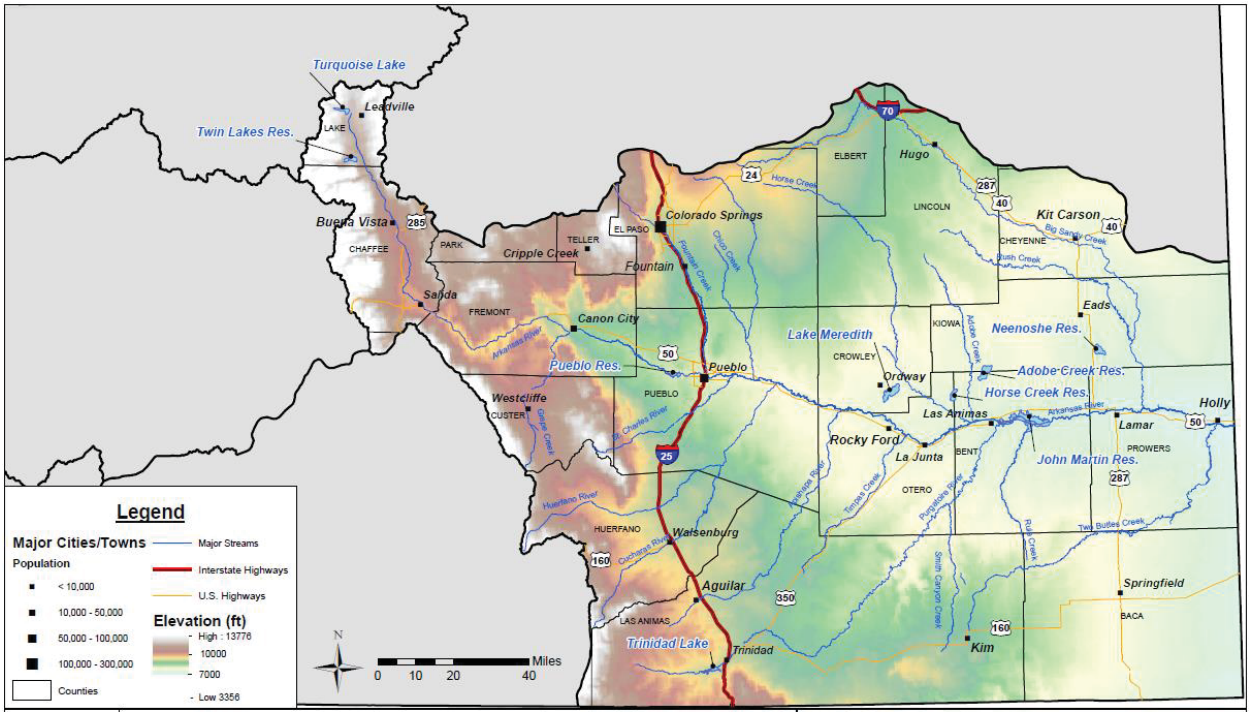
Arkansas River Colors of Water and Forecasting Tool Grant Proposal

Funding Opportunity No. BOR-DO-19-FO12

October 30, 2019



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Colorado Water Conservation Board
Department of Natural Resources

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Executive Summary

October 30, 2019

The applicant is the Colorado Water Conservation Board (CWCB), Denver, Denver County, Colorado, which is a Category A applicant (State). The CWCB is a Division of the Colorado Department of Natural Resources (DNR).

This grant proposal is applying for Funding Group 1: $150,000 with a 50% cash match within a 2-year schedule. The CWCB will be providing the $150,000 cash match from its Construction Fund which has been committed for this purpose. This proposal is for funding assistance of the Arkansas River Colors of Water and Forecasting Tool which is a tool that will be built for the State of Colorado Division of Water Resources (DWR) Division 2 office (Arkansas River basin). The tool will assist with administration of water rights and provide transparency of their administrative decision-making to water users and the general public. The project will be managed by the State of Colorado Colorado's Decision Support System (CDSS) team which is comprised of staff from both the CWCB and the DWR State Engineer's Office (DWR-SEO). The grant funding will be used to fund a consultant who can assist with modeling of water allocation, integration of the tool with Colorado's water resources database HydroBase, and web development for an interactive online tool and display. The State of Colorado, through the CWCB, DWR, and the Colorado Governor's Office of Information Technology (OIT), will also provide in-kind contributions to the project as it relates to model development, guidance, and integration into Colorado's suite of tools. As developers of the HydroBase water resources database, web tools, web service APIs, and water resources models, the State team is well qualified and necessary partners for this project to be integrated into the CDSS framework.

As part of the ongoing Arkansas River Decision Support Systems (ArkDSS) effort, the timing of deployment of this tool is flexible and will be completed within 2 years of the issuance of this grant.

The proposed project will communicate and potentially influence decision-making and operation of Bureau of Reclamation Fryingpan-Arkansas Project facilities including releases of project water from Turquoise and Twin Lakes Reservoirs to Pueblo Reservoir and releases of project water from Pueblo Reservoir to downstream project participants. The tool may also be applied to the Purgatoire River with releases from the Bureau of Reclamation Trinidad Reservoir Project or to track sources of water for exchange into Trinidad Reservoir.

Technical Project Description and Milestones

Description of Tool

The Colors of Water and Forecasting Tool will be a web-based modeling and communication tool on the Arkansas River in Colorado and its major tributaries (including Fountain and Monument Creeks, the Purgatoire River, and the South Arkansas River) that will break out the "colors" of water flowing in the river at any point of interest in real-time and forecasted into the near-term future. A "color of water" describes destination, use, type, or purpose of water in a river. The tool will use real-time telemetered gage and diversion data as well as stream properties in order to model transit time, transit loss, ungauged inflows, and groundwater interactions to predict flows at any location. Additionally, forecasts of hydrology, climate, and water user operations will result in forecasted flows and "color" breakouts into the future of roughly a week. This information will be displayed on a webpage and serve as a communication tool to water users who would otherwise not be privy to other water user operations on the river. There will also be tools that will only be available to DWR-Division 2 staff in order to estimate transit losses for reservoir releases and verify the potential for exchanges that are requested by water users.

Phase I Tool Functionality

The existing Phase I Colors of Water tool that was developed during Phase I of ArkDSS describes many different colors of water in the Arkansas river mainstem at major gaged locations from Granite, CO to Granada, CO. It does so through a web interface that displays the gaged locations on an interactive, selectable map, and then displays the colors of water in a stacked line graph and table format. Figure 1 shows the map display where selection of a river gage can be made.

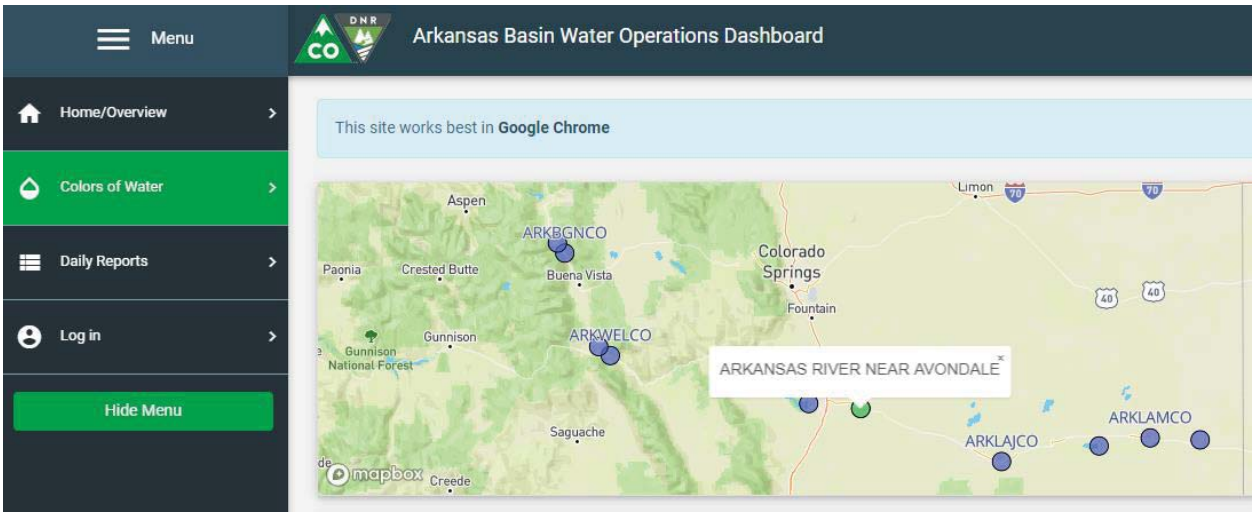


Figure 1. The Colors of Water Phase I webmap allows for selection of major river gages to display the colors of water. http://www.div2waterops.com.

