White River & Douglas Creek Conservation Districts

Promoting the wise use of all natural resources

June 22, 2022

Chris Sturm, Watershed Program Director
Colorado Water Conservation Board
1313 Sherman Street, Suite 721
Denver, CO 80203

Subject: White River Algae Research POGG1, PDAA, 202000002716 – Final Report

Dear Mr. Sturm,

We are pleased to provide the following final report for the Colorado Water Plan Grant POGG1, PDAA, 202000002716. All the data has been collected and analyzed for this study. USGS is in the process of finalizing the reports and ensuring accuracy through their quality control processes. The final USGS algae study reports are expected to be published and provided to CWCB by December 2022.

After many concerned citizens experienced trouble with "green stuff" in the river, fourteen local agency members were convened by the White River and Douglas Creek Conservation District (Districts) to create the Technical Advisory Group (TAG). This group worked with USGS and developed a Scope of Work (SOW) to study the potential causes of the excessive algae growth in the White River. Representatives of the following agencies make up the TAG: Rio Blanco Water Conservancy District, CO Parks and Wildlife, CO River Water Conservation District, Rio Blanco County, Town of Meeker, Town of Rangely, Meeker Sanitation District, White River Conservation District, Douglas Creek Conservation District, Natural Resource Conservation Service, US Forest Service, Bureau of Land Management, US Geological Survey, and Trout Unlimited. The TAG's mission is to ascertain what is driving the algae growth in the White River to improve the overall health of the watershed.

Therefore, the Districts hired the United States Geological Survey (USGS) who is guided by the Districts and TAG in data collection and research into potential causes of the nuisance levels of benthic algae growing in the White River. Since January 2018, the USGS has been collecting data related to streamflow, water quality, and algal occurrences in the White River. Data collection for Scope of Work (SOW) was completed October 2020.

In addition to the specific tasks identified in the SOW (listed below), the Districts obtained landowners' permission in many stretches of the White River to allow Rio Blanco County and the Districts to fly a drone and get photos of the river to see where the algae may be more/less prevalent. Pictures were taken three years in a row and are compared annually to better understand the behavior of the algae.

Multiple volunteer citizens took weekly and/or daily photos of the river at study sites to assist in identifying the peak algae bloom for USGS data collection. Photos were shared with the USGS through the Districts. This helped to involve local citizens in the project and saved USGS from making trips to the basin to monitor peak growth.

Additionally, the Districts partnered with CPW and Trout Unlimited to hire GEI Consultants to analyze collected data and develop the White River Macroinvertebrate Analysis Report. By hiring this third party, the report was finalized in time for the information to be included in the final USGS Algae Study Report.

The TAG has met approximately fourteen times over the last five years to identify the Scope of Work (SOW) for this project and to hear updates from USGS on the progress of the study. The TAG met several times in early 2022 to consider the data and analysis along with local knowledge and provide input on the USGS final report.

The following is a list of tasks, their descriptions and the items completed within each one from the USGS Scope of Work. Tasks 1-7 were completed as of October 2020. The Districts' commitment to Task eight is finalized. The final reports are written and are currently under review and formatting is being finalized by another USGS team. USGS indicates that the final reports are expected to be completed by December 2022.

**Green wording is from the WSRF grant application SOW

Task 1 Data Mining and Historical Synthesis: 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.

- ✓ Compilation and analysis of existing literature and data for study area and nearby areas. This provided additional temporal and spatial perspective using existing data sets.

Task 2 Continuous Monitoring: Dissolved oxygen and temperature at 19 sites.

- ✓ Three reconnaissance stream samplings were taken for determination of concentrations and loads of nutrients (total Nitrogen and Phosphorous and component chemical compounds), and suspended sediment concentrations. The importance of this was to reveal loading, spatial, temporal, sources; apportion source contributions to various input streams and perhaps diffuse groundwater inputs to specific reaches.
- ✓ Water quality sondes (DO, pH, water temp.) were deployed at the 19 study sites on the White River. Each sonde ran continuously for one week collecting data at 15-minute intervals.

Task 3 Pebble Counts Streambed 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 19 sites).

- ✓ Assessment of channel substrate size, orientation, and embeddedness on all study sites in 2018.

Task 4 Scouring-Flows 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. 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. 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.

The following activities were conducted all three years (2018 – 2020)

- ✓ 30 streamflow measurements and depth velocity profile measurements
- ✓ 30 high water surveys
- ✓ 30 hydrophone measurements for coarse bedload verification
- ✓ 30 radar targeted velocity verifications

Task 5 Scouring-flows 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.

- ✓ This was assessed during peak streamflow in 2018-20 using high-flow measurements, channel surveys, and grain-size analysis. High flows in 2018 and 2020 DID NOT cause streambed mobilization at the site WR below North Elk Creek near Buford, CO. High flows in 2019 DID mobilize the streambed at this location. Differences in streamflow magnitudes in 2018-2020 provided a good opportunity to characterize the lower and higher ranges of sediment mobility for each site.

Task 6 Isotope Sampling The relative abundance of measured stable isotopes from a water sample can act as a 'signature' to compare against when investigating different potential nutrient sources.

- ✓ The District Manager collected river water samples and Meeker Sanitation District Manager tested the samples for nitrate levels to determine if/when levels were high enough for USGS to collect and test isotopes.
- ✓ 27 water samples collected by USGS among 9 sites (3 replicate samples collected at each site for quality assurance).
- ✓ 12 water samples sent to the USGS lab. Only 4 of the 9 sites sampled had high enough nitrate concentrations for isotope analysis.

Task 6.1 Taxonomic Identifications The results will identify whether filamentous algae are Cladophora and will identify and quantify the presence of other algae including didymo and blue-green algae. The task includes field collection/sample processing and laboratory analysis. It will complement the chlorophyll-a and ash-free dry-mass analyses planned for the same sites and will provide additional data for relations among water quality, macroinvertebrates, and the physical system.

