Water Supply Reserve Fund – Grant and Loan Program
Water Activity Summary Sheet
November 14-15, 2018
Agenda Item 18(c)

Applicant & Grantee:	White River Conservation District
Water Activity Name:	White River Algae Research Project
Water Activity Purpose:	Multipurpose (Environmental/Recreational/Agricultural/M&I)
County:	Rio Blanco
Drainage Basin:	Yampa-White-Green
Water Source:	White River
Amount Requested:	$99,000 Yampa-White-Green Basin Account
Matching Funds:	Applicant & 3rd Party Match (Secured only cash & in-kind) = $303,047 • 306% of the Basin Account request (meets 25% min)

Staff Recommendation:

Staff recommends **conditional approval** of up to $99,000 from the Yampa-White-Green Basin Account to help fund the project titled: White River Algae Research Project, contingent upon the conditions stated in the **Issues/Additional Needs** section below.

Water Activity Summary: WSRF grant funds, if approved, will assist the White River Conservation District and the United States Geological Survey to improve their understanding of the cause of the excessive amount of benthic algae in the White River over the past 4-5 years. A better understanding based on science is expected to lead to the conception of mitigation strategies and management plans for decreasing benthic algae in the White River. This grant request is for data collection and analysis to be performed in 2019 -2021. USGS will have identified and began data collection in 20 semi-random sites in the White River above Meeker. Data collection in FY 2019 will include the following tasks: Scouring Flows, Scouring Flow Analysis, Pre/Peak and Post-Algae and water quality sampling events and Analysis and publication of results in the final year. Evaluation of data collected in 2018 and 2019 will determine if it will be necessary to conduct a third year (FY 2020) of study.
This study will provide exceptional information and background for a future Integrated Water Management Plan (IWMP) that could be developed within the next few years. It is important that this work be completed first so that there is the knowledge and background before embarking on the IWMP. Algae blooms decrease the recreational value of the river and indicate an ecosystem that is out of balance. This study will be integral in understanding that ecosystem better and provide tools for establishing mitigation plans. Doing so will improve the ability of the River to meet recreational, environmental, and economic needs, and allow the elaborate system of diversion, storage, treatment, use, and wastewater treatment to continue. In addition, keeping intake screens and pump inlets free of algae, artificial shortages created by fouling will not occur, and the existing infrastructure will function through the full range of depth of water in the river for which it was designed.

Discussion: This project assists the Yampa-White-Green Basin Roundtable in meeting their stated Basin Goals such as: Protect and encourage agriculture uses of water in the YWG Basin within the context of private property rights; Improve agricultural water supplies to increase irrigated land and reduce shortages; Identify and address municipal and industrial (M&I) water shortages; Quantify and protect environmental and recreational water uses at locations identified in the nonconsumptive needs study of the YWG BRT; Maintain and consider the existing natural range of water quality that is necessary for current and anticipated water uses; Restore, maintain, and modernize water storage and distribution infrastructure; Develop an integrated system of water use, storage, administration and delivery to reduce water shortages and meet environmental and recreational needs as identified in Section 1.2.2 of the Yampa-White-Green Basin Implementation Plan.

Issues/Additional Needs: As noted above (and below), the applicant has secured $303,047 in cash and in-kind matching contributions ($129,492 in 2018, $81,029 in 2019, $62,739 in 2020, and $29,787 in 2021) which satisfies the 25% minimum match on behalf of the applicant and constitutes a 306% match to the Yampa-White-Green WSRF Basin Account contribution. However, there is currently $171,000 in future pending matches that have yet to be confirmed, therefore staff recommends a **conditional approval** of this grant for the requested $99,000 contingent upon the applicant providing documentation on a yearly basis to staff's satisfaction that the pending matches have mature into secured matches whereupon staff will authorize the release of the yearly WSRF Grant distribution as indicated in the table below (Yearly WSRF Funding Distribution).

Eligibility Requirements: The application meets requirements of all eligibility components: General Eligibility, Entity Eligibility, Water Activity Eligibility, and Eligibility Based on Match Requirements.

Evaluation Criteria: This activity has undergone review and evaluation and staff has determined that it satisfies the Evaluation Criteria. Please refer to Basin Roundtable Chair's Recommendation Letter and the WSRF Grant Application for applicant's detailed response.

Funding Summary/Matching Funds:

2018 Funding Sources	**Cash**	**In-kind**	**Total**	**Status**
USGS	$0	$38,992	$38,992	Secured
Colorado River Water Conservation District	$25,000	$0	$25,000	Secured
Meeker Sanitation	$3,500	$0	$3,500	Secured
Rio Blanco Water Conservancy District	$2,000	$0	$2,000	Secured
Town of Meeker	$8,000	$0	$8,000	Secured
White River Conservation District	$2,000	$0	$2,000	Secured
Trout Unlimited	$5,000	$0	$5,000	Secured
Walton Foundation	$20,000	$0	$20,000	Secured
Elk Creek Ranch	$10,000	$0	$10,000	Secured
Trout Unlimited – Steamboat Springs Chapter	$5,000	$0	$5,000	Secured
Sub-total	$90,500	$38,992	$129,492	

2019 Funding Sources	Cash	In-kind	Total	Status
USGS	$0	$51,029	$51,029	Secured
Local Governments	$21,000	$0	$21,000	Pending
Private Parties	$20,000	$0	$20,000	Pending
Colorado State Conservation Board	$30,000	$0	$30,000	Secured
Sub-total	$71,000	$51,029	$122,029	
Yampa-White-Green Basin Account	$41,000	$0	$41,000	Secured
Sub-total	$112,000	$51,029	$163,029	

2020 Funding Sources	Cash	In-kind	Total	Status
USGS	$0	$62,739	$62,739	Secured
Local Governments	$20,000	$0	$20,000	Pending
Private Parties	$19,000	$0	$19,000	Pending
Colorado State Conservation Board	$15,000	$0	$15,000	Secured
CWCB Water Plan Grant	$66,000	$0	$66,000	Pending
Sub-total	$120,000	$62,739	$182,739	
Yampa-White-Green Basin Account	$33,000	$0	$33,000	Secured
Sub-total	$153,000	$62,739	$215,739	

2021 Funding Sources	Cash	In-kind	Total	Status
USGS	$0	$29,787	$29,787	Secured
Local Governments	$5,000	$0	$5,000	Pending
Private Parties	$5,000	$0	$5,000	Pending
Sub-total	$10,000	$29,787	$39,787	
Yampa-White-Green Basin Account	$25,000	$0	$25,000	Secured
Sub-total	$35,000	$29,787	$64,787	

Total 2018-2021 Match Funding Sources	Cash Match	In-kind Match	Total
2018	$90,500	$38,992	$129,492
2019	$71,000	$51,029	$122,029
2020	$120,000	$62,739	$182,739
2021	$10,000	$29,787	$39,787
Sub-total	$291,500	$182,547	$474,047
WSRF Yampa-White-Green Basin Account	$99,000	$0	$99,000
Total	$390,500	$182,547	$573,047

Total 2018-2021 Match Summary Status	Cash & In-kind
Secured Match	$303,347
Pending Match	$171,000
Secured (WSRF)	$99,000
Total	**$573,047**

Yearly WSRF Funding Distribution	
2019	$41,000
2020	$33,000
2021	$25,000
Total	$99,000

CWCB Project Manager: Craig Godbout

Yampa-White-Green Basin Roundtable

October 2, 2018

Craig Godbout
Colorado Water Conservation Board
1313 Sherman St., Room 718
Denver, CO 80203

Dear Craig Godbout,

At our September 12th meeting, the Yampa White Green Basin Roundtable (YWG BRT) voted to approve the funding of the White River Algae grant request. The motion, to fund $99,000 from the basin account, passed the membership with unanimous support.

At the meeting, Callie Hendrickson presented to the Roundtable on behalf of the White River and Douglas Creek Conservation Districts and reviewed the algae problem and the history of the project. Ms. Hendrickson explained that a technical advisory group was formed in the fall of 2017 to monitor the White River's algae problem and to develop a scope of work. This effort will assist with providing a complete understanding of why the excessive amount of benthic algae is occurring in the White River, and is being implemented by the USGS. The project, as you will note in the application, has extensive financial and organizational support. It is a model of collaboration and much time and consideration has been put into creating a thorough scope of work.

Please do not hesitate to contact me with any questions, and thank you for your consideration of this request.