Figure 2 shows the Colors of Water stacked line graph. The graph displays the colors of water on a particular date from upstream to downstream. The legend on the right breaks out the water at a gage on a particular date by category. These categories are further broken out by operation in a table below the graph.

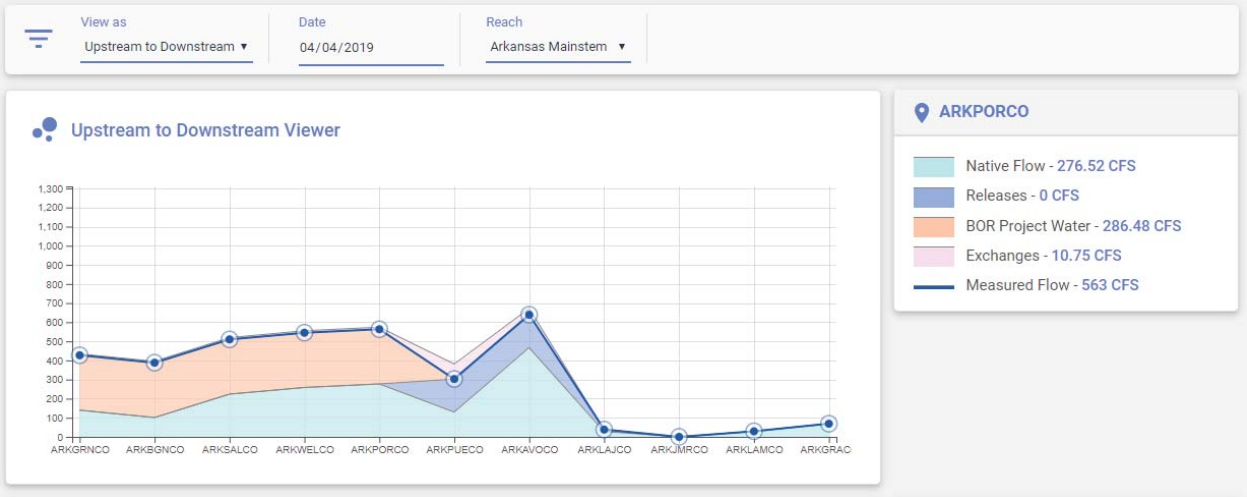


Figure 2. The Colors of Water Phase I stacked line graph displays the colors of water from upstream to downstream on a particular date. The legend on the right side of the graph shows the breakout of colors by category with the amount of flow for each category. http://www.div2waterops.com.

There are several limitations to the current Phase I implementation of the Colors of Water tool in ArkDSS Phase I that will be addressed in the Colors of Water and Forecasting tool.

1) Locations limited to stream gages. There are 11 stream gages in the reach from Granite to Granada, which is a reach of roughly 300 miles. The higher spatial density in the proposed project will require modeling of flows between reaches, which is one of the main tasks for the next version of the tool.
2) Data source is an operations spreadsheet, not HydroBase. The current tool uses a Google Sheets operations spreadsheet maintained by DWR-Division 2 to determine the colors of water in each reach.
3) Hosted by consultant using their "tech stack". The consultant team who developed the Phase I Colors of Water tool used a set of technologies that were familiar to them, which is a combination of Google sheets, Drupal, and JavaScript.
4) No dynamic modeling of transit time and losses. Development of a modeling system to perform routing and transit loss calculations will be another one of the main tasks for the next version of the tool.
5) No forecasting ability. The Phase I tool serves as a real-time and historical tool.

The proposed Colors of Water and Forecasting tool hopes to address all of these issues with the proposed project. This will address many needs in the Arkansas River basin, where the tool will initially be deployed, and allow for adoption in other basins in Colorado as the data sources and tool structure will be generically built and able to be maintained and hosted exclusively by State staff.

Uses of Tool

The Colors of Water and Forecasting tool fulfills several needs in the Arkansas River basin that also exist in several heavily managed basins throughout Colorado. As a communication tool, the webpage will display colors of water, broken out by specific operations of individual water users in a table, and allows other water users to evaluate water availability. The ability of water users to perform short-term planning will become more accessible as operational decisions such as reservoir releases, diversions, and upstream exchanges often rely on forecasts of available flow and priority of the calling water right, which are often impacted by operational decisions of other water users. The tool may also facilitate longer term evaluation of water availability including evaluation of the potential to appropriate new rights for upstream water exchanges. Finally, protection of water rights from injury is an important issue for water rights holders in Colorado. Water rights decrees issued by water courts dictate how a water right must be operated and any terms and conditions required for operation, but decrees can be complicated and operation outside of the terms and conditions of the decree is possible. This may cause injury to other water rights holders, who can only be vigilant if they are informed of the operations of other water rights holders on the river. This tool allows water rights holders to remain informed of the operations amongst all water rights holders on the river.

The tool also fulfills several administrative needs for DWR-Division 2 in their mandate to administer water rights decrees and protect water rights holders from injury. The tool will be used to assess transit loss and transit timing to reservoir releases as well as aid in allocation of high flows. The tool currently used to assess transit loss and transit timing on the mainstem Arkansas River below Pueblo Reservoir is called the Arkansas River Transit Loss and Accounting Program (TLAP). It is used when reservoir releases are made out of Pueblo Reservoir and John Martin Reservoir to downstream locations, which can be more than 100 miles downstream. In most cases, the DWR-Division 2 staff is responsible for determining when the release arrives at the downstream structure (potentially several days later and following a curve pattern as the front of the release disperses as it travels downstream), how much of the release is lost to evaporation, and how much of the release can be captured at the headgate given attenuation caused by dispersion and groundwater interaction. Similarly, a tool currently maintained by the USGS is used by DWR to evaluate transit losses for trans-mountain and other consumable return flows in Fountain and Monument Creeks and determine the amounts of these return flows that can be reused or exchanged when they reach the Arkansas River mainstem. The functionality of

the current models will be incorporated into the Colors of Water and Forecasting tool and operational deficiencies that have been identified in the current tools can be improved.

Correct administration and accounting of reservoir storage and releases is also imperative to DWR-Division 2 staff in light of the Arkansas River Interstate Compact with Kansas. Proper assessment of transit losses are critical for determination of water delivered into Kansas reservoir accounts in John Martin Reservoir, water delivered from John Martin Reservoir to Kansas, or water that is used to augment pumping depletions under provisions of the Kansas v. Colorado decree. Administration of timing and transit losses for Colorado operations can also affect water flow at the state line. The data, methods and results used to administer water in Colorado must be transparent to the state of Kansas and this transparency will be improved with a more modern, visual, web-based system.

In the Upper Arkansas basin, a key water user driven program, the Voluntary Flow Management Program (VFMP), began in 1989 when the Arkansas Headwaters Recreation Area was formed and assisted by a Citizens Task Force. The fundamental objectives of the VFMP were to work with the Southeastern Colorado Water Conservancy District and the Bureau of Reclamation to either supplement natural flows on the Arkansas River or avoid adding to natural flows on the Arkansas River through reservoir deliveries to:

- Maintain a minimum year-round flow of at least 250 cfs at the Arkansas River Near Wellsville gauge to protect the fishery;
- Attempt to achieve winter incubation flows in the optimal range from 250 cfs to 400 cfs from October 15th to November 15th of each year;
- Attempt to maintain flows within the range of 250-400 cfs between April 1st and May 15th;
- Attempt to achieve a minimum flow target of 700 cfs at the Arkansas River Near Wellsville gauge during the peak summer months in support of the recreational rafting industry from July 1st through August 15.