- ✓ Algae samples were taken and analyzed from the 20 study-area sites

Task 6.2 Supplementing Streamflow Measurements This task better separates flow quantity in the North and South forks of the White River, in areas where no currently installed stream gages exist and to aid in the State of Colorado gaging station during high-flow on the White River near Sleepy Cat. This helps to better understand streamflow correlations between sites and to have a better understanding of peak flows throughout the upper basin. Measurements taken during high flow conditions helped

characterize stream channel mobility, or the tendency for the channel bed to have moved. Bed movement can help control algae levels by cleaning or abrading rock surfaces.

- ✓ Streamflow measurements collected at three sites that bracket the confluence of the North and South Forks.

Task 7 Pre-, Peak-, Post- Algae and Water -Quality Sampling Events 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. Determinations of these periods will be based on local observations and flow conditions.

- ✓ Sampling in 2019 and 2020 included the following parameters on all sites: Chlorophyll a, ash free dry mass, salinity (major ions), alkalinity, Streamflow, turbidity, pH, specific conductance, temperature, dissolved oxygen (DO).

Task 8 Analysis & Publication 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).

Task 8.1 Water Quality Report –

- ✓ The draft manuscript for the Water Quality report is 90% through the review process as of May 2022. No additional cost will be billed to the Districts to finalize the report.

Task 8.2 Algae Report –

- ✓ The draft manuscript for the Algae report is 90% through the review process as of May 2022. No additional cost will be billed to the Districts to finalize the report.

Task 8.3 Fact Sheet –

- ✓ The fact sheet is a quick way for the lay person to understand the results of the study. It is 80% through the review process as of May 2022. No additional cost will be billed to the Districts to finalize the Fact Sheet.

The USGS will be providing two reports on the White River Algae Study. The first is the *Characterization of Streamflow and Nutrient Occurrence in The Upper White River Basin, Colorado, 1980-2020* (Identified as Task 8.1) which describes historical streamflow and water quality characteristics. The second is the *Investigation of Factors Controlling Benthic Algae in The Upper White River Watershed, Colorado, 2018–21 (*Identified as Task 8.2). There will also be a fact sheet made available that will help convey the findings to the laymen who just wants the results but doesn't have the time to spend studying the research.

The final USGS Algae Study reports noted above, and a Fact Sheet are expected to be ran through all USGS quality control processes. Unfortunately, they are not expected to be completed until December 2022. USGS indicates this is due to COVID and staffing issues. The Districts will provide a copy of the final report to the Yampa, White, Green Basin Round Table and the Colorado Water Conservation Board when available.

White River Algae Study summary: Reduced spring and summer streamflow was identified as a major contributor to algal blooms across years. Several other factors including water temperature, nutrients, and streambed stability also contribute to increased benthic algal biomass.

Please see the attached White River Algae Study Summary for more information on the results from the Study. All meeting notes and resources are available on the White River and Douglas Creek Conservation Districts' website at www.WhiteRiverCD.com.

Matching Funds: This grant was specific to task #8, Analysis and Publication of the final reports. The total cost incurred through June 2022 for task #8 was $254,950. USGS contributed $168,750 (66%) and the Districts have contributed $86,200 (34%) to task #8 through this and the WSRF grants.

Photographs: Please see the attached photos taken over the years.

Thank you for your support in this study. Please contact me with any questions you may have.

Sincerely,

Callie Hendrickson

Callie Hendrickson
Executive Director

Attachments: White River Algae Study Summary
Invoice and backup documents
Photos

White River Algae Study

Summary

The United States Geological Survey (USGS) three-year study is complete. USGS provided a public presentation on June 2, 2022 with the following information.

Algal blooms are becoming common in lakes and reservoirs and some rivers, often because of higher water temperatures and excess nutrients. A historical data analysis determined algal blooms are less studied in mountainous rivers like the White River.

Algae is known to need a stable environment, temperatures above 13 degrees Celsius, light, and nutrients to grow. Therefore, this study included studying algae biomass, peak-streamflow velocities, streambed particle size, cross-section surveys, canopy cover, titrate isotopes, nutrient synoptic and algal taxonomy.

Data collection and analysis tested the following hypotheses:

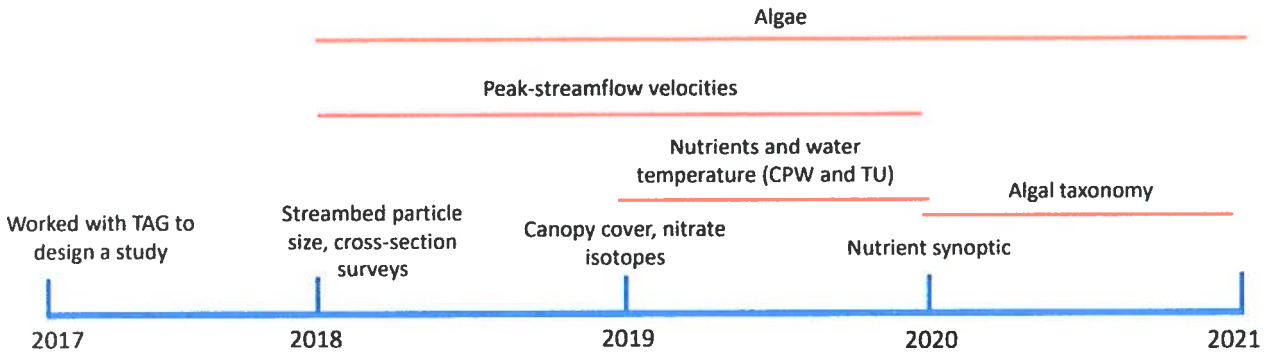
1. Streamflow-induced movement of the streambed during snowmelt runoff may limit accumulation of algae.
2. Physical and chemical characteristics associated with streambed particle size, water temperature, light availability, and nutrient availability, will promote growth of algal biomass.