Sincerely,

Jackie Brown

Yampa White Green Basin Roundtable, Chair

Last Update: August 3, 2017

Colorado Water Conservation Board

Water Supply Reserve Fund
Grant Application

Instructions

All WSRF grant applications shall conform to the current 2016 WSRF Criteria and Guidelines.

To receive funding from the WSRF, a proposed water activity must be approved by a Roundtable(s) **AND** the Colorado Water Conservation Board (CWCB). The process for Roundtable consideration and recommendation is outlined in the 2016 WSRF Criteria and Guidelines. The CWCB meets bimonthly according to the schedule on page 2 of this application.

If you have questions, please contact the current CWCB staff Roundtable liaison:

Arkansas	**Gunnison | North Platte | South Platte | Yampa/White**	**Colorado | Metro | Rio Grande | Southwest**
Ben Wade	Craig Godbout	Megan Holcomb
ben.wade@state.co.us	craig.godbout@state.co.us	megan.holcomb@state.co.us
303-866-3441 x3238	303-866-3441 x3210	303-866-3441 x3222

WSRF Submittal Checklist (Required)

	I acknowledge this request for funding was recommended for CWCB approval by the sponsoring Basin Roundtable(s).
X	I acknowledge I have read and understand the 2016 WSRF Criteria and Guidelines.
X	I acknowledge the Grantee will be able to contract with CWCB using the Standard Contract.(1)
Exhibit A	
X	Statement of Work(2) *(Word – see Exhibit A Template)*
X	Budget & Schedule(2) *(Excel Spreadsheet – see Exhibit A Template)*
	Letters of Matching and/or Pending 3rd Party Commitments(2)
Exhibit C	
	Map(2)
	Photos/Drawings/Reports
	Letters of Support
	Certificate of Insurance(3) (General, Auto, & Workers' Comp.)
Contracting Documents	
	Certificate of Good Standing(3)
	W-9(3)
	Independent Contractor Form(3) (If applicant is individual, not company/organization)
	Electronic Funds Transfer (ETF) Form(3)

(1) Click "Grant Agreements". For reference only/do not fill out or submit/required for contracting
(2) Required with application if applicable.
(3) Required for contracting. While optional at the time of this application, submission can expedite contracting upon CWCB Board approval.

Last Update: August 3, 2017

Schedule		
CWCB Meeting	**Application Submittal Dates**	**Type of Request**
January	December 1	Basin Account; BIP
March	February 1	Basin/Statewide Account; BIP
May	April 1	Basin Account; BIP
July	June 1	Basin Account; BIP
September	August 1	Basin/Statewide Account; BIP
November	October 1	Basin Account/BIP

Desired Timeline	
Desired CWCB Hearing Month:	November 2018
Desired Notice to Proceed Date:	Feb. 1, 2019

Water Activity Summary	
Name of Applicant	White River Conservation District
Name of Water Activity	White River Algae Research Project

Approving Roundtable(s)	Basin Account Request(s)(1)
Yampa, White, Green	WRSF
Basin Account Request Subtotal	$ 99,000
Statewide Account Request(1)	$ 0
Total WSRF Funds Requested (Basin & Statewide)	$ 99,000
Total Project Costs	$164,000

(1) Please indicate the amount recommended for approval by the Roundtable(s)

Last Update: August 3, 2017

Grantee and Applicant Information	
Name of Grantee(s)	White River Conservation District
Mailing Address	P.O. 837 Meeker, CO 81641
FEIN	
Grantee's Organization Contact(1)	Neil Brennan
Position/Title	President
Email	neilbrennan@hotmail.com
Phone	(970) 878-4091
Grant Management Contact(2)	Callie Hendrickson
Position/Title	Executive Director
Email	callie.districts@gmail.com
Phone	970-878-9838 or 970-250-6825 (c)
Name of Applicant (if different than grantee)	N/A
Mailing Address	
Position/Title	
Email	
Phone	

(1) Person with signatory authority
(2) Person responsible for creating reimbursement invoices (Invoice for Services) and corresponding with CWCB staff.

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Description of Grantee
Provide a brief description of the grantee's organization (100 words or less).
The Soil Conservation District Act (now Conservation District) was passed by Colorado Legislature on May 6, 1937. This act is found in Colorado Revised Statues Title 35 article 70. The Districts are managed by a board elected at a general election by the landowners within the District. The White River Conservation District has cooperated with individuals and government agencies including county, state and federal departments and agencies for over 50 years treating resource problems. The Districts were formed to provide a legal entity to organize local landowners to voluntarily control soil erosion and manage natural resources such as soil, water, animals, plants and air quality. This act then enabled the Federal Government to provide technical and monetary assistance to the local agriculture community to protect private property from degradation of the natural resources. Through partnerships with NRCS, BLM, and other agencies, Best Management Practices (BMP) are planned and implemented to treat and protect the soil, water and related resources on lands within the District's boundaries. The Conservation District partnerships serve all landowners within the district by promoting voluntary conservation practices and providing technical assistance, planning, and practice installation assistance.

Type of Eligible Entity (check one)	
	Public (Government): municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
X	**Public (Districts):** authorities, Title 32/special districts (conservancy, conservation, and irrigation districts), and water activity enterprises
	Private Incorporated: mutual ditch companies, homeowners associations, corporations
	Private Individuals, Partnerships, and Sole Proprietors: are eligible for funding from the Basin Accounts but not for funding from the Statewide Account.
	Non-governmental organizations: broadly, any organization that is not part of the government
	Covered Entity: as defined in Section 37-60-126 Colorado Revised Statutes

Type of Water Activity (check one)	
X	Study
	Implementation

Category of Water Activity (check all that apply)	
X	Nonconsumptive (Environmental)
X	Nonconsumptive (Recreational)
X	Agricultural
X	Municipal/Industrial
	Needs Assessment

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X	Education & Outreach	
	Other	Explain:

Location of Water Activity	
Please provide the general county and coordinates of the proposed activity below in **decimal degrees**. The Applicant shall also provide, in Exhibit C, a site map if applicable.	
County/Counties	Rio Blanco County, White River above Meeker
Latitude	
Longitude	

Water Activity Overview
Please provide a summary of the proposed water activity (200 words or less). Include a description of the activity and what the WSRF funding will be used for specifically (e.g. studies, permitting, construction). Provide a description of the water supply source to be utilized or the water body affected by the activity. Include details such as acres under irrigation, types of crops irrigated, number of residential and commercial taps, length of ditch improvements, length of pipe installed, area of habitat improvements. If this project addresses multiple purposes or spans multiple basins, please explain. The Applicant shall also provide, in Exhibit A, a detailed Statement of Work, Budget, and Schedule.
The White River Algae Study Project's Scope of Work (SOW) will be implemented by USGS to improve the understanding of why the excessive amount of benthic algae is occurring in the White River over the past 4 – 5 years. A better understanding based on science is expected to lead to the conception of mitigation strategies and management plans for decreasing benthic algae in the White River. There is a definite sense of urgency to determine the driving forces of the excessive algae. Therefore, the study began in 2018. This grant request is for data collection and analysis to be done in 2019 - 2021. USGS will have identified and began data collection in 20 semi-random sites in the White River above Meeker. Data collection in FY 2019 will include the following Tasks: (#4) Scouring Flows (channel condition, form, and scouring forces), (#5) Scouring flow analysis, (#7) Pre-, Peak, and Post-Algae and water quality sampling events and (#8) Analysis and publication of results in the final year. Evaluation of data collected in 2018 and 2019 will determine if it will be necessary to conduct a third year (FY 2020) of study. The full SOW includes analysis and publication of the findings in the year following the final year of study.

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Measurable Results		
To catalog measurable results achieved with WSRF funds please provide any of the following values.		
	New Storage Created (acre-feet)	
	New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive	
	Existing Storage Preserved or Enhanced (acre-feet)	
Full length of White River. Approx. 190 miles	Length of Stream Restored or Protected (linear feet)	
	Efficiency Savings (indicate acre-feet/year OR dollars/year)	
	Area of Restored or Preserved Habitat (acres)	
	Length of Pipe/Canal Built or Improved	
The full length of the White River	Other	Explain: This is a study. Therefore, rather than measurable results directly related to the study, we anticipate that it will identify actions that can be taken in the future to restore and protect the White River

Water Activity Justification
Provide a description of how this water activity supports the goals of Colorado's Water Plan, the most recent Statewide Water Supply Initiative, and the respective Roundtable Basin Implementation Plan and Education Action Plan [(1)]. The Applicant is required to reference specific needs, goals, themes, or Identified Projects and Processes (IPPs), including citations (e.g. document, chapters, sections, or page numbers). For applications that include a request for funds from the Statewide Account, the proposed water activity shall be evaluated based upon how well the proposal conforms to Colorado's Water Plan criteria for state support (CWP, Section 9.4, pp. 9-43 to 9-44;) (Also listed pp. 4-5 in 2016 WSRF Criteria and Guidelines).