Finally, there is a need in other basins of the state for a colors of water tracking tool. For example, in the Rio Grande basin, administrators are required to deliver a certain flow to the New Mexico state line in accordance with the Rio Grande Interstate Compact, which requires curtailment of water users. Forecasting of operations and flows for a week into the future would aid in this operation and avoid over or under-curtailment of water rights users. In the Colorado River basin (including all its the tributaries in Colorado such as the San Juan, Yampa, Gunnison, etc.) the Demand Management Feasibility study aims to reduce consumption and shepherd water to a protected pool in Lake Powell. These Colorado basins currently have no tool to track and shepherd conserved water to the Colorado state line, and this tool, if adapted to the Colorado River basin, may offer an applicable framework for such a tool.

Inputs to Tool

The Colors of Water and Forecasting Tool will consume data from a variety of sources, but will focus its ongoing data retrieval from HydroBase, Colorado's water resources database. This focus on HydroBase will facilitate the transfer of the tool to other basins in Colorado since it is a statewide database used by every DWR Division office. These data, which are often updated in real-time and available on a 15-minute basis, include river gage data provided by the USGS, diversion data, reservoir release and river exchange data, and administrative call data.

Structure information such as stream mile and priority data of water rights are accessible through HydroBase and are important for determining distances for transit loss and transit time as well as modeling and forecasting of in-priority diversion. These values are static and will only need to be accessed through HydroBase during development of the model system and parameters.

The current mainstem and Fountain Creek models assume constant monthly evaporation rates to determine transit losses. These estimates could be improved by using real-time estimates of water evaporation. DWR has been developing a gridded climate dataset that estimates water evaporation at ~2.5 mile grid points across the state. This project may facilitate production of these data in real time, ingestion of these data into HydroBase, and development of HydroBase REST web services to allow query of this data by the Colors of Water and Forecasting Tool.

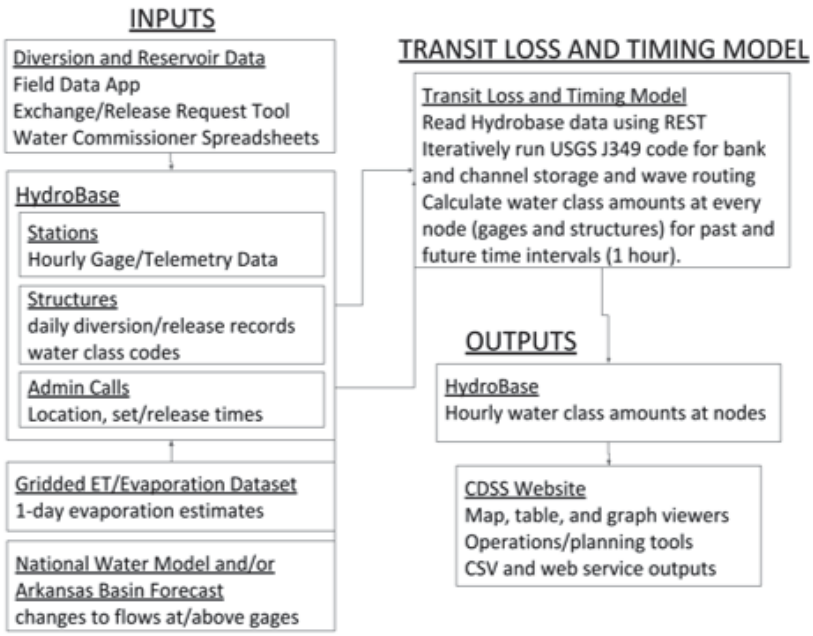


Figure 3. Schematic of inputs, modeling, and outputs for the Colors of Water and Forecasting Tool.

A hydrologic forecast will be used to estimate flows up to 30 days into the future. Although the Arkansas-Red Basin River Forecast Center (ABRFC), a program within the National Oceanic and

Atmospheric Administration (NOAA), does not currently issue daily forecasts for the basin in Colorado, personal communication with the agency has indicated that they will issue forecasts at the request of State agencies at key gages in the basin. This forecasted hydrology considers precipitation, snowmelt, water management, and other factors to generate streamflow forecasts into the 5 day future. Alternatively, output from the NOAA National Water Model (NWM) (https://water.noaa.gov/) may be used to identify predicted changes in gauged flows and/or tributary inflows throughout the river system. The NWM produces short-range (18-hour), medium-range (8.5-day), and long-range (30-day) forecasts for streams in the National Hydrography Dataset using the WRF-Hydro hydrologic model, numerous climate forcing data sources, and USGS stream gage data. Personal communication with NWM collaborators suggests that they may also be able to assist the state with use of these data.

Modeling and Data Processing

Transit loss models have already been developed for the mainstem Arkansas River from Pueblo Reservoir to John Martin Reservoir and from John Martin Reservoir to the Colorado/Kansas stateline, and for Fountain/Monument Creeks to the Arkansas River. These models utilize the U.S. Geological Survey's J349 fortran program to represent channel storage and stream-aquifer interactions for bank storage and perform both kinematic and dispersive wave routing. The Fountain Creek study developed transit loss parameters based on flow rates while the mainstem models run J349 under steady-state conditions.

For the Colors of Water and Forecasting Tool, a modeling and data processing software component will be built that will extract data from HydroBase and from NWM output files, perform transit loss and timing calculations to estimate water class amounts at all desired nodes in the river, and make these data available for re-ingestion into HydroBase and/or the web visualization software. The modeling tool will call the J349 program to perform the underlying transit loss and timing calculations within each river subreach and operate on an hourly timestep using transient conditions.

The J349 program requires several aquifer and stream parameters such as transmissivity, storage coefficient, aquifer and stream widths, average gains/losses, and stage-discharge relationships. These parameters have already been developed for the lower Arkansas River mainstem and for Fountain and Monument Creeks. However, the consultant will develop these parameters for the mainstem above Pueblo Reservoir and other major tributaries. At a minimum these other tributaries will include the South Arkansas and Purgatoire Rivers but development for many other tributaries may also be possible.

DWR has been developing a modeling system that produces a statewide daily gridded climate dataset that estimates water evaporation at ~2.5 mile grid points. The system estimates reference evapo-transpiration (ET) based on the ASCE standardized ET method using CoAgMet and NOAA climate station data and GridMET gridded forcing data. Water evaporation is

estimated using methods from FAO-56 (Allen et. al. 1998) and other literature. The Colors of Water project may facilitate production of these data in real time, ingestion of these data into HydroBase, and development of HydroBase REST web services to allow query of this data by the Colors of Water and Forecasting Tool.

Outputs from Tool

The tool will result in several outputs for use by the public, water users, and administrators in the basin. The main output of the tool will be estimated flow at each structure in the basin divided by account or water type (color). To determine flow at each structure location in the basin, transit loss and transit time will be estimated and also be available as an output. The output will be shown as a map viewer, tables, graph viewers, CSVs, and through web services. For river administrators, volume and timing of reservoir releases will be a product of the modeling which will allow more accurate capture of those releases, increased efficiency, and reduced potential injury to other users in the basin. Forecasted flows, operations, and water color will be an output of the tool which will assist water users in planning their own operations, such as when a particular water right may come into priority.