The significant findings include:

1. Streamflows, which are considered a "master variable" in stream ecosystems, have decreased significantly over the past 20 years. Streamflows impact temperature, light, nutrient concentrations, and the stability of the streambed.
2. Temperatures have increased over the past 20 years.
3. Nitrogen has declined in all areas of the White River over the past 20 years. This is true in most areas in the United States.
    a. Phosphorus has increased in all areas of the White River over the past 20 years and is believed to contribute to algae growth. A relatively uniform increase in total phosphorus between the North and South Forks indicates that the factors contributing to the increases may be regional in scope. Note, a similar increase is also found in the Yampa River as well as across the United States.

Below are copies of slides from USGS' presentation on the White River Algae Study. The slides provide a more detailed glimpse into the findings of the 2018 – 2020 study and final reports that are expected to be available in December 2022.

Timeline of USGS activities in Upper White River Basin



TAG= Technical Advisory Group
CPW= Colorado Parks and Wildlife
TU= Trout Unlimited
USGS= U.S. Geological Survey

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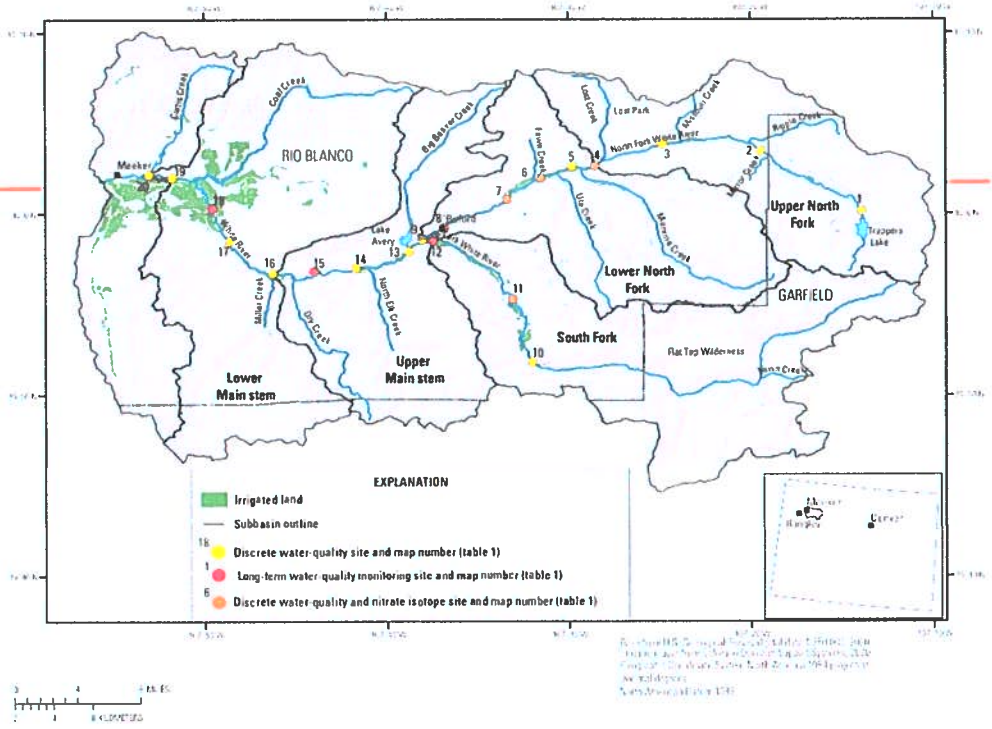
USGS Benthic Algae Study Design

- Collected new data to better explore spatial differences in algae and factors that affect algae.
- Study done over multiple years to capture annual variability in the factors potentially important to algae.
- Used long-term data to assess if streamflow and nutrient conditions have become more favorable to algae over time.



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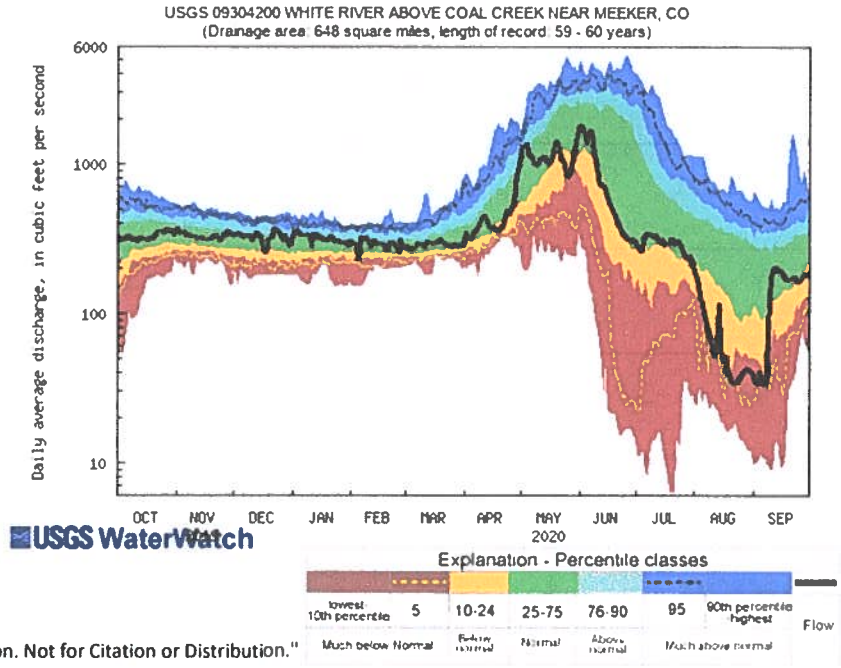
Streamflow

Streamflow is considered a 'master variable' in stream ecosystems. It influences

- Physical disturbance of the streambed;
- Water-quality conditions including light availability, dissolved oxygen, dilution of nutrients, and water temperature.