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Water Activity Justification

Colorado Water Plan:

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This study will meet all five goals stated in the Environmental and Recreational Projects and Methods section (page 6-157) of the Colorado Water Plan. It will provide exceptional information and background for a future Integrated Water Management Plan that we anticipate developing within the next few years. It is important that this work be completed first so that we have the knowledge and background before embarking on the IWMP. Algae blooms decrease the recreational value of the river and indicate an ecosystem that is out of balance.

This study will be integral in understanding that ecosystem better and provide tools for establishing mitigation plans. Doing so will improve the ability of the River to meet recreational, environmental, and economic needs, and allow the elaborate system of diversion, storage, treatment, use, wastewater treatment and reintroduction back into the river ecosystem to continue.

Also, by keeping intake screens and pump inlets free of algae, artificial shortages created by fouling will not occur, and the existing infrastructure will function through the full range of depth of water in the river for which it was designed.

(1) Access Basin Implementation Plans or Education Action Plans from Basin drop down menu.

Matching Requirements: Basin Account Requests

Basin (only) Account grant requests require a 25% match (cash and/or in-kind) from the Applicant or 3rd party and shall be accompanied by a **letter of commitment** as described in the 2016 WSRF Criteria and Guidelines (submitted on the contributing entity's letterhead). Attach additional sheet if necessary.

Contributing Entity	Amount and Form of Match (note cash or in-kind)
Private Landowners & NGO's 2018 work (see attachment)	$50,000 in cash
Local Governments for 2018 work (see attachment)	$40,500 in cash

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Matching Requirements: Basin Account Requests	
USGS (2018 work)	$39,000
It is anticipated that local governments' will provide match for 2019 – 2021. However, local governments cannot commit prior to their budgeting process each fall. Therefore, we are using committed 2018 funds for match for this grant. Noted above: We received $95,500 from local governments and private funding for 2018 work on this project.	
Total:	**$134,500**
If you requested a Waiver to the Basin Account matching requirements, indicate the percentage you wish waived.	

Matching Requirements: Statewide Account Requests	
Statewide Account grant requests require a 50% match as described in the 2016 WSRF Criteria and Guidelines. A minimum of 10% match shall be from Basin Account funds (cash only). A minimum of 10% match shall be provided by the applicant or 3rd party (cash, in-kind, or combination). The remaining 30% of the required match may be provided from any other source (Basin, applicant, or 3rd party) and shall be accompanied by a **letter of commitment.** Attach additional sheet if necessary.	
Contributing Entity	Amount and Form of Match (note cash or in-kind):
N/A	

Last Update: August 3, 2017

Matching Requirements: Statewide Account Requests	
Total Match	$
If you requested a Waiver to the Statewide Account matching, indicate % you wish waived. (Max 50% reduction of requirement).	

Related Studies
Please provide a list of any related studies, including if the water activity is complimentary to or assists in the implementation of other CWCB programs.
This study is a precursor to a potential Integrated Water Management Plan (IWMP) on the White River in the coming years. We feel this study needs to be near completion before the IWMP process is initiated because it is expected to have very valuable information for the IWMP to be built upon. This study will utilize data that has been and will continue to be collected from the Colorado Parks and Wildlife (CPW) on the algae issue. This study will also utilize data that has been and will continue to be collected by USGS in the White River Water Quality Monitoring project.

Previous CWCB Grants
List all previous or current CWCB grants (including WSRF) awarded to both the Applicant and Grantee. Include: 1) Applicant name; 2) Water activity name; 3) Approving RT(s); 4) CWCB board meeting date; 5) Contract number or purchase order
N/A

Last Update: August 3, 2017

Previous CWCB Grants

Tax Payer Bill of Rights

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

The White River Conservation District de-TABORed in 1996.

Colorado Water Conservation Board

Water Supply Reserve Fund

Exhibit A - Statement of Work

Date:	
Water Activity Name:	White River Algae Study
Grant Recipient:	White River Soil Conservation District
Funding Source:	WSRF

Water Activity Overview: (Please provide brief description of the proposed water activity (no more than 200 words). Include a description of the overall water activity and specifically what the WSRF funding will be used for.

A group of 14 entities, mostly local governments, have formed the Technical Advisory Group (TAG) to develop and monitor the White River Algae Study Project's Scope of Work (SOW) to improve the understanding of why the excessive amount of benthic algae is occurring in the White River over the past 4 – 5 years. The study will be implemented by USGS. A better understanding based on science is expected to lead to the conception of mitigation strategies for decreasing benthic algae in the White River.

There is a definite sense of urgency to determine the driving forces of the excessive algae. Therefore, this study has begun in 2018. USGS has identified and began data collection in 20 semi-random sites in the White River above Meeker. This grant request is for work to be done in the federal FY 2019 - 2021. WSRF funding will be utilized entirely for the study to develop a better understanding of physical and chemical properties controlling algal growth in the main stem of the White River. Details are below.

Evaluation of data collected in 2018 and 2019 will determine if it will be necessary to conduct a third year (FY 2020) of study. The full SOW is included below and includes work done in 2018, planned work for 2019 & 2020, and analysis and publication of the findings in the year following the final year of study.

Objectives: (List the objectives of the project)

The objective of the study is to document and understand benthic algal occurrence, characteristics, and controls at multiple locations within the White River are of interest. Specific objectives include:

1. Conduct data mining and historical synthesis of information relevant to the timing and occurrence of nuisance algal blooms in the White River Basin (to be completed in 2018);
2. Develop a better understanding of physical and chemical properties controlling algal growth in the main stem of the white River. (data collection continues into 2019 & potentially 2020 with analysis and reports developed in 2021)

Tasks
Provide a detailed description of each task using the following format:
Task 1 - (Data Mining and Historical Synthesis) To be completed in FY 2018
Description of Task:
USGS will do a literature search for algal topics and determine from the search what information is relevant to the White River. Evaluation of findings from other local studies will be completed and synthesized into a single document that is relevant to the conditions in the White River. These reports and other historical information (from local interviews and surveys) will be used to guide further investigations in the White River.
Method/Procedure:
Literature review will be completed in 2018 and therefore not covered under this grant. However, the information gathered in this task will be documented and used to guide the remainder of this study.
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
This report will be delivered to the WRCD, TAG, and publicly available. It will be utilized to inform any necessary adjustments to the current SOW.
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
WRCD will provide a copy of the report to CWCB and BRT as well as a presentation if desirable.

Tasks
Provide a detailed description of each task using the following format:
Task 2 - (Continuous Monitoring)
Description of Task:
Dissolved Oxygen and Temperature at 20 sites.
Method/Procedure:
An intensive, continuous monitoring (at 15-min intervals) of selected water-quality parameters will be completed in 2018 to address data gaps in the diurnal changes in water temperature and dissolved oxygen along the White River. This effort will monitor and record complete diurnal cycles at 20 sites (about 7 days per site) during a three-week period in July. The water-quality monitors will characterize conditions at each location and will be indicative of the range of conditions throughout the reach during peak algal growth. Monitors will be deployed at each of the 20 sites and is slated for 2018. Measurement of diel variations in dissolved oxygen and water temperature will determine ranges of conditions aquatic communities are exposed to as well as calculate stream metabolism using the single-site method (Hondzo, 2013). These calculations can help support findings from site-specific algal biomass measurements and identification of sites as heterotrophic or autotrophic providing additional metrics to assess stream health and function.
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
This portion of the Study will be conducted and reviewed in 2018. USGS will present the findings to the TAG in late 2018. The information will be used to inform the 2019 SOW.
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks
Provide a detailed description of each task using the following format:
Task 3 - (Pebble Count)
Description of Task:
Bed-material measurements will be made by the USGS using standard methods to determine particle-size characteristics of the channel and, if present, of the alluvial bars at up to 60 cross sections in the White River (three cross sections at each of the 20 sites).
Method/Procedure:
Wolman "pebble counts" will be made in a linear traverse of the channel cross section where the channel is wadable in late summer or early fall 2018. In unwadable sections, pebble counts of the streambed will be made in a random manner at one-footstep intervals in shallower areas. Sediment-size characteristics will be calculated from the bed-material measurements and used to determine the critical shear stress for sediment entrainment utilizing methods successfully demonstrated by Elliott and Hammack (1999, 2000).
Grantee Deliverable: (Describe the deliverable the grantee expects from this task)
This portion of the Study will be conducted and reviewed in 2018. USGS will present the findings to the TAG in late 2018. The information will be used to inform the 2019 SOW.
CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)
A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks
Provide a detailed description of each task using the following format:
Task 4 - (Scouring Flows)
Description of Task:
An important consideration regarding the proliferation of algae in certain reaches of the White River is peak streamflow and duration. Peak streamflow magnitude can play a crucial role in scouring benthic algae from streambeds thus decreasing or resetting total algal biomass on an annual basis (Cullis, 2011). However, streamflow peak and duration are not the only factors governing the amount of scour that occurs in a given water year. Specific channel characteristics also play a role in benthic algal control but are less apt to change from year to year. Characteristics such as bed-sediment particle size and channel form can place large controls on algal growth. Particle size of the streambed can dictate the suitability of algal attachment points and, if large enough, can armor the channel and minimize scour even during wet years. Channel form is the sinuosity, area, width and depth of the channel at a given point. These characteristics can control light penetration, stream velocity, and sediment deposition rates. Cross-section surveying and particle-size analysis in conjunction with incipient motion analysis is needed to address data gaps and promote understanding of the role of streamflow in algal proliferation. This analysis will also assist in the prediction of where algae will be most prolific (Petts,