Project Schedule (Tasks, milestones, and dates)

Table 1. Project tasks and schedule

Tasks	**Months**
1. DWR develops initial modeling/data processing component	0-3
2. RFP issued for consultants	0-1
3. Choose consultants and contracting	1-3
4. Biweekly check-in meetings / phone calls	3-24
5. Continued development of modeling components	3-16
5.a. Timing	3-12
5.b. Transit Loss	3-12
5.c. Real-time evaporation data	6-16
5.d. Aquifer/stream modeling parameters	6-16
6. Development of data standardization and water classes	3-12
6.a. HydroBase 15-minute provisional records	3-6
6.b. Institution of To: water classification	6-12
6.c. REST web services APIs	9-12
7. Development of web interface	3-24
7.a. Web/data architecture	3-12
7.b. Mapping interface	6-12

7.c. Connection of modeling data to display data	12-18
7.d. Hosting	18-24
7.e. Incorporation of feedback	18-24
8. Stakeholder meetings and feedback	18-24
9. Compliance with reporting requirements	6-24
10. Project Management and Travel	0-24

Milestones:

1. Awarding of grant
2. RFP for consultant
3. Choose consultant
4. Kickoff meeting to coordinate efforts of consultant and Colorado team
5. Institution of data standards and water classes
6. Development of modeling back-end
7. Development of web interface
8. Launch of beta tool and collection of stakeholder feedback
9. Launch of final tool

Project Location

This project will be based in the Arkansas River basin of Colorado, but will be designed to have statewide applicability. The project managers for the project are housed at the CWCB and DWR-SEO in Denver, CO and DWR-Division 2 in Pueblo, CO. Please see the attached .pdf map of the Arkansas River basin in Colorado.

Data Management Practices

One of the main advantages of the tool is that it integrates with the CDSS data model and will be data-centered around HydroBase, the CDSS water resources database. The Phase I Colors of Water tool data source was based on a Division 2 operations Google Sheet, which was only applicable to administration of the Arkansas River in Colorado. HydroBase is a statewide, publicly available database that contains river gage data, diversion records, climate data, administrative call records, well pumping records, and other types of data. The sources of these data range from water commissioner classified diversion records from every basin of the state to outside Federal agency data such as telemetered USGS stream gage records. HydroBase uses consistent standards and data retrieval APIs, so constructing the tool off of this platform will greatly enhance its applicability statewide. As a statewide database, HydroBase has been in consistent use since the mid-1990s and has robust standards and QA/QC programs.

Evaluation Criteria

Evaluation Criterion A - Benefits to Water Supply Reliability (40 points)

Describe how your project will benefit water supply reliability:

1. **Describe the *water management issue(s)* that your project will address. For example, will your project address water supply shortfalls or uncertainties, the need to meet competing demands for water, complications arising from drought, conflicts over water, or other water management issues? Describe the severity of the water management issues to be addressed through your project.**

The Arkansas River in Colorado is one of the most actively managed and over-appropriated rivers in the State, while the Arkansas River Interstate Compact and requirements of the Kansas v. Colorado settlement have added to the scrutiny of water administration throughout the basin. Water rights junior to the 1949 Compact call are rarely in priority (have not been in 20 years) and many pre-Compact water rights are commonly not satisfied. There is currently a gap of 617,000 acre-feet (AF)/year between agricultural demand for full crop production and supply, and it could potentially grow to over 800,000 AF/year by 2050 according to the Colorado Water Plan Technical Update. The population of the Arkansas River basin is projected to grow from 1,008,000 in 2015 to 1,626,000 by 2050, and climate change is projected to reduce late summer flows by 25-40% by 2050. These impacts will further strain water resources and require the best possible water management, including management of reservoir releases and river exchanges.

Water rights are administered by the prior appropriation doctrine, and water administrators and water users rely on rudimentary tools to perform and communicate administrative decisions. Active administration often involves accounting for transit loss, transit time, multiple dry-up locations, river exchanges, complicated reservoir accounting, and Interstate Compact considerations, and water users are often not informed of other operations, confused by how other operations change river flows, and unclear how much water they may have a right to use.

This tool will address the need for communication from administrators to water users, the need to accurately track water accounting, and the need to maximize beneficial use in the Arkansas River basin within the parameters of the prior appropriation system and the Arkansas River Interstate Compact. An important “color of water” to convey to the public will be amount of Bureau of Reclamation Fryingpan-Arkansas water being moved from upstream facilities to Pueblo Reservoir, and from Pueblo Reservoir to downstream project participants.

2. **Explain how your project will address the water management issues identified in your response to the preceding bullet. In your response, please explain how your project will contribute to one or more of the following water management objectives and provide support for your response:**
    a. **water supply reliability,**

b. management of water deliveries,
c. water marketing activities,
d. drought management activities,
e. conjunctive use of ground and surface water,
f. water rights administration,
g. ability to meet endangered species requirements,
h. watershed health,
i. conservation and efficiency, or
j. other improvements to water supply reliability.

This tool addresses the needs of water administrators for making informed decisions as well as a mode of communication to broadcast these decision-making parameters to water users. The tool will act as a mode of communication by offering a web-based interactive map, tables, and database for water users to observe operations by other water users as well as river and reservoir accounting. The tool will aid in tracking of water accounting by performing back-end modeling of transit time and transit losses and displaying the colors of water in location and time on the map as it travels downstream as well as incorporating near real-time HydroBase data of diversions, releases, and exchanges. Finally, it will maximize beneficial use within the basin by more accurately forecasting operations and hydrologic drivers, such as flood events. These forecasts will allow administrators to better distribute high flows to junior priority water users as the wave makes its way downstream without causing injury to senior water users.

The tool will contribute to the water management objectives of management of water deliveries and water rights administration through better modeling tools, a better data-driven approach to decision-making by incorporating real-time HydroBase data, and better communication of water rights administration to water users through a web interface.

3. Describe *to what extent* your project will benefit one of the water management objectives listed in the preceding bullets. In other words, describe the significance or magnitude of the benefits of your project, either quantitatively or qualitatively, in meeting one or more of the listed objectives.

Many releases from Pueblo, John Martin, Twin Lakes, and Trinidad Reservoirs experience an estimated travel time of 3 to 4 days with a margin of error of 1 to 2 days. Similarly, estimates of transit loss in the Arkansas River can range from roughly 0.1% to 0.5% per mile depending on many fluctuating factors. Improvements to the accuracy of assessed transit time and transit loss can improve administration by tens of thousands of AF per year basin-wide as hundreds of thousands of AF are released by these four reservoirs each year. Table 2 shows that 331,850 AF were released downstream out of the major reservoirs in the Arkansas River basin during water year 2018. With an estimated average delivery distance of 50 miles, and a potential error of 0.4% per mile, this results in a potential error of 66,370 AF in 2018. An improvement of estimated

transit loss and timing will reduce this potential error and aid in maximizing Colorado's beneficial use of its water.

Table 2. Reservoir releases for delivery to downstream canal during WY 2018.

Reservoir	AF released for delivery 11/1/2017 - 10/31/2018
Pueblo	99,939
John Martin	158,253
Twin Lakes	52,927
Trinidad	20,731
Total	***331,850***

The impact of better communication of water rights administration and operations will be felt by a strengthening of trust between the many disparate stakeholders in the basin, who have been in conflict for decades and will continue to compete for water resources as supplies diminish, the population grows in the basin, and values in areas such as agriculture and recreation evolve. The tool will assist in reducing conflict in Colorado's water court system, in operations and accounting of water administration, and in interstate litigation with the State of Kansas, which closely monitors Colorado's water use. In addition, water users can learn about each other's operations that greatly impact flows in the basin, such as the Fryingpan-Arkansas project and the Voluntary Flow Management Program.

4. **Explain how your project complements other similar applicable to the area where the project is located. Will your project complement or add value to other, similar efforts in the area, rather than duplicate or complicate those efforts? Applicant should make a reasonable effort to explore and briefly describe related ongoing projects.**

As the provider of much of the data and source of administrative decisions within the Arkansas River basin, we are not aware of projects from other entities that apply the same forecasting and modeling or web-based communication or seek to accomplish similar goals to this project. Once fully operational, this tool will replace the Phase I CDSS Colors of Water tool.