Differences in the timing, duration, and magnitude of high and low streamflows can influence conditions that affect algae.



Hypotheses

Data collection and analysis were presented testing the following hypotheses:

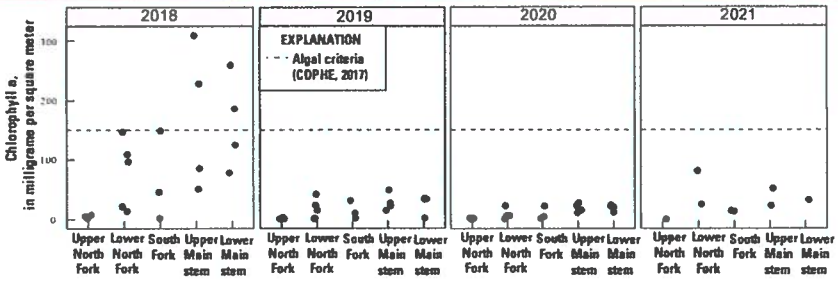
1. Streamflow-induced movement of the streambed during snowmelt runoff may limit accumulation of algae.
2. Physical and chemical characteristics associated with streambed particle size, water temperature, light availability, and nutrient availability, will promote growth of algal biomass.

Photo taken by Natalie Day, USGS

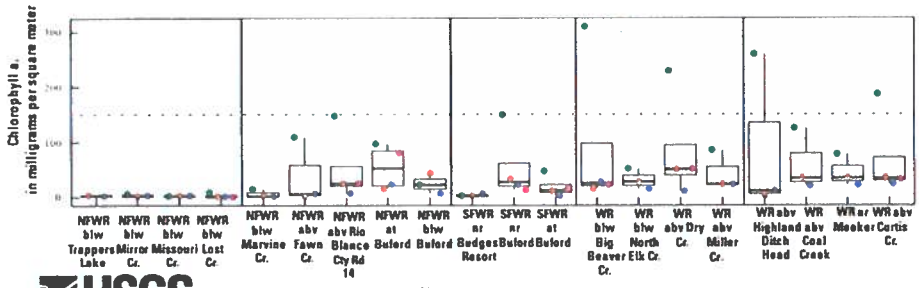
Results- Algal Biomass

Temporal

- Algal bloom in 2018; low in 2019, 2020, and some higher values in 2021.

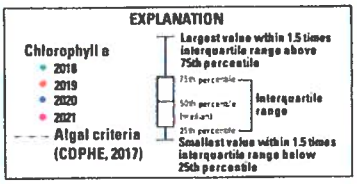


Colorado Department of Public Health and Environment [CDPHE]. 2017. Water Quality Control Commission. Regulation No. 31—The Basic Standards and Methodologies for Surface Water: Colorado Water Quality Control Commission, 230 p., at https://www.colorado.gov/pacific/cdphe/clean-watermutrients.



Spatial

- 6 sites always had low algal biomass during the study.
- More variable at other sites.



USGS science for a changing world

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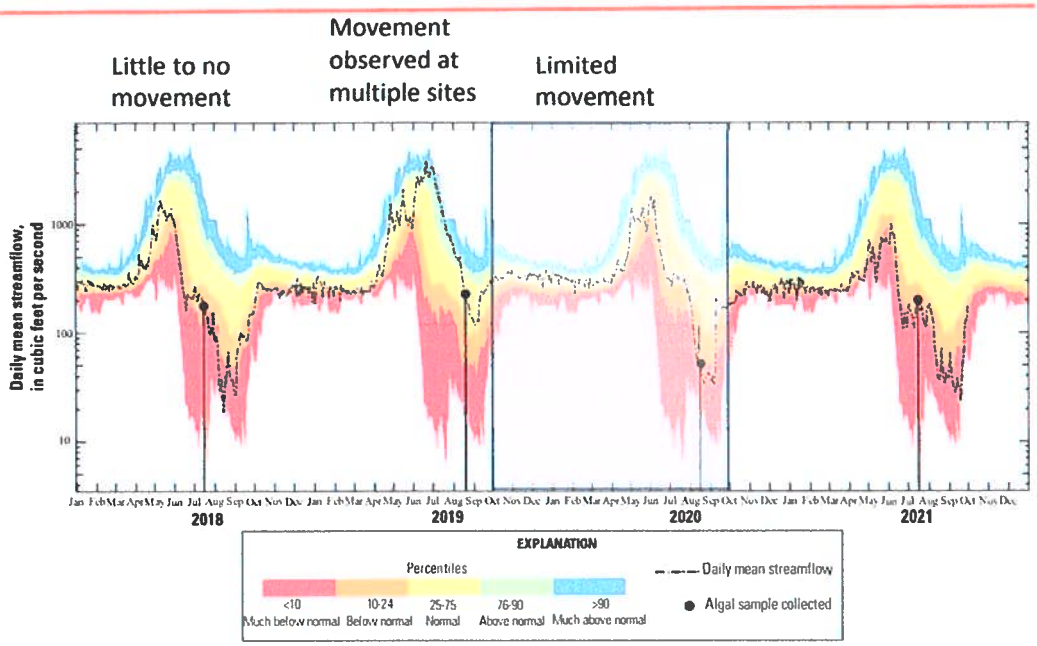
Results- Streambed movement during peak runoff

- Calculated streambed movement during peak runoff at 20 sites in 2018, 2019, and 2020.
- Field measurements, including cross-section surveys, streambed surface particle size, and streamflow velocity, were used to assess streambed movement using the modified critical shear method.