1997).

Method/Procedure:

The USGS proposes to assess channel condition, form, and scouring forces present at selected sites and use that information to assess the potential for channel scour present under varying streamflow conditions. Thresholds for critical flows needed to scour algae will be provided. These thresholds can be used annually by land managers to forecast conditions and verify the effect that scouring flows had on the system if critical-flow thresholds are exceeded. This task will be performed in 2018, 2019, and 2020 (if necessary) to provide ample data for comparison and on years with various run-off volume.

Grantee Deliverable: (Describe the deliverable the grantee expects from this task)

This portion of the Study will be conducted and reviewed in 2018 and repeated over the following two years. USGS will present the findings to the TAG at the end of each year. The information will be used to inform the following year's SOW.

CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)

A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks

Provide a detailed description of each task using the following format:

Task 5 - (Scouring Flow Analysis)

Description of Task:

Sediment transport, or movement, in streams occurs when the forces acting on the particle exceed the resistive forces. Transport of bed material (the particles that are representative of the range of particle sizes commonly occurring along the streambed) is approximated through comparisons of boundary shear stress (a tangential stress created by flowing water acting on sediment particles resting on the streambed or other inundated alluvial surfaces) and particle size and shape. Entrainment potential for sediment on a specific geomorphic surface is estimated by relating flood generated boundary shear stress and the critical shear stress of the sediment particles.

Method/Procedure:

Bed material characteristics obtained from onsite measurements at 20 locations in the study reach will be compared to the observed high-flow conditions during snowmelt runoff, during 2018-2020. Additional measures of acoustic energy (sound) utilizing hydrophones will be used to assess the presents or absence of moving particles during field visits during high-flow each year (Marineau and others, 2015) and will be compared to separate estimate of critical shear stress made from particle-size information (shear velocity, from Simoes, 2014) and cross-section surveys (boundary shear stress, Elliott and Capesius, 2009). These three methods will provide a comparison of observed conditions (2018-2020) and particle characteristics in each reach and will inform estimates of streamflow needed to scour algae in each reach.

Bed-material measurements will be made by the USGS using standard methods to determine particle-size characteristics of the channel and, if present, of the alluvial bars (Wolman, 1954) at up to 60 cross sections in the White River (three cross sections at each of the 20 sites). Wolman "pebble counts" will be made in a linear traverse of the channel cross section where the channel is wadeable in late summer or early fall 2018. In unwadeable sections, pebble counts of the streambed will be made in a random manner at one-footstep intervals in shallower areas. Sediment-size characteristics will be

calculated from the bed-material measurements and used to determine the critical shear stress for sediment entrainment utilizing methods successfully demonstrated by Elliott and Hammack (1999, 2000).

Grantee Deliverable: (Describe the deliverable the grantee expects from this task)

This data will be collected and incorporated into the multivariate-regression analysis. The raw data and report will be provided to the WRCD and the public.

CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)

A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks

Provide a detailed description of each task using the following format:

Task 6 - (Isotope Sampling)

Description of Task:

In nature, elements occur with differing numbers of neutrons, resulting in slightly different masses for any given atom. These differences in mass occur at ranges that are defined as isotopes and are recorded for each element in conjunction with their abundance on earth. Some isotopes occur in arrangements that are unstable, and undergo radioactive decay; other isotopes are stable and persist in the environment indefinitely. Isotopic enrichment of heavier or lighter stable isotopes occurs at different locations in the world, and/or as a result of local geochemical or biological processes. As such, the relative abundance of measured stable isotopes from a water sample can act as a 'signature' to compare against when investigating different potential sources.

Method/Procedure:

To better understand the potential for isotopic testing to determine sources of nutrients in the White River, the USGS proposes to analyze isotopic-signatures of oxygen and nitrogen from nitrate. Samples will be collected in reaches of the North and South Fork White River as well as the mainstem channel. Sample locations will target land use activities such as forest, agriculture, aquaculture, and wastewater treatment. Where appropriate, stable isotope signatures will be obtained from the literature and compared to those observed from the mainstem of the White River. Samples will be submitted to the USGS National Water Quality Laboratory to determine nutrient concentrations and the USGS Reston Isotopes Laboratory for isotopic analysis. All results will be available to the public through National Water Information System web interface (http://dx.doi.org/10.5066/F7P55KJN).

Grantee Deliverable: (Describe the deliverable the grantee expects from this task)

CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)

A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks

Provide a detailed description of each task using the following format:

Task 7 - (Pre-, Peak-, Post- Algae and Water Quality Sampling Events)

Description of Task:

Water-quality samples (primarily nutrients) will be analyzed under varying conditions (pre-algal growth, peak-algal growth, and post-algal growth) as part of this study. Determination of these periods will be based on local observations and flow conditions (U.S. Geological Survey, 2018).

Method/Procedure:

- Pre-algal growth analysis (sampling post snowmelt runoff, prior to the onset of algal growth in mid spring) will evaluate selected water-quality concentrations in the White River at the designated 20 sites. This sampling will help determine the concentration levels present in the White River prior to uptake by algal species as a means to better understand nutrient variability. The data will be used in a statistical analysis (described below) as a variable to determine if there is a correlation between nutrient levels prior to the onset of algal growth during peak periods. The data can also be used to identify where the highest nutrient concentrations are located for the purpose of understanding possible source locations for subsequent sampling later in the summer and fall.
- Peak-algal growth analysis will coincide with peak algal biomass in July or early August depending on conditions observed during the summer. The sampling will also take place at the same 20 pre-designated sites sampled prior to the onset of algal growth (pre-algal). Nutrient concentrations and streamflow data will be collected along with major ions. Major ions will help in the understanding of the role hardness and other ions may play in controlling algal growth as well as providing some possible conservative tracers that may help in the understanding sources as well as the proportion of nutrient uptake by algae. These data will be used in the statistical analysis to determine if there is a correlation between peak algal biomass and concentration/load data. Also, loads and concentrations will be qualitatively compared to concentration data collected prior to the onset of algal growth in the spring (pre-algal) to further improve the understanding of where nutrient sources are located.
- Post-algal growth analysis will consist of a low-flow, steady-state sampling effort at the same 20 sites. The post-algal growth sampling will be done during the fall when nutrients in the water column behave more conservatively and streamflow variability is minimized. This will help in the comparison of nutrient load at each site because algae uptake of nutrients at this time is expected to be minimal relative to periods of peak growth. If variability in streamflow (a condition of changing river stage or streamflow rate) is not minimized as much as possible, it is difficult to compare and interpret sources of a given constituent in a large river system. However, when streamflow variability is minimized, a large component of the variability in the loading data is removed, providing a clearer picture of where sources may be emanating from (Kimball, 2004). This analysis primarily is focused on assessing sources of nutrients but will be evaluated in the statistical analysis.