This tool does complement many tools and models also provided by the CDSS program. The CDSS Map Viewer (https://gis.colorado.gov/dnrviewer/Index.html?viewer=mapviewer) provides a web-based viewer of GIS data such as irrigated cropland, structure locations, and in-stream flow reaches. It does not, however, show any flows, detailed accounting, or river operations. A water allocation model is currently being built in StateMod, the State of Colorado's surface water allocation modeling software (https://www.colorado.gov/pacific/cdss/statemod). While this model focuses on accurately portraying the prior appropriation system and river operations, it is a planning model that simulates historical hydrology and operations. Alternatively, the Colors of Water and Forecasting tool is a short-term forecasting and operations modeling tool that starts at the present time and forecasts out for a multiple day horizon.

Evaluation Criterion B - Need for Project and Applicability of Project Results (25 points)

Explain how your project will result in readily useful applied science tools that meet an existing need:

1. **Does your project meet an existing need identified by a water resource manager(s) within the 17 Western States?**
    a. **Explain who has expressed the need and describe how and where the need for the project was identified (even if the applicant is the primary beneficiary of the project). For example, was the need identified as part of a prior water resources planning effort, through the course of normal operations, or raised by stakeholders? Provide support for your response (e.g., identify the entities that have expressed a need or cite planning or other documents expressing a need for the project).**

The Colors of Water and Forecasting Tool was requested by water users in the Arkansas River basin and Colorado DWR-Division 2. According to Bill Tyner, the Division Engineer of DWR-Division 2, the idea arose from a combination of stakeholders and administrators expressing the need for better communication and transparency and shortcomings of the existing administrative tool-set. This need was described in the ArkDSS Feasibility Study (December 2011, p. 4-10) which listed as a need: "A tool that tracks different colors of water … in real time at a given location could enhance the ability Division 2's ability to administer the river and would provide more timely information to water users. Including functionality to help Division 2 with short-term forecasting (i.e. reservoir spills) would provide additional benefit for administration purposes".

    b. **Provide letters of support from any resource managers, stakeholders or partners that have stated that they will benefit from the project, or, for Category B applicants, letters of participation from partners who have committed to participate in the proposed project. Identify any contribution (e.g., cost share, staff time, or other resources) by partners other than the applicant to the non-Federal cost share requirement for the project.**

See letter of support from the Arkansas River Basin Roundtable and Southeastern Colorado Water Conservancy District. Also see letters of support and commitment from the Colorado Division of Water Resources - State Engineer's Office and Colorado Division of Water Resources - Division 2 (Arkansas River basin). These letters commit staff from each of these DWR offices to perform technical work and oversight of the consultant team.

2. **Will the project result in an applied science tool(s) or information that is readily applicable, and highly likely to be used by water resource managers in the West?**
    a. **How will the project results be used?**

b. **Will the results of your project inform water resource management actions and decisions immediately upon completion of the project, or will additional work be required?**
c. **Will the results of your project be transferrable to other users and locations?**
d. **If the applicant is not the primary beneficiary of the project (e.g., if the applicant is a university or research institute), describe how the project beneficiaries have been or will be involved in planning and implementing the project?**

The results of this project will be used by Arkansas River basin water users and administrators immediately upon the deployment of the tool to the web. There is already great curiosity by water users about operations and accounting within the Arkansas River basin that are not currently readily accessible or in an easy to understand visual format. There has been feedback that the Phase I tool is used and is useful for water managers in understanding operations, but lacks the spatial resolution or forecasting necessary for individual water users to make informed decisions about their particular operations. The new tool will be used by administrators to verify transit losses and timing for reservoir releases to downstream users, to verify the timing of and water availability for exchanges, to perform forecasting and communicate decision-making to water users, and will be used by water users in understanding river operations and accounting and to plan their own operations based on this information.

One of the main purposes of this project is to build the tool in the statewide platform that is data-centered with HydroBase, Colorado's water resources database, with tools and in a web deployment environment that are maintainable by state staff. This will result in a tool that is easily transferrable to other basins within Colorado, where interest has already been shown for similar tools. The CDSS program has shown expertise in applying map-based and visual web-based tool frameworks to statewide HydroBase datasets. See the CDSS Map Viewer (https://gis.colorado.gov/dnrviewer/Index.html?viewer=mapviewer) and the CDSS Online Tools (https://dwr.state.co.us/Tools).

The project may also result in dissemination of water evaporation and crop evapo-transpiration data for ~2.5 mile grid points covering the state of Colorado through REST services. These data were developed and are being professionally peer reviewed as part of other projects; but services to disseminate these data have not been developed. Besides being used to calculate transit losses in the Colors of Waters tool, these data could also be used by water resource managers to estimate reservoir evaporation, water requirements for ponds and wetlands, and historical consumptive uses of water rights.

Evaluation Criterion C - Project Implementation (15 points)

Describe your project implementation plan:

1. **Describe the objectives of the project and the methodology and approach that will be undertaken. Provide support for your methodology and approach.**

The objectives of the project are to create a tool for Colorado DWR-Division 2 that communicates river operations and accounting to the general public in a web-based mapping format, performs modeling of transit loss and transit timing of individual water deliveries, and performs short-term forecasting based on projected hydrology and future operations. The tool will be data-centered in HydroBase, Colorado's water resources database, will be built using tools and development environments maintainable by state staff, and will be adaptable to other basins in Colorado.

The methodology and approach to building this tool will involve the hiring of a contractor (or two contractors) who will focus on a) modeling of colors of water between river gages using HydroBase data as input, and b) the deployment of a website and mapping application that communicates the information built in a platform maintainable by the state of Colorado. The consultant team will be overseen by staff at the CWCB, DWR-SEO, and DWR-Division 2 to ensure that the tool accurately reflects DWR-Division 2 operations and accounting, interfaces with HydroBase correctly to ingest data, and follows OIT protocols for security, web deployment, and future maintenance. This management will involve regular meetings between the consultant team and state staff and in-kind support in critical areas where state staff are better equipped to perform technical and expertise work. Finally, review of the product will occur and revisions will take place where required.

This methodology and approach of hiring a consultant team overseen by the CDSS team has proven to be a successful formula and has been used by dozens of projects since the inception of the CDSS program in 1993, such as:

-The Basin DSS efforts, most recently ArkDSS Phase I.

-The Colorado River Water Availability Study (http://cwcb.state.co.us/technical-resources/colorado-river-water-availability-study/Pages/main.aspx)

-Development of the CDSS software suite (https://www.colorado.gov/pacific/cdss/software)

2. Describe the work plan for the project. Include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates.

The project will be phased such that the technical leads at DWR develop the initial modeling and data processing framework while the CWCB is conducting the competitive hiring process and contracting. During the work phase of the project, the contractor will develop the modeling component, data standardization and water classes, and web interface. This phase will be supervised by DWR technical leads to ensure that OIT security protocol is adhered to, the data management interaction with HydroBase is done correctly, and that the tool accurately conveys accounting and river properties specific to the Arkansas River. The task list and schedule can be found above in the section "Project Schedule (Tasks, milestones, and dates)" in Table 1.

Several key milestones are necessary to reach in order for the successful completion of the project. The milestones listed below are generally listed in order, though there may be some overlap or swapping of milestones, especially the technical work conducted by the consultant team (milestones 5-7).

Milestones:

1. Awarding of grant
2. RFP for consultant
3. Choose consultant
4. Kickoff meeting to coordinate efforts of consultant and Colorado team
5. Institution of data standards and water classes
6. Development of modeling back-end
7. Development of web interface
8. Launch of beta tool and collection of stakeholder feedback
9. Launch of final tool

3. Describe the availability and quality of existing data and models applicable to the project.

A majority of the input data for the tool already exists but in some instances will need to be reformatted for inclusion in HydroBase in order to make the tool data-centered from HydroBase. Data that will be used by the tool that already exists as high quality data in HydroBase includes river gage data, climate data, and diversion data. Gridded water evaporation estimates are produced by DWR for past months, but this project will enable production of real-time estimates, inclusion, and delivery from HydroBase. Reservoir releases, exchanges, and reservoir accounting transfers currently exist in Google Sheets maintained by DWR-Division 2 and special coding may need to be created to enable more automated entry of this data into HydroBase. Transit loss models that are currently used for administration do exist for the Arkansas River below Pueblo and Fountain/Monument Creeks. The methodologies and results from these models will aid in the development of the new tool, and the calibrated channel and aquifer properties to simulate channel and bank storage developed for those models will also be used. However, channel and aquifer properties will need to be developed and calibrated for other portions of the study area. See the "Inputs to Tool" section of this proposal for a more detailed explanation of input data and models.