USGS science for a changing world

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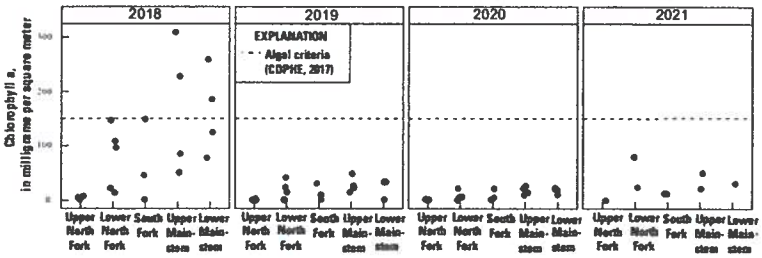
Hypotheses

Data collection and analysis were presented testing the following hypotheses:

1. **Streamflow-induced movement of the streambed during snowmelt runoff may limit accumulation of algae.**

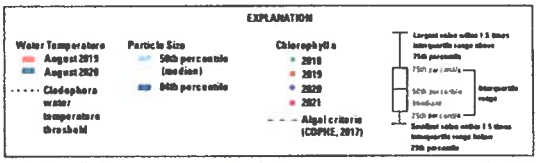
2. Physical and chemical characteristics associated with streambed particle size, water temperature, light availability, and nutrient availability, will promote growth of algal biomass.



Takeaways:

Relatively large, late, and long-lasting peak streamflows, such as those measured in 2019, may limit algal blooms during the same water year and into subsequent years, as evidenced by extremely low algal biomass during the summers of 2019 and 2020 at all sites.

Results- Factors that may be important to algal biomass



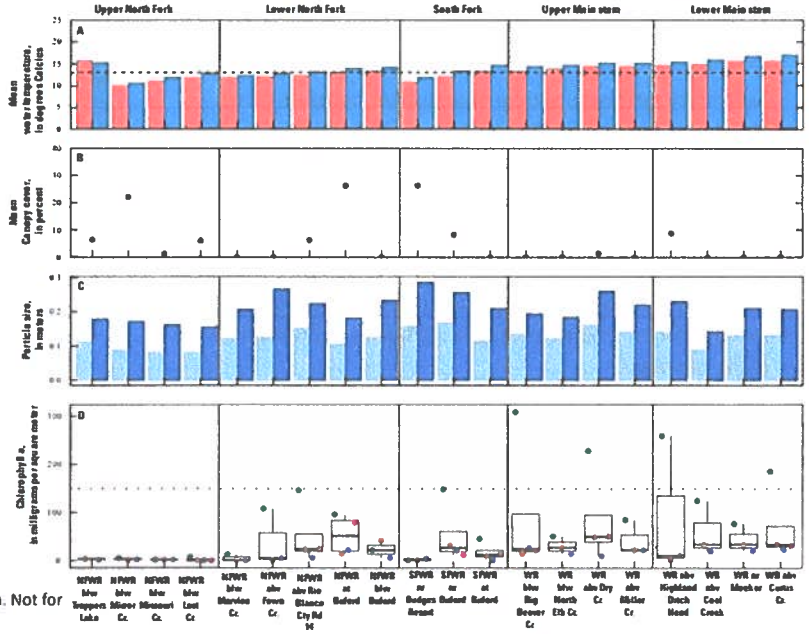
Colorado Department of Public Health and Environment [CDPHE], 2017, Water Quality Control Commission, Regulation No. 31 The Basic Standards and Methodologies for Surface Water: Colorado Water Quality Control Commission, 230 p., at https://www.colorado.gov/pacific/cdphe/clean-watermutrients.

- A linear mixed effects model evaluated the relative concurrent roles of different factors, including water temperature, canopy cover, particle size, and nutrients, on algal biomass across study sites.

- Mean August water temperature had a positive effect on algae.

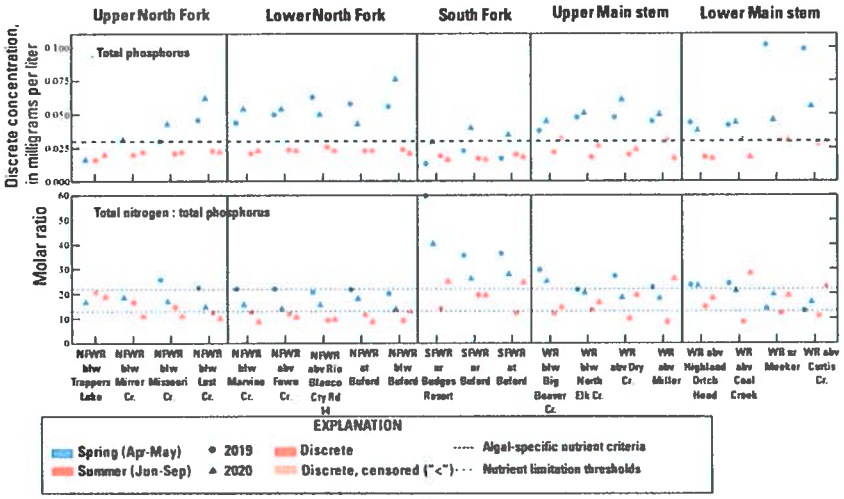
- No effect from canopy cover.

- Median particle size had a positive effect on algae. Greater stability of the streambed likely promotes algal accumulation.



Results- Factors that may be important to algal biomass

- Multiple sites on the main stem exceeded an algal-specific nutrient criteria for phosphorus.
- Greater phosphorus availability (lower total nitrogen: total phosphorus ratio) had a positive effect on algae.
- For benthic algae, nitrogen limitation is indicated at total nitrogen: total phosphorus ratios <13, and phosphorus limitation is indicated when N:P ratios are greater than 22 (Hillebrand and Sommer, 1999).