Results from the analyses of streamflow, field parameters, and concentrations and loads of various constituents (including nutrients and total dissolved solids) will be presented spatially and temporally as maps and plots in the final report. Additionally, the analysis will look at correlations between various water-quality constituents and algal biomass for use in the statistical analysis. The information provided will help land managers and stakeholders gain a better perspective regarding possible temporal and spatial links between water-quality and algal productivity. These links could ultimately help with mitigation strategies designed to control nuisance algal blooms.

Grantee Deliverable: (Describe the deliverable the grantee expects from this task)

CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the

completion of this task)

A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Tasks

Provide a detailed description of each task using the following format:

Task 8 - (Analysis and Publications)

Description of Task:

An analysis of factors contributing to nuisance-levels of benthic algae in the White River will utilize multivariate-regression techniques. In this analysis, the data collection (described previously) provides a dataset designed to assess the role and importance of several potential contributing or mitigating conditions (explanatory variables: field parameters, water-column chemical properties, channel condition, channel form, and scouring forces) in controlling the range of observed conditions in algal abundance (dependent variable: chlorophyll a or ash-free dry mass).

Method/Procedure:

STATISTICAL ANALYSIS

Simultaneous testing for a statistical relation between different conditions within the stream provides a means to quantify the relative importance of these factors and to what extent these factors predict/explain the variability observed in the algae. Once a statistically significant relation is determined, estimates of the effect of changes to these explanatory conditions can be made. These estimates can be used to identify strategies to mitigate nuisance-level algal growth.

The analysis can provide context within a conceptual model for resource managers to identify best management practices (BMP's) that reduce algal growth. This approach simultaneously assesses differing covariates, providing a quantitative comparison of the importance of each in explaining algae abundance; while also evaluating how independent the effects are between covariates. In this manner, the importance of factors and processes represented by these explanatory variables can be collectively weighed to identify causes and inform decision making. As a result, interested stakeholders can identify feasible counter measures and/or best practices to reduce algae abundance.

Grantee Deliverable: (Describe the deliverable the grantee expects from this task)

To keep the stakeholders apprised of progress as results from each of the various components of the study are completed, the USGS will provide a presentation of the interim-progress and approved preliminary data to the group, at least annually. Upon completion of the study in the final year (2021), the USGS will publish a technical document containing the methods and interpretive findings as a peer-reviewed Scientific Investigations Report (SIR). This publication will serve as the primary product of this investigation. In the same timeframe, an abbreviated version of the findings will also be published as a USGS Fact Sheet. In the Fact Sheet, a 4-6 page document, the main findings of the report will be presented for a general audience. The combination of products will provide an effective means to disseminate and share the results of the investigation with different technical groups and the general public.

CWCB Deliverable: (Describe the deliverable the grantee will provide CWCB documenting the completion of this task)

A copy of the annual report and/or Power Point presentation with preliminary data will be provided to the CWCB. CWCB will be provided a copy of the final report and fact sheet including the statistical analysis information.

Budget and Schedule
Budget: This Statement of Work and Schedule shall be accompanied by a Budget (link?) that reflects the Tasks identified in the Statement of Work and Schedule and shall be submitted to CWCB in an excel format.
Schedule: This Statement of Work and Budget shall be accompanied by a Schedule (link?) that reflects the Tasks identified in the Statement of Work and Budget and shall be submitted to CWCB in an excel format.

Reporting Requirements
Reporting: The grantee shall provide their respective Roundtable(s) and the CWCB a Progress Report every 6 months, beginning from the date of executed contract. The Progress Report shall describe the status of the water activity, the completion or partial completion of the tasks indentified in the Statement of Work including a description of any major issues that have occurred and any corrective action to address these issues. The CWCB may withhold reimbursement until satisfactory Progress Reports have been submitted.
Final Deliverable: At the completion of the water activity, the grantee shall provide their respective Roundtable(s) and the CWCB a final report on the grantee's letterhead that: • Summarizes the water activity and how the water activity was completed • Describes any obstacles encountered, and how these obstacles were overcome • Explains the Proposed Budget versus the Actual Budget • Confirms that all matching commitments have been fulfilled • Includes photographs, summaries of meeting and engineering reports/design, if appropriate The CWCB will withhold the last 10% of the entire water activity budget until 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 water activity and purchase order or contract will be closed without any further payment. Any entity that fails to complete a satisfactory Final Report and submit to CWCB within 90 days of the expiration of a purchase order or contract may be denied consideration for future funding of any type from CWCB.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Supply Reserve Fund

EXHIBIT B - BUDGET AND SCHEDULE - Direct & Indirect (Administrative) Costs

Date: Oct 31, 2018

Water Activity Name: White River Algae Study

Grantee Name: White River Conservation District

Task No.[1]	Description	Start Date[2]	End Date	Matching Funds (cash & in-kind)[3]	WSRF Funds (Basin & Statewide combined)[3]	Total
1	Historical analysis	4/1/2018	12/31/2018	$17,326	$0	$17,326
2	Continuous monitoring (DO, temp) (20 sites)	4/1/2018	12/31/2018	$39,872	$0	$39,872
3	Pebble counts	4/1/2018	12/31/2018	$24,333	$0	$24,333
4	Scouring Flows Data Collection	4/1/2018	12/31/2020	$80,721	$0	$80,721
5	Scouring Flows Analysis	4/1/2018	12/31/2020	$17,942	$0	$17,942
6	Isotope sampling	4/1/2018	12/31/2020	$19,599	$0	$19,599
7	Pre-, Peak-, Post-Algae and Water Quality Sampling	4/1/2018	12/31/2020	$204,467	$84,000	$288,467
8	Analysis and publications	1/1/2020	12/31/2021	$69,786	$15,000	$84,786
			Total	$474,046	$99,000	$573,046

(1) The single task that include costs for Grant Administration must provide a labor breakdown (see Indirect Costs tab below) where the total WSRF Grant contribution towards that task does not exceed 15% of the total WSRF Grant amount.

(2) Start Date for funding under $100K - 45 Days from Board Approval; Start Date for funding over $100K - 90 Days from Board Approval.

(3) Round values up to the nearest hundred dollars.

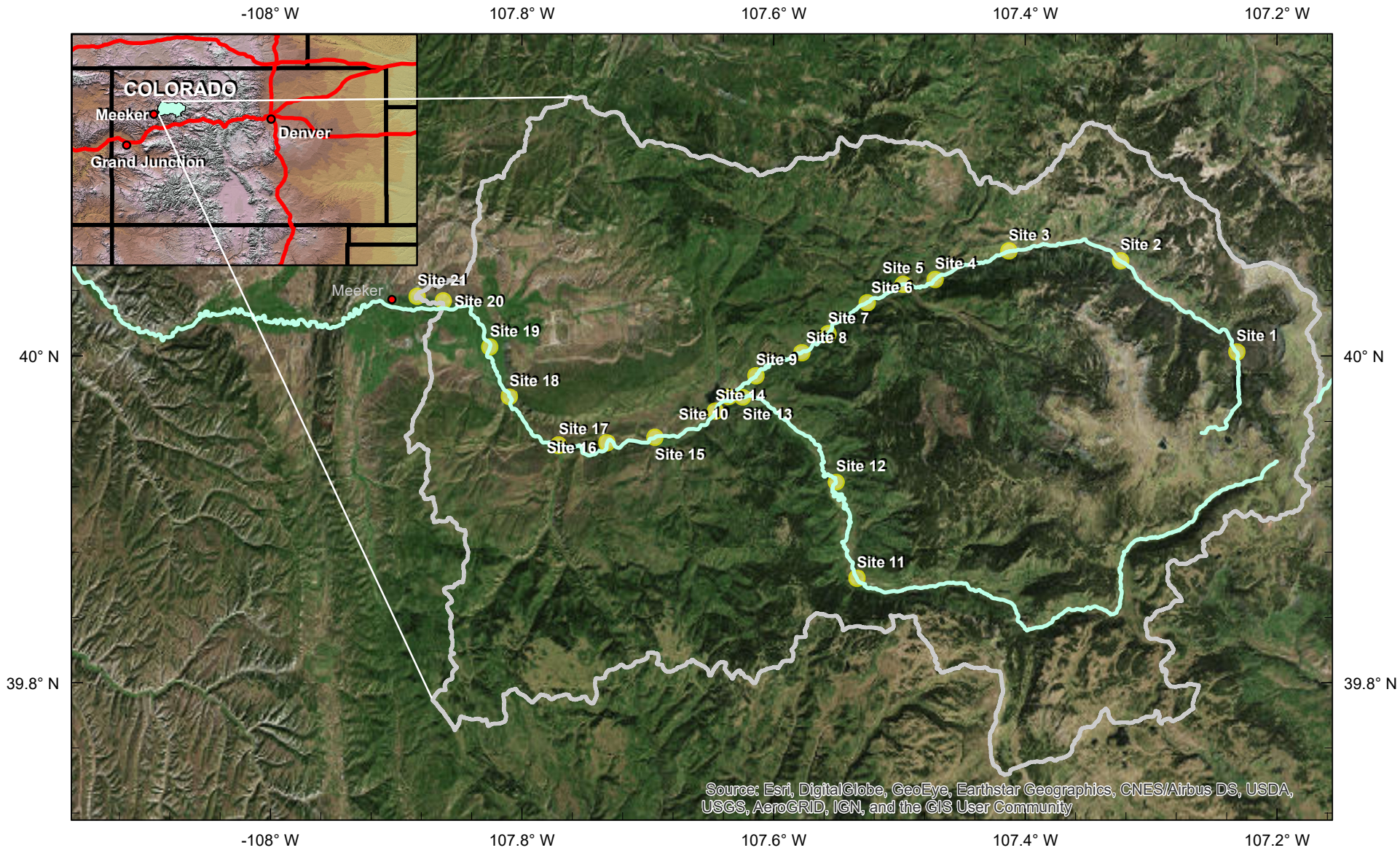
• Reimbursement eligibility commences upon the grantee's receipt of a Notice to Proceed (NTP)