4. Identify staff with appropriate credentials and experience and describe their qualifications. Describe the process and criteria that will be used to select appropriate staff members for any positions that have not yet been filled. Describe any plans to request additional technical assistance from Reclamation or via a contract.

Brian Macpherson, P.E. - Project Manager - Brian is the CWCB's Decision Support Systems specialist and is the program manager for Colorado's Decision Support Systems and the project

manager of the Arkansas River Decision Support System. He also has 5 years of relevant experience in Colorado water rights engineering, operations, and administration.

John Rodgers, P.E. - Web Development and HydroBase Technical Lead - John is DWR-SEO's HydroBase Coordinator. He manages a team of programmers at DWR-OIT who implement HydroBase web tools and web services. John also has 25 years of experience in consulting where he implemented technology and web solutions to water resources issues.

Kelley Thompson, P.E. - Modeling Technical Lead - Kelley has been DWR-SEO's Lead Modeler for the Arkansas River basin for almost 8 years. He maintains and updates the Arkansas River basin Hydrologic-Institutional (H-I) model, which is used for administration of the Arkansas River Compact between Colorado and Kansas under conditions of Kansas v. Colorado. He developed the CDSS "Lease Fallow Tool" software tool and DWR's system to produce statewide gridded evaporation and evapo-transpiration data.

Bill Tyner, P.E. - Division 2 Engineer - Bill is the Arkansas River basin's Division Engineer with 23 years of experience administering water rights in the basin and another 14 years in water engineering. He will advise the project from an administrative and Interstate Compact standpoint. Bill has served as the administrative lead during development of the ArkDSS.

A consultant team will be chosen in a competitive process through an RFP. The RFP will be based on the requirements outlined in this proposal and will be broken into two categories: one for the web development component of the project and one for the modeling and forecasting component of the project. One consulting firm will be eligible to bid on both components of the project, or two firms may be chosen that specialize in each category. Once the consultant team has been chosen by a selection committee, they will enter into a contract with the CWCB and be funded for $300,000 to complete the project. The consultant team will work under the direction of the CWCB and DWR project manager and technical leads. Special care will need to be taken to properly interact with OIT security protocols as well as data management specifications within HydroBase, Colorado's water resources database.

a. Have the project team members accomplished projects similar in scope to the proposed project in the past either as a lead or team member?

Yes, all of the team members have accomplished projects similar in scope to the proposed project. Currently, the team of Brian Macpherson, John Rodgers, Kelley Thompson, and Bill Tyner manage the ArkDSS Phase I project that consists of three components being accomplished by three consulting firms. In addition, the CWCB, DWR-SEO, and DWR-Division 2 offices perform in-kind review and technical QA/QC of the work products. To manage the project, the entire State internal team holds bi-weekly phone meetings and assigns tasks to staff. In addition, the team is in regular contact with the consultant teams and holds regular working meetings to advise them. In addition, John Rodgers leads a team that produces web tools and web services, available at https://dwr.state.co.us/Tools, that accomplish many of the same goals of data dissemination as the proposed project on a statewide level.

b. **Is the project team capable of proceeding with tasks within the proposed project immediately upon entering into a financial assistance agreement? If not, please explain the reason for any anticipated delay.**

At the beginning of the project period, DWR will immediately commence in-kind development of the initial modeling and data processing component. For consultant work, there will be a delay after entering into the financial assistance agreement in order for the CWCB to issue an RFP, make the consultant team selection, and to enter into a contract with the consultant team. Although the RFP will be written before any financial assistance agreement is entered into, the RFP will need to be issued for 30 days, the consultant team review process will take another 30 days, and the contract will take up to 45 days to be issued. This 3 ½ month delay will be accounted for in the schedule.

5. **Provide a summary description of the products that are anticipated to result from the project. These may include data, metadata, digital or electronic products, reports and publications.**

This project will result in a web-based tool and interface that the public can use to increase their understanding of colors of water in the Arkansas River as well as reservoir accounting and forecasted operations and flow. From the State's perspective, the project will result in a data-centered framework for disaggregating river accounting within a river basin and for populating that data into a mapping interface. This framework will be easily adaptable to other basins in the state with similar administration challenges as the Arkansas River basin. Finally, the project will result in new modeling and forecasting tools for the Arkansas River basin that will aid the DWR-Division 2 office with administration of the river.

Evaluation Criterion D - Dissemination of Results (10 points)

Explain how project results will be disseminated, including:

1. **Describe how the tools, frameworks, or analyses being developed will be disseminated, communicated, or made available to water resources managers who may be interested in the results.**
    a. **If the applicant is the primary beneficiary of the project, explain how the project results will be communicated internally, and to interested stakeholders and interested water resources managers in the area, if appropriate.**
    b. **If the applicant is not the primary beneficiary of the project (e.g., universities or research institutes) describe how project results will be communicated to project partners and interested water resources managers in the area.**
    c. **Explain why the chosen approach is the most effective way to disseminate the information to end users in a usable manner.**

The tool will be disseminated in several ways to water users who will be directed to the public-

facing website as well as demonstrations of how to use the tool to assist in decision-making. The CDSS program has a quarterly newsletter with over 300 subscribers that shares new projects such as the Colors of Water and Forecasting tool. Additionally, the CDSS webpage, (https://www.colorado.gov/cdss) advertises links to tools such as this and received 60,000 unique page visits and had 14,000 unique visitors in 2018. The Colors of Water and Forecasting Tool will be shared on both of these platforms. The project managers and consultants for the Phase I Colors of Water tool have presented the tool at over 5 Colorado water events including Colorado Water Congress, a Colorado American Water Resources Association (AWRA) luncheon, the CDSS Workshop, and at the Arkansas River Roundtable. A similar outreach effort is expected for the next phase of the tool. For presentation to other State water administrators, a presentation at the annual State Engineer Meeting and/or Colorado Water Official Association (CWOA) meeting will be planned which will target State water officials from the other 6 water divisions in Colorado for future adaptation of the framework into administration of their own basins.

Evaluation Criterion E - Department of the Interior Priorities (10 points)

Explain how your project supports Department of the Interior Priorities (or at least one priority):

1. **Creating a conservation stewardship legacy second only to Teddy Roosevelt**
    a. **utilize science to identify best practices to manage land and water resources and adapt to changes in the environment;**
    b. **examine land use planning processes and land use designations that govern public use and access;**
    c. **revise and streamline the environmental and regulatory review process while maintaining environmental standards;**
    d. **review DOI water storage, transportation, and distribution systems to identify opportunities to resolve conflicts and expand capacity;**
    e. **foster relationships with conservation organizations advocating for balanced stewardship and use of public lands;**
    f. **identify and implement initiatives to expand access to DOI lands for hunting and fishing;**
    g. **shift the balance towards providing greater public access to public lands over restrictions to access.**

This project utilizes science and technology to increase efficiency within the highly managed water rights framework of Colorado's Arkansas River basin. The basin faces many uncertainties and challenges including:

- Projected reduced flow due to climate change - according to the Colorado Water Plan Technical Update, mid to late-summer flows in the Arkansas River basin are projected to decrease by 25-40% by 2050 due to climate change.

- Over-appropriation - there is currently a gap of 617,000 AF/year between agricultural demands and supply in the basin.
- Interstate litigation - Kansas v. Colorado was a 24 year court case that resulted in Colorado paying Kansas $35 million in damages and required future modeling and verification of Colorado's water use under the 1949 Arkansas River Compact.
- A growing population that pressures agricultural water use - the Arkansas River basin's population in Colorado is projected to grow from 1,008,000 in 2015 to 1,626,000 by 2050.