Hillebrand, H. and Sommer, U., 1999, The nutrient stoichiometry of benthic microalgal growth: Redfield proportions are optimal: Limnology and Oceanography, v. 44, p. 440-446.

Hypotheses

Data collection and analysis were presented testing the following hypotheses:

1. Streamflow-induced movement of the streambed during snowmelt runoff may limit accumulation of algae.
2. **Physical and chemical characteristics associated with streambed particle size, water temperature, light availability, and nutrient availability, will promote growth of algal biomass.**

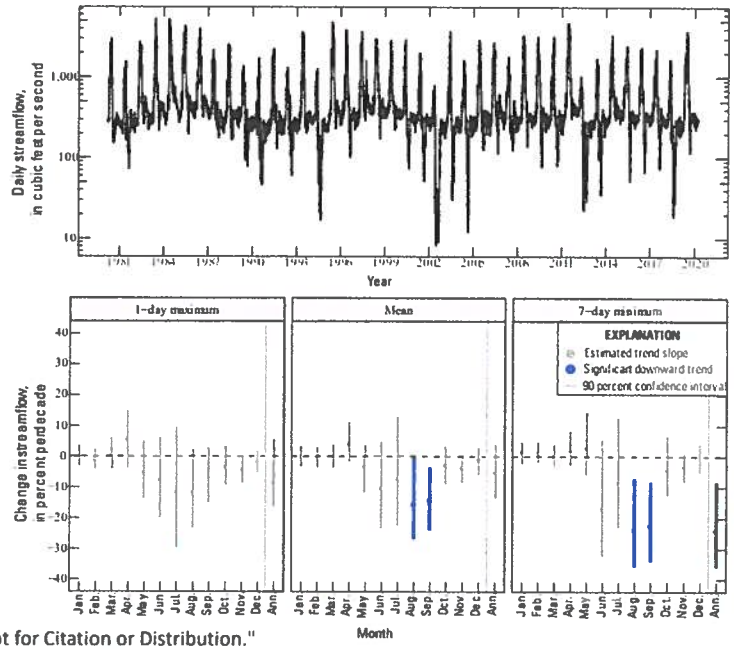
Takeaways:

Sites with greater stability (larger median particle sizes), higher water temperatures, and greater phosphorus availability had greater algal biomass.

Results-Long-term changes in streamflow

- Looked for changes in streamflow using data from White River above Coal Creek, near Meeker, CO from 1980 to 2020.
- Decreases in streamflow during summer months (blue lines), August and September and annually.
- Decreases in May and June streamflows and increase in April may indicate a shift toward earlier snowmelt runoff and a decrease in peak streamflow.

Streamflow conditions have become more favorable for algal blooms



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Streamflow

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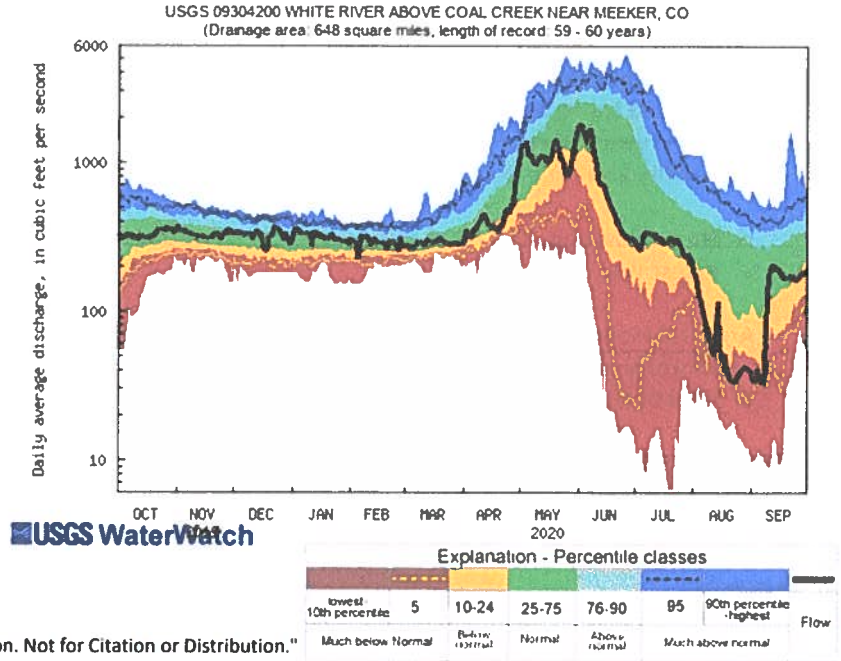
Differences in the timing, duration, and magnitude of high and low streamflows can influence conditions that affect algae.

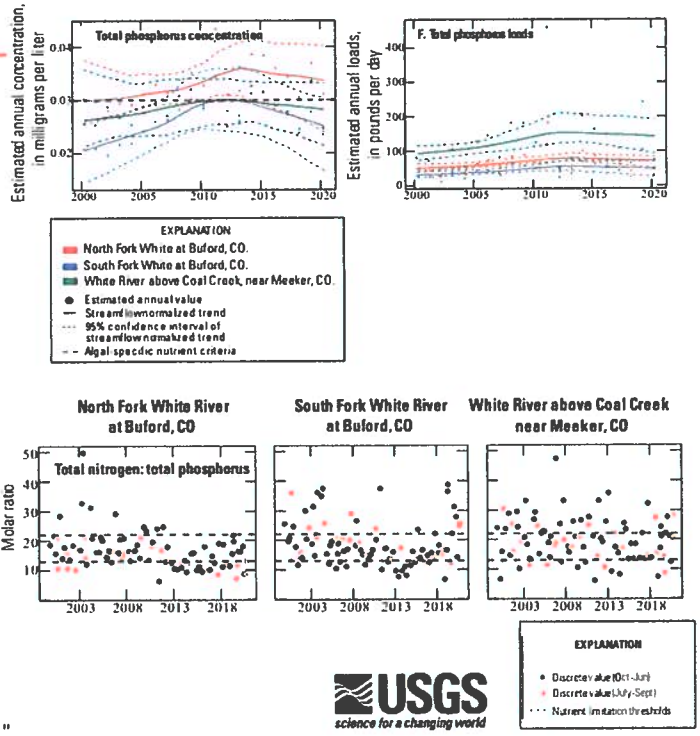


USGS science for a changing world "Preliminary Information-Subject to Revision. Not for Citation or Distribution."