• NTP will not be accepted as a start date. Project activities may commence as soon as the grantee enters contract and receives formal signed State Agreement.

The CWCB will pay the last 10% of the entire water activity budget when the Final Report is completed to the satisfaction of the CWCB staff project manager. Once the Final Report has been accepted, the final payment has been issued, the water activity and purchase order (PO) or contract will be closed without any futher payment. Any entity that fails to complete a satisfactory Final Report and submit to the CWCB with 90 days of the expiration of the PO or contract may be denied consideration for future funding of any type from the CWCB.

• Additonally, the applicant shall provide a progress report every 6 months, beginning from the date of contract execution

• Standard contracting proceedures dictate that the Expiration Date of the contract shall be 5 years from the Effective Date.



USGS. White River Algae Study Sites (v. 6-14-18)

0 5 10 20 Miles

0 5 10 20 Kilometers

* Note: 1 extra site is shown. Pending landowner permission, onesite will be eliminated. Renaming of many sites will be done. An updated map will be created at that time.

Data source: USGS

ESRI base map

Coordinate System: WGS 1984 World Mercator
Projection: Mercator
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Units: Meter

White River Algae

Slide presented by CPW researcher, Melynda May

July Periphyton on Rock Photos

.Fk blw Lost Cr	N.Fk CR 14	N. Fk Abv. Westlands	N. Fk. @ Westlands	N. Fk Bel Aire
				

Fk. Bel Aire	White @ Sleepy Cat	White @ Wakara	White @ Meeker Pasture	White @ 5th St Bridge
				

Picture Credit *CPW*
White River Algae
Report on 2016 Data

U.S. GEOLOGICAL SURVEY (USGS)
SOUTHWEST REGION
COLORADO WATER SCIENCE CENTER (CWSC)
Statement of Work
May 8, 2018

TITLE: Investigation of benthic algae and stream conditions in the upper White River watershed, Rio Blanco County, Colorado, 2018-2021

INTRODUCTION

Benthic algae (algae attached to the stream bottom), a component of stream food webs, can reach uncharacteristic and nuisance levels on substrates when water chemistry and physical factors are out of balance with biological and physical removal mechanisms. The typical cycle for algae growth begins in the spring following snowmelt runoff, peaks in the late summer when temperature and light levels are most favorable and senescence in the fall and winter when water temperatures are cooler and period of daylight is less. Local observations and work done by Colorado Parks and Wildlife (2016) have highlighted nuisance benthic algal productivity in the White River (fig. 1) from the upper watershed downstream to Meeker, Colorado. The high levels of benthic algae have reportedly developed in the last 3-5 years and have caused problems with the aesthetic values and recreational use of some reaches of the White River. Benthic algae also reportedly accumulates and affects drinking-water intakes for the town of Rangely, Colorado.

Understanding the occurrence and distribution of algae may lead to mitigation strategies for decreasing benthic algae in the White River. Limiting conditions for the occurrence and growth include: (1) physical and chemical conditions in the water column such as water depth and velocity, length of growing season, water quality, water temperature, and light conditions; (2) stream substrate conditions including particle size, and bed sediment mobility; and (3) antecedent streamflow conditions such as scouring flows, timing of snowmelt, low-flow conditions, and nutrient storage. The complexity of these factors can make it difficult to understand which processes are the most important controls on algal growth. As such, the following scope of work is designed to address data-gaps previously identified by recent investigations. The approach: (1) utilizes cost-effective strategies to provide an improved understanding of what conditions are driving nuisance algae growth; and (2) standardizes and expands measurements and observations of algae along the White River in a focused section of the river upstream of USGS streamflow-gaging station 09304800 (White River below Meeker).

Identification and quantification of algal mass between locations and at a location over-time is critical to understanding the mechanisms that have led to algal issues and annual variation of algal abundance. Reporting of algae conditions within a river system can be hindered by the subjective nature of anecdotal accounts and the lack of data to describe year-to-year variations. Systematic comparison of algae within the study reach is needed to identify the extent of growth and standardize the observations in time, space, and method. This approach will better identify variations in algal abundance and location as well as characterize specific conditions contributing to nuisance-levels algal growth throughout the reach.

OBJECTIVE

The objective of the study is to document and understand benthic algal occurrence, characteristics, and controls at multiple locations within the White River area of interest. Specific objectives include:

1) Conduct data mining and historical synthesis of information relevant to the timing and occurrence of nuisance algal blooms in the White River Basin;

2) Develop a better understanding of physical and chemical properties controlling algal growth in the main stem of the White River.

Approach and analysis steps for objectives 1 and 2 are presented below in the Approach section of this proposal.

APPROACH

Specific Objective 1: Data mining and historical synthesis

This objective will be addressed using several methods. Initially, the USGS will do a literature search for algal topics and determine from the search what information is relevant to the White River. Literature has been presented through recent investigation efforts but is drawn from locations that may not be applicable to conditions in the White River. Evaluation of findings from other studies will be completed and synthesized into a single document that is relevant to conditions in the White River. Recent reports by the Colorado Parks and Wildlife (2016) and Hydrosolutions (2017) suggest that several factors may be controlling algal growth in the White River. These reports and other historic information will be used to guide further investigations in the White River Basin as part of a local effort by stakeholders to better understand the algal problem. The USGS will continue this analysis of historical data in the White River and look for signals and relationships that indicate changes in streamflow and water-quality (primarily nutrients) as well as source locations for solid and dissolved phases of nutrient transport. This analysis will build from water-quality findings in recent investigations (nutrients, suspended sediment, and streamflow), but will expand and refine the analysis to include additional seasonal and flow-regime specific trends that have not been evaluated previously using the Weighted Regressions on Time Discharge and Season model (WRTDS; Hirsch and others, 2010) within the Exploration and Graphics for RivEr Trends software (EGRET; Hirsch and De Cicco, 2015). Dissolved oxygen, water temperature, pH, and hardness will also be explored. The information will be reported and used to inform subsequent tasks and findings for this study to maximize effective data collection strategies and locations.

Specific Objective 2: Understanding physical and chemical properties controlling algal growth in the main stem of the White River

Study Area and Site Selection

The study area for this proposed work is defined as the portion of the White River Basin just upstream of Meeker Colorado to the headwaters of the North and South Fork White Rivers (Fig 1.) This area is referred to locally as the Upper White River Basin or UWRB. Land use in the

basin is primarily agricultural and recreational. There are no cities or densely populated areas in the UWRB, with the exception of the town of Meeker, which is at the outflow of the study area. Agricultural activity is focused in the river valley and some upland areas near Meeker. U.S Forest Service land comprises the majority of ownership in the UWRB.
The proposed study will have 20 sites selected for assessment and sampling based on the amount historical data available as well as several logistical considerations such as accessibility and owner permission if the desired site is on private land. Selection will also strive to represent the gradient of chemical and physical conditions controlling algae in the UWRB. This gradient can be represented through assessment of historic information and reconnaissance or using partial randomization techniques (Scott, 1990).