Optimization of operations is one way to increase overall system efficiency and mitigate these challenges on the basin-wide system. With this tool, water administrators will be able to make better decisions that maximize beneficial use of the water consistently with the prior appropriation doctrine, and water users will be able to operate their own systems with better knowledge and forecasting of the state of the river.

2. Restoring trust with local communities

a. Be a better neighbor with those closest to our resources by improving dialogue and relationships with persons and entities bordering our lands;

b. Expand the lines of communication with Governors, state natural resource offices, Fish and Wildlife offices, water authorities, county commissioners, Tribes, and local communities.

This project strives to increase the level of communication and transparency between state water officials and water rights holders within the basin, as well as with stakeholders such as the State of Kansas, through the Arkansas River Interstate Compact, and the Bureau of Reclamation which operates several projects within the basin. Through this tool, administrative decisions are broadcast to the public and available for scrutiny if a water user feels that their water rights are being injured. This instills a level of confidence in water users that water rights decree administration is being handled accurately enough to present publicly in real-time. Previously, the public would be unaware in real-time how water rights administration was being handled.

A program in the basin that connects agricultural and municipal water users with the environmental and recreation community is the Voluntary Flow Management Program, which augments flows in the Upper Arkansas River from July 1 to August 15 with releases out of Twin and Turquoise Lakes. This tool will be used to display forecasted releases and flows for the environmental community to plan boating and fishing trips. In 2013, 250,000 people boated on the Arkansas River (38% of boating in Colorado) and contributed $60 million to the local economy. In 2014, an estimated 80,000 people fished the Arkansas River and contributed $8 million to the local economy. This recreational community has historically been excluded from water administration decisions and communication and this tool hopes to expand communication to this group. Furthermore, the tool will attribute these increased flows for recreation to the project partners, the Bureau of Reclamation and the Southeastern Colorado Water Conservancy District.

Project Budget

Funding Plan and Letters of Funding Commitment

The CWCB will be providing a cash match of $150,000, for a total project budget of $300,000. The CWCB has $150,000 in cash reserve from appropriation in the 2018 CWCB Projects Bill (Colorado Senate Bill 18-218, Section 3) for the continuation of the Arkansas River DSS. A letter of commitment from the Director of the CWCB is included that confirms the availability of the $150,000 cash match for the duration of the project. In addition, the CWCB and DWR will be providing in-kind contribution to the project at an estimated value of $85,576 for project management and technical leadership of the consulting team.

Budget Proposal

Table 3. Total project cost table

SOURCE	AMOUNT
Costs to be reimbursed with the requested Federal funding	$150,000
Costs to be paid by the applicant	$150,000
Value of in-kind contributions	$85,576
TOTAL PROJECT COST	**$385,576**

Table 4. Budget proposal for the Arkansas River Colors of Water and Forecasting Tool

BUDGET ITEM DESCRIPTION	$/Unit	Quantity	Quantity Type	TOTAL COST
Salaries and Wages				
Project Management	$46.15	282	Hours	$13,014 (in-kind)
Technical Leads	$58.19	958	Hours	$55,746 (in-kind)
Fringe Benefits				

Project Management	$10.20	282	Hours	$2,876 (in-kind)
Technical Leads	$14.55	958	Hours	$13,939 (in-kind)
Travel				
Local travel	$0.58	1,000	Miles	$580
Equipment				
Supplies and Materials				
Contractual/Construction				
Contractor Senior	$180	562	Hours	$101,160
Contractor Mid	$120	871	Hours	$104,580
Contractor Junior	$80	1,171	Hours	$93,680
Third-Party In-Kind Contributions				
Other				
TOTAL DIRECT COSTS				$385,576
Indirect Costs				$0
TOTAL ESTIMATED PROJECT COSTS				$385,576

Budget Narrative

Salaries and Wages - No salaries and wages of staff within the applying agency (CWCB) or its sister agency (DWR) will be paid for by this Financial Assistance Agreement. All contributions by CWCB and DWR staff for project management and technical lead/support will be treated as in-kind contributions. The in-kind contribution value of salaries and wages was determined by using each employee's 2019 hourly labor rate and multiplying it by the number of estimated hours

contributed to the project. The labor rates of the technical leads of Kelley Thompson, John Rodgers, and Bill Tyner were averaged and it was assumed that they would spend equal time on the project. See the attached spreadsheet budget for estimated hours allocated to each task, including for compliance with the reporting requirements. The following State staff will accomplish the following tasks as in-kind contribution to the project:

Brian Macpherson (project management):

Task 2 - RFP issued for consultants

Task 3 - Choose consultant and contracting

Task 4 - Biweekly check-in meetings / phone calls

Task 8 - Stakeholder meetings and feedback

Task 9 - Compliance with reporting requirements

Task 10 - Project management and travel

*Total - 282 hours * $46.15/hour = $15,891*

Kelley Thompson (technical lead):

Task 1 - DWR develops initial modeling/data processing component

Task 4 - Biweekly check-in meetings / phone calls

Task 5 - Continued development of modeling components

*Total - 319 hours * $58.19/hour = $18,563*

John Rodgers (technical lead):

Task 1 - DWR develops initial modeling/data processing component

Task 4 - Biweekly check-in meetings / phone calls

Task 6 - Development of data standardization and water classes

*Total - 320 hours * $58.19/hour = $18,621*

Bill Tyner (technical lead):

Task 4 - Biweekly check-in meetings / phone calls

Task 5 - Continued development of modeling components

Task 6 - Development of data standardization and water classes

*Total - 319 hours * $58.19/hour = $18,563*

Fringe Benefits - No fringe benefits of staff within the applying agency (CWCB) or its sister agency (DWR) will be paid for by this Financial Assistance Agreement. All contributions by CWCB and DWR staff for project management and technical lead/support will be treated as in-kind contributions. The in-kind contribution value of fringe benefits was determined using the same task allocation and estimation of hours as the salaries and wages category, using the hourly fringe benefits rate for each employee.

Brian Macpherson (project management): 282 hours * $10.20/hour = $2,876

Kelley Thompson (technical lead): 319 hours * $14.55/hour = $4,641

John Rodgers (technical lead): 320 hours * $14.55/hour = $4,656

Bill Tyner (technical lead): 319 hours * $14.55/hour = $4,641

Travel - Travel costs were estimated by using the 2019 federal mileage reimbursement rate of $0.58/mile. Based on previous work performed for the CWCB, it is anticipated that the chosen contractor will be in the Colorado front range area, within roughly 100 miles of both Denver and Pueblo. Three meetings in Pueblo and three meetings in Denver are expected between the contractor and State staff. Other communication is anticipated to occur via email and phone calls. No overnight meetings are planned. $580 was budgeted for these travel costs.

Equipment - No specialized equipment costs are budgeted for this project.

Materials and Supplies - No specialized materials and supplies are budgeted for this project.

Contractual - A contractor (or contractor team) will be selected through a competitive RFP process in compliance with the State of Colorado Procurement Code and Rules (Colorado Revised Statues, Title 24, Article 101-112). Contractor costs were estimated using representative hourly rates for senior, mid, and junior level staff at a water resources consulting firm. The rates chosen ($180, $120, and $80) are in line with several projects managed by the CWCB of similar technical nature, including all three components of ArkDSS Phase I. We anticipate that rates during the two year contracting window will be locked in at the issuance of a contract in 2020 and will not be significantly higher than current rates. The contractor (or contractor team) will be performing the majority of the technical work for this project and will be interacting with State staff to conform to OIT security, DWR HydroBase, and other State web and data protocols. The contractor team will be responsible for the following tasks:

Task 4 - Biweekly check-in meetings / phone calls

Task 5 - Continued development of modeling components

Task 6 - Development of data standardization and water classes

Task 7 - Development of web interface

Task 8 - Stakeholder meetings and feedback

Hourly compensation, multiplied by the estimated hours required for each role yields the following estimate of costs:

Senior Contractor: 562 hours * $180/hour = $101,160

Mid Contractor: 871 hours * $120/hour = $104,580

Junior Contractor: 1,171 hours * $80/hour = $93,680

The total budgeted costs for contractor costs is $299,420.