Results- Long-term changes in nutrients

- Looked for changes in nutrient concentrations and loads using data from 3 sites, 2000-2020:
  - 1 on main stem
  - 1 on North Fork
  - 1 on South Fork
- Phosphorus concentrations and loads increased over time across sites, while nitrogen concentrations and loads decreased.
  - A relatively uniform increase in total phosphorus between the North and South Forks indicates that the factors contributing to the increases may be regional in scope.
- Changes in the relative availability of nitrogen to phosphorus, represented by the molar ratio of nitrogen to phosphorus, show that conditions in the North and South Forks changed from colimited to nitrogen limited around 2012.

Nutrient conditions have become more favorable for algal blooms



What questions can we answer?

Why did these algal blooms start occurring in the Upper White River Basin?

- Reduced spring and summer streamflow was identified as major contributors to algal blooms across years. Several other factors including water temperature, nutrients, and streambed stability also contribute to elevated benthic algal biomass.
- Streamflow and nutrient conditions have become more favorable to benthic algae over varying timescales.

Are algal blooms happening everywhere in the basin or do some sites have conditions that promote more algal biomass?

- Algal blooms occur on both the North Fork and the South Fork White River.
- Algae begin at locations where temperatures are warm enough to promote algal growth (about 13 degrees C).

Next Steps:

The Conservation Districts and the Technical Advisory Group (TAG) will contract with USGS again this year to collect algae, temperature, and nutrients at five sites to provide more data in an effort to verify the current findings and understanding of the algae in the White River.

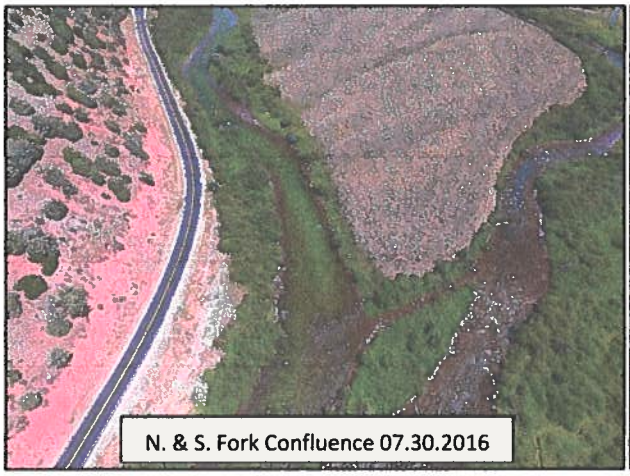
With a better understanding that reduced spring and summer streamflow are the major contributors to algal blooms and that the increase in phosphorus is region wide, Rio Blanco County citizens can rest assured there is not a point-source for the nutrients. However, water temperatures and nutrients are something that can be influenced through land management practices. Therefore, the Conservation Districts, landowners, and other entities can use this information to implement best management practices reducing nutrient inputs as well as improve riparian management practices that can also provide better shade

White River & Douglas Creek Conservation Districts

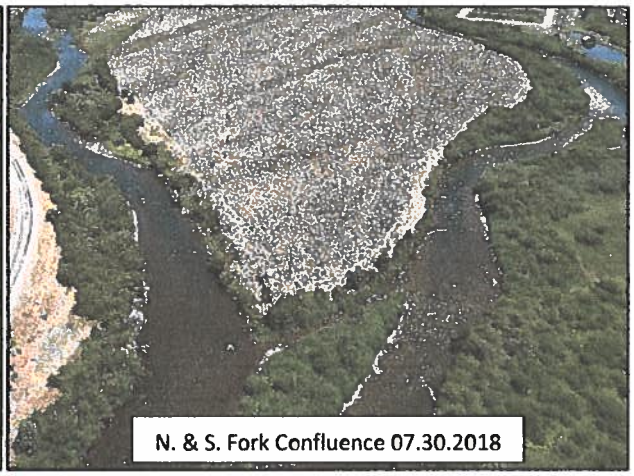
Promoting the wise use of all natural resources