Stream hydraulics and channel characteristics

An important consideration regarding the proliferation of algae in certain reaches of the White River is peak streamflow and duration. Peak streamflow magnitude can play a crucial role in scouring benthic algae from streambeds thus decreasing or resetting total algal biomass on an annual basis (Cullis, 2011). However, streamflow peak and duration are not the only factors governing the amount of scour that occurs in a given water year. Specific channel characteristics also play a role in benthic algal control, but are less apt to change from year to year. Characteristics such as bed-sediment particle size and channel form can place large controls on algal growth. Particle size of the streambed can dictate the suitability of algal attachment points and, if large enough, can armor the channel and minimize scour even during wet years. Channel form is the sinuosity, area, width and depth of the channel at a given point. These characteristics can control light penetration, stream velocity, and sediment deposition rates. Cross-section surveying and particle-size analysis in conjunction with incipient motion analysis is needed to address data gaps and promote understanding of the role of streamflow in algal proliferation. This analysis will also assist in the prediction of where algae will be most prolific (Petts, 1997).

The USGS proposes to assess channel condition, form, and scouring forces present at selected sites and use that information to assess the potential for channel scour present under varying streamflow conditions. Thresholds for critical flows needed to scour algae will be provided. These thresholds can be used annually by land managers to forecast conditions and verify the effect that scouring flows had on the system if critical-flow thresholds are exceeded.

- *Scouring Flow Analysis*

Sediment transport, or movement, in streams occurs when the forces acting on the particle exceed the resistive forces. Transport of bed material (the particles that are representative of the range of particle sizes commonly occurring along the streambed) is approximated through comparisons of boundary shear stress (a tangential stress created by flowing water acting on sediment particles resting on the streambed or other inundated alluvial surfaces) and particle size and shape. Entrainment potential for sediment on a specific geomorphic surface is estimated by relating flood generated boundary shear stress and the critical shear stress of the sediment particles. Bed material characteristics obtained from onsite measurements at 20 locations in the study reach will be compared to the observed high-flow conditions during snowmelt runoff, during 2018-2020. Additional measures of acoustic energy (sound) utilizing hydrophones will be used to assess the presents or absence of moving particles during field visits during high-flow each year (Marineau and others, 2015) and will be compared to separate estimate of critical shear

stress made from particle-size information (shear velocity, from Simoes, 2014) and cross-section surveys (boundary shear stress, Elliott and Capesius, 2009). These three methods will provide a comparison of observed conditions (2018-2020) and particle characteristics in each reach and will inform estimates of streamflow needed to scour algae in each reach.

Bed-material measurements will be made by the USGS using standard methods to determine particle-size characteristics of the channel and, if present, of the alluvial bars (Wolman, 1954) at up to 60 cross sections in the White River (three cross sections at each of the 20 sites). Wolman "pebble counts" will be made in a linear traverse of the channel cross section where the channel is wadeable in late summer or early fall 2018. In unwadeable sections, pebble counts of the streambed will be made in a random manner at one-footstep intervals in shallower areas. Sediment-size characteristics will be calculated from the bed-material measurements and used to determine the critical shear stress for sediment entrainment utilizing methods successfully demonstrated by Elliott and Hammack (1999, 2000).

Water-quality

The amount and type of algae in river systems is dependent on several water-quality conditions. Important conditions include nutrient levels, turbidity, pH, water temperature, and major ions (Peterson, 2001). Nutrient concentration levels in any river system act as the food source for growth. Nuisance algal blooms can exist in locations in a river system where nutrient concentrations exceed that of historical background levels. Other factors, such as turbidity and temperature, can enhance or limit algae growth in river systems. River systems that experience long periods of highly turbid conditions may see algal levels decrease as a result of a reduction in light penetration for photosynthesis; however, high turbidity may also be an indicator of increased nutrient availability. The response of algae to temperature is also important owing to the fact that rates of photosynthesis can increase as temperature increases. River systems with temperatures that are higher than historical background levels may also experience longer growing seasons. Levels of phosphorus that sustain algal growth can vary according to other water parameters such as hardness and alkalinity (Carole, 1973). Hardness and alkalinity are typically determined as part of a laboratory analysis of major ions.

Water-quality conditions in the main stem of the White River will be measured during the onset (in the spring following snowmelt runoff), peak (late summer), and senescence (fall and winter) of algae for a given year at the 20 locations in the study reach. This will include collection of benthic algae (chlorophyll a and ash-free dry mass), field parameters (water temperature, pH, specific conductance, turbidity, and dissolved oxygen), water-column chemical properties (major ions, nutrients, and isotopes of nitrogen and oxygen at select locations). The lab analyses for benthic algae include a metric of photosynthetic content (Chlorophyll a) for comparison to the State of Colorado numeric standard (WQCC, 2016), while algal abundance is more directly assessed through measurement of the ash-free dry mass sample. Chlorophyll a and ash-free dry mass samples are collected at each site by compositing multiple subsections from multiple cross sections in accordance with the USGS National Field Manual (USGS, variously dated). The water-quality data will be used in statistical tests to help determine controls governing algal productivity as well as to indicate specific anthropogenic effects to determine sources or source areas where nutrient reductions could be targeted.

- *Isotope Analysis*

In nature, elements occur with differing numbers of neutrons, resulting in slightly different masses for any given atom. These differences in mass occur at ranges that are defined as isotopes and are recorded for each element in conjunction with their abundance on earth. Some isotopes occur in arrangements that are unstable, and undergo radioactive decay; other isotopes are stable and persist in the environment indefinitely. Isotopic enrichment of heavier or lighter stable isotopes occurs at different locations in the world, and/or as a result of local geochemical or biological processes. As such, the relative abundance of measured stable isotopes from a water sample can act as a 'signature' to compare against when investigating different potential sources. To better understand the potential for isotopic testing to determine sources of nutrients in the White River, the USGS proposes to analyze isotopic-signatures of oxygen and nitrogen from nitrate. Samples will be collected in reaches of the North and South Fork White River as well as the mainstem channel. Sample locations will target land use activities such as forest, agriculture, aquaculture, and wastewater treatment. Where appropriate, stable isotope signatures will be obtained from the literature and compared to those observed from the mainstem of the White River. Samples will be submitted to the USGS National Water Quality Laboratory to determine nutrient concentrations and the USGS Reston Isotopes Laboratory for isotopic analysis. All results will be available to the public through National Water Information System web interface (http://dx.doi.org/10.5066/F7P55KJN).

- *Water-quality characterization and source analysis*

Water-quality samples (primarily nutrients) will be analyzed under varying conditions (pre-algal growth, peak-algal growth, and post-algal growth) as part of this study. Determination of these periods will be based on local observations and flow conditions (U.S. Geological Survey, 2018).

- Pre-algal growth analysis (sampling post snowmelt runoff, prior to the onset of algal growth in mid spring) will evaluate selected water-quality concentrations in the White River at the designated 20 sites. This sampling will help determine the concentration levels present in the White River prior to uptake by algal species as a means to better understand nutrient variability. The data will be used in a statistical analysis (described below) as a variable to determine if there is a correlation between nutrient levels prior to the onset of algal growth during peak periods. The data can also be used to identify where the highest nutrient concentrations are located for the purpose of understanding possible source locations for subsequent sampling later in the summer and fall.
- Peak-algal growth analysis will coincide with peak algal biomass in July or early August depending on conditions observed during the summer. The sampling will also take place at the same 20 pre-designated sites sampled prior to the onset of algal growth (pre-algal). Nutrient concentrations and streamflow data will be collected along with major ions. Major ions will help in the understanding of the role hardness and other ions may play in controlling algal growth as well as providing some possible conservative tracers that may help in the understanding sources as well as the proportion of nutrient uptake by algae. These data will be used in the statistical analysis to determine if there is a correlation between peak algal biomass and concentration/load data. Also, loads and concentrations will be qualitatively

compared to concentration data collected prior to the onset of algal growth in the spring (pre-algal) to further improve the understanding of where nutrient sources are located.

- Post-algal growth analysis will consist of a low-flow, steady-state sampling effort at the same 20 sites. The post-algal growth sampling will be done during the fall when nutrients in the water column behave more conservatively and streamflow variability is minimized. This will help in the comparison of nutrient load at each site because algae uptake of nutrients at this time is expected to be minimal relative to periods of peak growth. If variability in streamflow (a condition of changing river stage or streamflow rate) is not minimized as much as possible, it is difficult to compare and interpret sources of a given constituent in a large river system. However, when streamflow variability is minimized, a large component of the variability in the loading data is removed, providing a clearer picture of where sources may be emanating from (Kimball, 2004). This analysis primarily is focused on assessing sources of nutrients but will be evaluated in the statistical analysis.