Third-Party In-Kind Contributions - No third-party in-kind contributions are budgeted for this project. All in-kind contributions are provided by the applying agency (CWCB) and its sister agency (DWR) and have been quantified in the salaries and wages and fringe benefits categories.

Environmental and Regulatory Compliance Costs - No environmental and regulatory compliance costs are budgeted for this project.

Other Expenses - No other expenses are budgeted for this project.

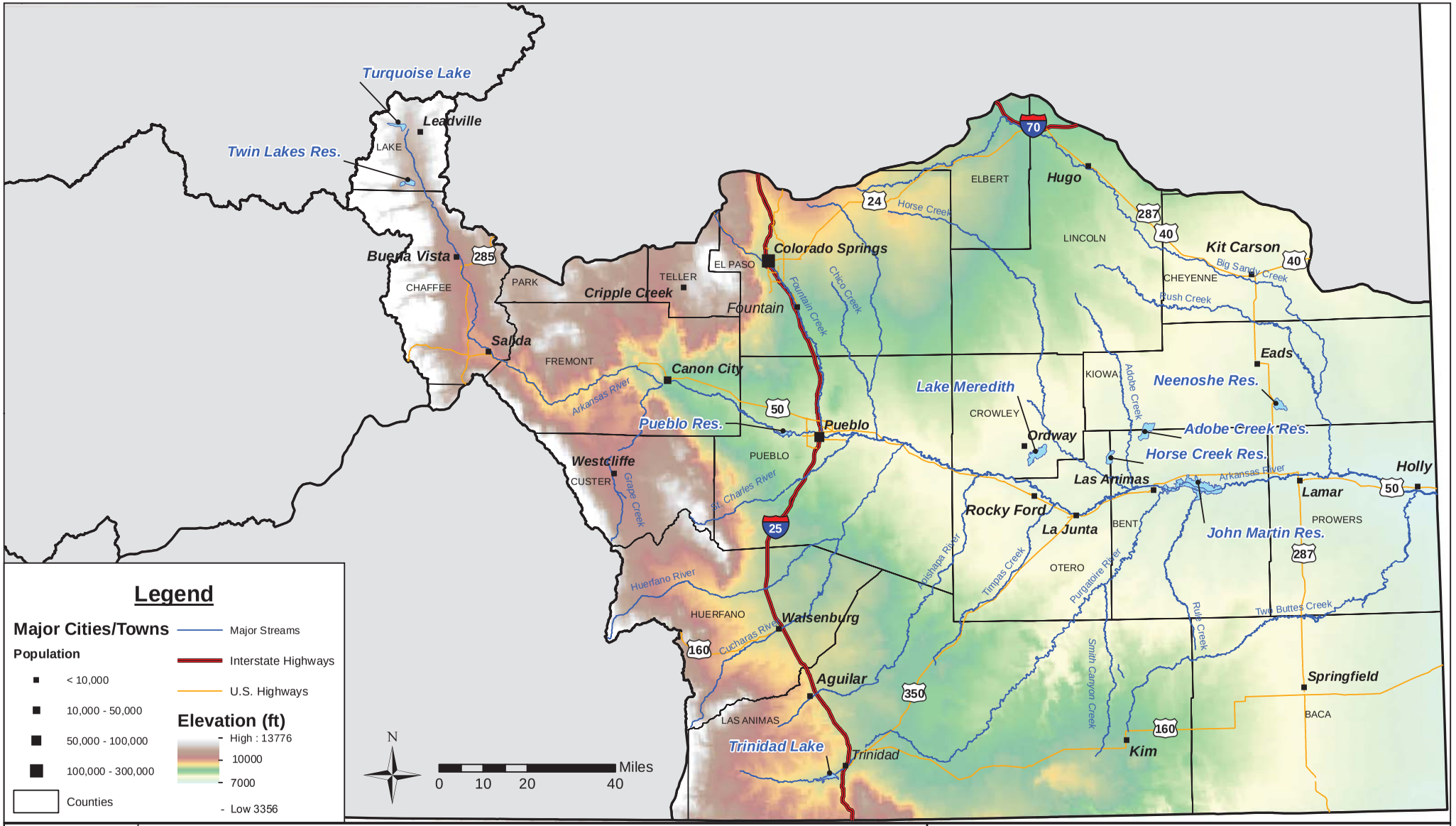
Indirect Costs - No indirect costs are budgeted for this project.

Letters of Support and Letters of Participation

See the following attached letters of support and commitment:

1. Letter of support from the Arkansas River Basin Roundtable
2. Letter of support from the Southeastern Colorado Water Conservancy District
3. Letter of support and commitment from the Colorado Division of Water Resources - Division 2 (Arkansas River basin)
4. Letter of support and commitment from the Colorado Division of Water Resources - State Engineer's Office
5. Letter of commitment from the Colorado Water Conservation Board

[redacted]



Legend

Major Cities/Towns

Population

- < 10,000
- 10,000 - 50,000
- 50,000 - 100,000
- 100,000 - 300,000

Counties

Major Streams

Interstate Highways

U.S. Highways

Elevation (ft)

- High : 13776
- 10000
- 7000
- Low 3356

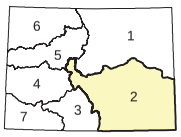


Figure 1-1

Overview of Arkansas River Basin, Division 2

Arkansas River Decision Support System Feasibility Study

Data sources: Colorado's Decision Support Systems, Colorado Department of Local Affairs

State of Colorado
Department of Natural Resources
Colorado Water Conservation Board
Division of Water Resources
Prepared by: Brown and Caldwell

COLORADO DIVISION OF WATER RESOURCES
DEPARTMENT OF NATURAL RESOURCES

Brown AND Caldwell

Colors of Water and Forecasting Tool Budget		**DRAFT - For planning purposes only**									
Task No.	Task Description	Contractor Senior		Contractor Mid		Contractor Junior		In-Kind PM		In-Kind Technical Leads	
		$180		$120		$80		$56		$73	
		Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost
1	DWR develops initial modeling/data processing component									200	$14,548
2	RFP issued for consultants							40	$2,254	24	$1,746
3	Choose consultants and contracting							40	$2,254	32	$2,328
4	Biweekly check-in meetings / phone calls	42	$7,560	21	$2,520	21	$1,680	42	$2,367	126	$9,165
5	Continued development of modeling components										
5.a	Timing and Transit Loss	20	$3,600	20	$2,400	20	$1,600			80	$5,819
5.b	Aquifer/Stream Modeling Parameters	100	$18,000	100	$12,000	100	$8,000				
5.c	Calibration and Verification	100	$18,000	100	$12,000	100	$8,000				
5.d	Real-time evaporation data	20	$3,600	20	$2,400	20	$1,600			80	$5,819
6	Development of data standardization and water classes										
6.a	HydroBase 15-minute provisional records	40	$7,200	40	$4,800	10	$800			120	$8,729
6.b	Institution of To: water classification			80	$9,600	80	$6,400			80	$5,819
6.c	REST web services APIs	40	$7,200	40	$4,800	40	$3,200			60	$4,364
7	Development of web interface										
7.a	Web/data architecture	80	$14,400	200	$24,000	120	$9,600			24	$1,746
7.b	Mapping interface			50	$6,000	220	$17,600			16	$1,164
7.c	Connection of modeling data to display data			80	$9,660	160	$12,800			12	$873
7.d	Hosting				$0	80	$6,400				
7.e	Incorporation of feedback	40	$7,200	40	$4,800	120	$9,600				
8	Stakeholder meetings and feedback	80	$14,400	80	$9,600	80	$6,400	40	$2,254	32	$2,328
9	Compliance with reporting requirements							40	$2,254		
10	Project Management and Travel							80	$4,508	72	$5,237
	TOTAL	562	$101,160	871	$104,580	1171	$93,680	282	$15,891	958	$69,685
		Total Contractor	$300,000								
		Total In-Kind	$85,576								