Photos of the White River Algae Study 2018 - 2022

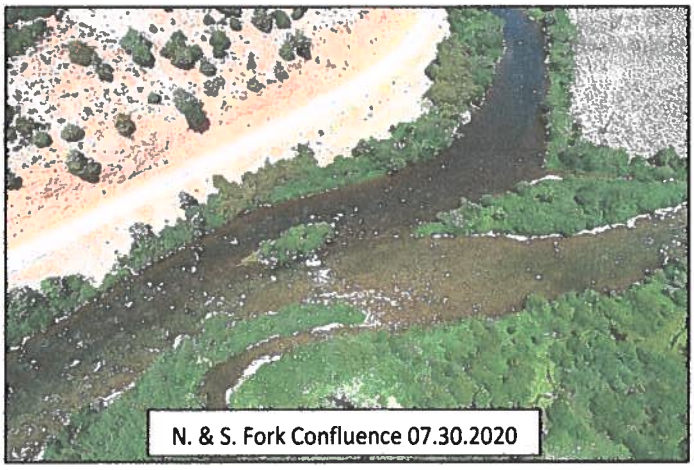
Drone Photos



N. & S. Fork Confluence 07.30.2016



N. & S. Fork Confluence 07.30.2018



N. & S. Fork Confluence 07.30.2020

P.O. Box 837 – Meeker - CO 81641 – Phone (970) 878-9838

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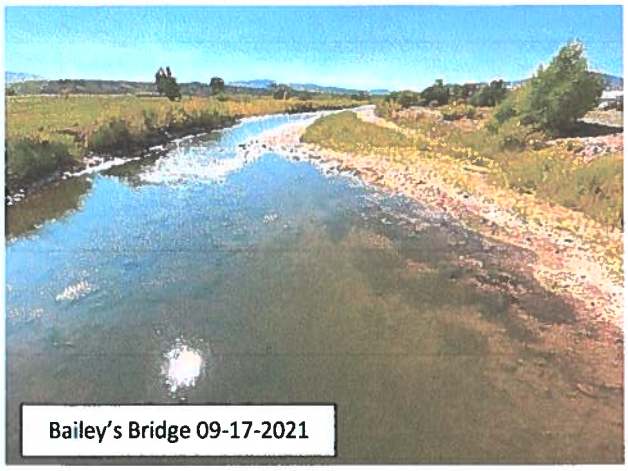
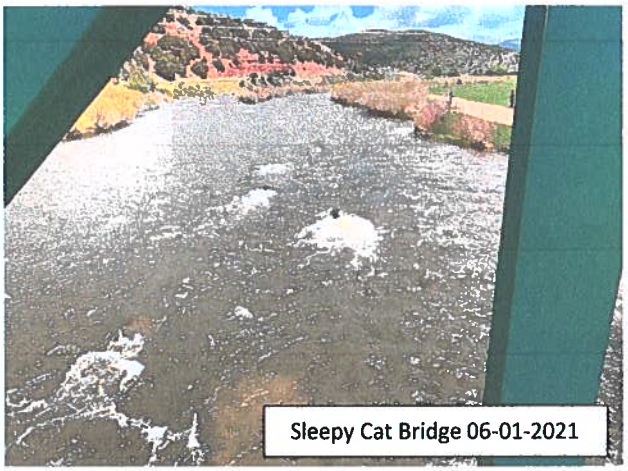
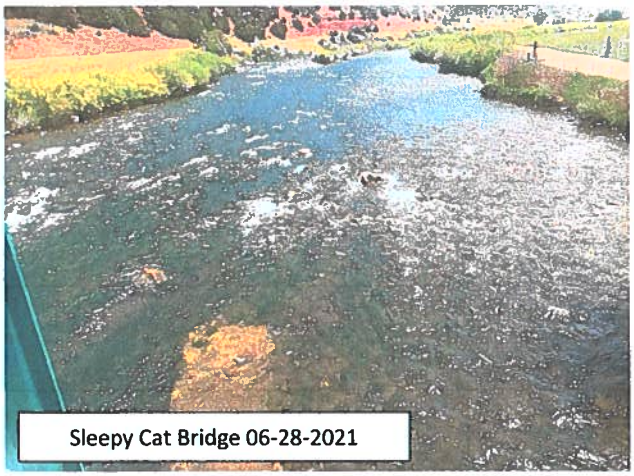
Volunteer River Photos

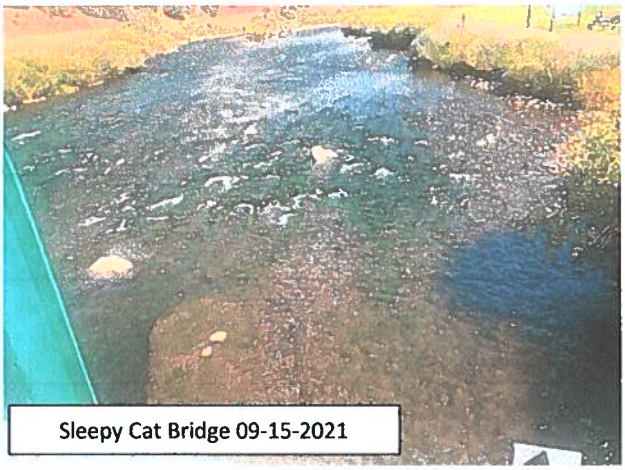

Bailey's Bridge 06-06-2021


Bailey's Bridge 06-27-2021


Bailey's Bridge 09-17-2021


Sleepy Cat Bridge 06-01-2021


Sleepy Cat Bridge 06-28-2021


Sleepy Cat Bridge 09-15-2021

P.O. Box 837 – Meeker - CO 81641 – Phone (970) 878-9838

White River & Douglas Creek Conservation Districts

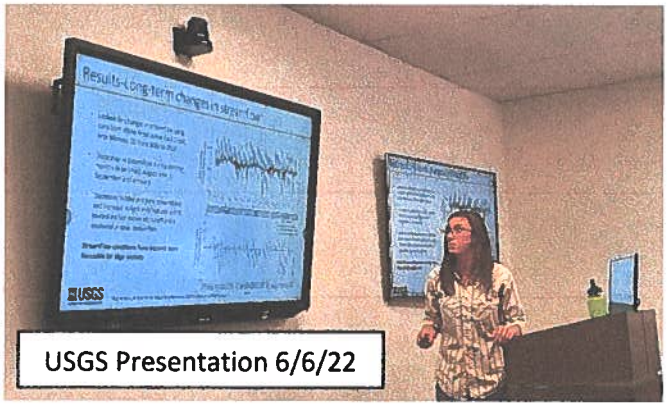
Promoting the wise use of all natural resources

Activity Photos

Scraping algae from river rocks in the White River PC: USGS

TAG Meeting 07-19-2018

USGS Presentation 6/6/22



USGS Presentation 6/6/22