Results from the analyses of streamflow, field parameters, and concentrations and loads of various constituents (including nutrients and total dissolved solids) will be presented spatially and temporally as maps and plots in the final report. Additionally, the analysis will look at correlations between various water-quality constituents and algal biomass for use in the statistical analysis. The information provided will help land managers and stakeholders gain a better perspective regarding possible temporal and spatial links between water-quality and algal productivity. These links could ultimately help with mitigation strategies designed to control nuisance algal blooms.

- *Continuous water-quality monitoring and analysis*

An intensive, continuous monitoring (at 15-min intervals) of selected water-quality parameters will be done to address data gaps in the diurnal changes in water temperature and dissolved oxygen along the White River. This effort will monitor and record complete diurnal cycles at 20 sites (about 7 days per site) during a three-week period in July. The water-quality monitors will characterize conditions at each location and will be indicative of the range of conditions throughout the reach during peak algal growth. Monitors will be deployed at each of the 20 sites and is slated for 2018. Measurement of diel variations in dissolved oxygen and water temperature will determine ranges of conditions aquatic communities are exposed to as well as calculate stream metabolism using the single-site method (Hondzo, 2013). These calculations can help support findings from site-specific algal biomass measurements and identification of sites as heterotrophic or autotrophic providing additional metrics to assess stream health and function.

Statistical Analysis

An analysis of factors contributing to nuisance-levels of benthic algae in the White River will utilize multivariate-regression techniques. In this analysis, the data collection (described previously) provides a dataset designed to assess the role and importance of several potential contributing or mitigating conditions (explanatory variables: field parameters, water-column chemical properties, channel condition, channel form, and scouring forces) in controlling the

range of observed conditions in algal abundance (dependent variable: chlorophyll a or ash-free dry mass). Simultaneous testing for a statistical relation between different conditions within the stream provides a means to quantify the relative importance of these factors and to what extent these factors predict/explain the variability observed in the algae. Once a statistically significant relation is determined, estimates of the effect of changes to these explanatory conditions can be made. These estimates can be used to identify strategies to mitigate nuisance-level algal growth.

The analysis can provide context within a conceptual model for resource managers to identify best management practices (BMP's) that reduce algal growth. This approach simultaneously assesses differing covariates, providing a quantitative comparison of the importance of each in explaining algae abundance; while also evaluating how independent the effects are between covariates. In this manner, the importance of factors and processes represented by these explanatory variables can be collectively weighed to identify causes and inform decision making. As a result, interested stakeholders can identify feasible counter measures and/or best practices to reduce algae abundance.

PRODUCTS

To keep the stakeholders apprised of progress as results from each of the various components of the study are completed, the USGS will provide a presentation of the interim-progress and approved preliminary data to the group, at least annually. Upon completion of the study in the final year (2021), the USGS will publish a technical document containing the methods and interpretive findings as a peer-reviewed Scientific Investigations Report (SIR). This publication will serve as the primary product of this investigation. In the same timeframe, an abbreviated version of the findings will also be published as a USGS Fact Sheet. In the Fact Sheet, a 4-6 page document, the main findings of the report will be presented for a general audience. The combination of products will provide an effective means to disseminate and share the results of the investigation with different technical groups and the general public.

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WORK PLAN

Work Plan Element	FY-2018*				FY-2019				FY-2020				FY-2021			
Historical analysis			x													
Continuous monitoring (DO, temp) (20 sites)				x												
Pebble counts				x												
Scouring flows			x	x			x	x			x	x				
Scouring flows analysis								x								
Isotope sampling			x		x											
Pre-, peak-, post- algae and water-quality sampling events							x	x			x	x	x			
Analysis and publications													x	x	x	x

*Joint Funding Agreement provides funding for work plan elements in 3rd and 4th quarter of fiscal year 2018 and 1st quarter of fiscal year 2019 only.

FUNDING.

	FY- 2018	FY- 2019	FY- 2020	FY- 2021
Funding Source	(all values in gross dollars)			
External Cooperator(s)	$ 90,423	$ 112,777	$ 134,524	$ 55,319
USGS	$ 38,992	$ 51,029	$ 62,739	$ 29,787
Totals	$ 129,415	$ 163,807	$ 197,264	$ 85,107

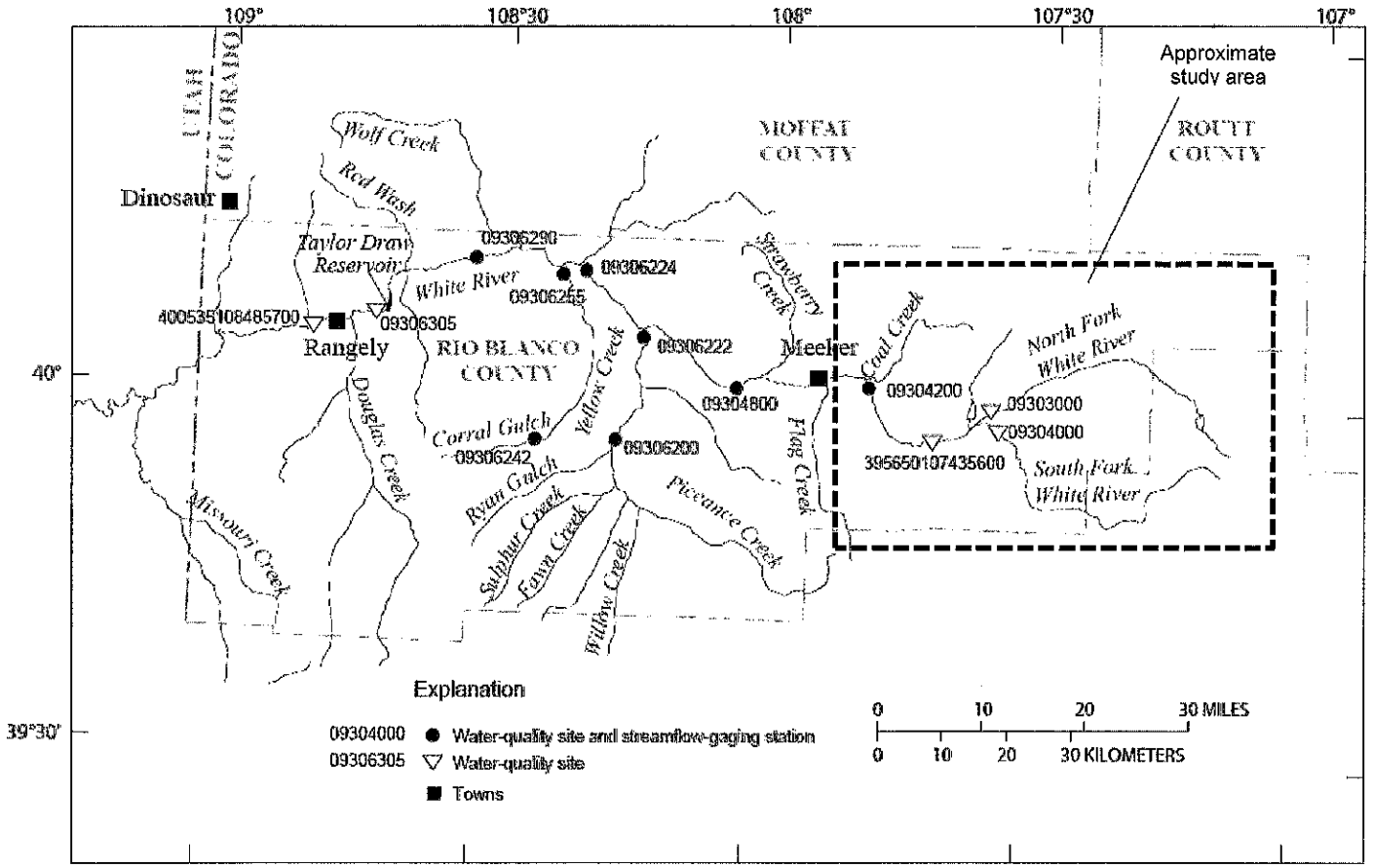

Figure 1. Location of streamflow-gaging stations and water-quality sites (modified from Thomas and others, 2013).