flow, and other watershed characteristics. These models will be used to predict what 1 additional acre of impervious surface cover or urban land (with a mix of pervious and impervious area) produces in terms of streamflow and what the role is of other watershed characteristics. The streamflow predictive model will use current imperviousness but future imperviousness from the Denver Regional Council of Governments will also be explored. Using these models, the Grantee will determine what watershed or weather characteristics most affect the streamflow change from undeveloped to traditionally developed watersheds.

The Grantee will perform data analysis of the streamflow change from an undeveloped watershed to one with centralized rainwater harvesting. This will be carried out in partnership with the Grantee's consultant and Mile High Flood District (MHFD). The Grantee's consultant will be monitoring and sharing data on runoff and streamflow under developed conditions starting in 2023 in Sterling Ranch areas that are anticipated for pilot scale centralized rainwater harvesting infrastructure development. The Grantee will be monitoring streamflow upstream and downstream of the rainwater harvesting release point both pre- and post-harvesting. The Grantee will be monitoring the post-development runoff conditions, and in subsequent years, streamflow monitoring with active rainwater harvesting. The Grantee anticipates that more pre-development streamflow information from a similar climate and land use will be needed beyond that collected by the Grantee's consultant. Therefore, the Grantee has been monitoring streamflow in a similar rangeland watershed in West Stroh Gulch, Parker, Colorado since June 2020 (in partnership with MHFD and others), which the Grantee will use as supplementary and control pre-development streamflow information.

Streamflow data from undeveloped, grassland watersheds in Rocky Flats, West Stroh Gulch, and Sterling Ranch will be compared to the historic natural depletion estimation procedure for estimating allowable capture for rainwater harvesting that is used by Colorado Water Conservation Board (CWCB) and does not require streamflow data. Lastly, the Grantee will use streamflow data to compare how streamflow changes during development from a rangeland when using centralized rainwater harvesting.

Deliverable:

The Grantee will provide CWCB with a summary report of the data analysis of the effects of urban development and centralized rainwater harvesting on streamflow and a peer-reviewed open-access journal article. The statistical model will be available to all users on an interactive website using R-Shiny.

Tasks

Task 2 – Modeling of the effects of urban development and centralized rainwater harvesting on streamflow

Description of Task:

Examination and modeling of the streamflow changes between an undeveloped watershed vs. a traditionally developed watershed vs. a developed watershed with centralized rainwater harvesting.

Method/Procedure:

Using Stormwater Management Model (SWMM), the Grantee will develop models to predict streamflow given climate data and watershed and stormwater infrastructure characteristics. SWMM is a model that relates stormwater management (such as directly connected impervious area, and rainwater collection and use) to streamflow. Three scenarios will be calibrated:

1. Undeveloped watershed

   The Grantee will construct and compare two undeveloped watershed models. One will be of West Stroh Gulch and will be built on an existing pre-development model of the watershed

that was developed in part by Wright Water Engineers. The Grantee will calibrate this existing model to the pre-development streamflow observations in the grassland West Stroh Gulch (see Task 1: Objective 2). The Grantee will develop a second model of Sterling Ranch pre-development and will use the watershed-specific data (see scenario 3) as well as be informed by the pre-development model of West Stroh Gulch.

2. Developed without centralized rainwater harvesting
   The Grantee will build this model on an existing model of developed conditions in West Stroh Gulch without centralized rainwater harvesting developed in part by Grantee partners Wright Water Engineers and MHFD.

3. Developed with centralized rainwater harvesting
   The Grantee will develop this model with publicly available data to represent the watershed streamflow monitoring in Sterling Ranch. The climate data, rainwater harvesting and stormwater infrastructure, topography, and watershed characteristics in Sterling Ranch will be used to develop this model in partnership with the Grantee's consultant. The model will be calibrated using publicly available streamflow monitoring data from Sterling Ranch.

Using these three calibrated scenarios, the Grantee will use the model to conduct sensitivity analysis to answer the more general question of: *"What most affects how much streamflow change there is when transitioning between these scenarios?"* For example, the Grantee will quantify the impact of the following on streamflow:

- Volume of centralized rainwater harvesting (with and without direct roof connections)
- Operations of centralized rainwater harvesting using the best practices from the Sterling Ranch feasibility study (Mitisek et al., 2022) (facility capacity can limit yields)
- Weather conditions in different locations of the state of Colorado
- Topographic and soil conditions before development
- Housing density and levels of imperviousness
- Extreme weather conditions (wet, dry, hot, cold)
- Urban landscaping and irrigation (ability to use water to free storage capacity for next event)
- Impacts to deep percolation to alluvial groundwater (reduce precipitation infiltration vs. lawn irrigation returns)

The outcome of this analysis is also on the effects of this type of green infrastructure on a watershed scale for stormwater management effectiveness and is also of importance and high interest to MHFD.

Deliverable:

The Grantee will provide CWCB with a summary report of Modeling of the effects of urban development and centralized rainwater harvesting on streamflow and a peer-reviewed open-access journal article. All final models generated by this project will be made publicly available on the Consortium of Universities for the Advancement of Hydrologic Science, Inc (CUAHSI) HydroShare repository (https://www.hydroshare.org/).

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.

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

Colorado Water Conservation Board						
Water Plan Grant - Exhibit A						
Budget						
Prepared Date: 11/28/2022						
Name of Applicant: The Regents of the University of Colorado						
Name of Water Project: Modeling and analysis of the effects of centralized rainwater harvesting on streamflow						
Task No.	**Task Description**	**Estimated Task Start Date**	**Estimated Task End Date**	**Grant Funding Request**	**Match Funding**	**Total**
1	Data analysis of the effects of urban development and centralized rainwater harvesting on streamflow	8/15/2023	8/14/2026	$60,290.21	$24,009.06	$84,299.27
2	Modeling of the effects of urban development and centralized rainwater harvesting on streamflow	8/15/2023	8/14/2026	$90,427.94	$33,770.94	$124,198.88
3	Indirect Costs	8/15/2023	8/14/2026	$22,607.85	$0.00	$22,607.85
			Total	$173,326.00	$57,780.00	$231,106.00