White River Algae Technical Committee Workgroup Recommendations

3/13/18

The White River Algae Technical Committee was tasked with **ascertaining what is driving the algae growth in the White River to improve the overall health of the watershed.** To accomplish that, the Technical Committee worked with USGS over several months last fall/winter and then appointed a five-member Workgroup to sit down with USGS and refine the Scope of Work (SOW) to help find the drivers of the algae in the most cost effective and scientifically sound manner. The Workgroup's recommendation includes three years of data collection and will focus on the river above Meeker. It includes annual interim-results which will be considered before moving forward with the next year's research.

Below is a summary of their recommendations, much of which is pulled from the developing SOW. This summary will help the Rio Blanco County residents better understand the tasks and purpose of each task within the recommended scope of work.

Local observations and work done by Colorado Parks and Wildlife (2016) highlighted nuisance benthic algal productivity in the White River from the upper watershed downstream to Meeker, Colorado. The high levels of benthic algae have been reported to have developed recently (the last 3-5 years) and have caused problems with the aesthetic values and recreational use of some reaches of the White River, as well as accumulations of benthic algae at drinking-water intakes at Rangely, Colorado.

Understanding the occurrence and distribution of algae may lead to the conception of 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 (water depth and velocity, length of growing season, water quality, water temp, light conditions);
2) stream substrate (particle-size, mobility, and quality of bed sediments),
3) antecedent conditions of streamflow (scouring flows, timing of snowmelt, low-flow conditions, and nutrient storage) and
4) presence and abundance of macro-invertebrates.

The complexity of these factors can make it difficult to understand which processes are the most important controls on algal growth. As such, the developing scope of work is designed to address data-gaps previously identified by recent investigations.

The recommended approach will:

1) utilize cost-effective strategies to provide an improved understanding of what conditions are driving nuisance algae growth, and
2) standardize and expand 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 observation 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.

Study 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 mainstem of the White River.

Objective 1: Data mining and historical synthesis

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, but will expand and refine the analysis to include additional seasonal and flow-regime specific trends that have not been evaluated using the Weighted Regressions on Time Discharge and Season model within the Exploration and Graphics for RivEr Trends software. 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.

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

Stream Hydraulics and Channel Characteristics

Specific channel characteristic such as 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.

The Workgroup recommends having USGS 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. It is believed that 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 and will be compared to separate estimate of critical shear stress made form particle size information and cross-section surveys.

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.

Water-quality

Measurement of water-quality conditions within the mainstem of the White River will be collected prior to or during the onset, peak, and senescence 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 (total dissolved solids, nutrients, with a subset of locations including isotopes of nitrogen and oxygen). 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 identify different sources or nutrients in the White River, the Workgroup recommends the USGS proposal to analyze isotopic-signatures of oxygen and nitrogen from nitrate in various source materials and in the river. In this study, the stable isotopic signature of oxygen and nitrogen (in water as nitrate) will be evaluated to assess nutrient sources. Identification of typical nitrogen and oxygen isotopes in fish waste, artificial fertilizers, forest runoff, and animal and human waste will be done and a sensitivity analysis completed to test how distinct the signatures are from these differing sources by fall 2018.

If oxygen and nitrogen stable isotopes signatures are sufficiently distinct between multiple sources, stream water samples will be collected and analyzed from 6 of the 20 sites beginning in late 2018. Similarities in the isotopic signatures between water samples and distinct sources will be used to gage relative contributions of these sources. 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 NWISweb.

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.

- 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 semi-random sites. Constituent concentrations are the primary focus for this first analysis. 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 at this time. 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. This 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 pre-selected 20 sites. The low-flow sampling will be done during a period when streamflow variability is minimized. This will help in the comparison of nutrient mass at each site. If variability in streamflow 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. This analysis primarily is focused on assessing sources of nutrients but will be evaluated in the statistical analysis as well.

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 temp 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. 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 be done utilizing multivariate regression techniques. In this analysis, the data collection (described previously) provides a data set 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) to 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 BMP's to reduce algal growth. This approach simultaneously assess 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-results to the group, at least annually. The USGS will publish a technical document containing the methods and interpretive findings as a peer-reviewed Scientific Investigations Report (SIR) in 2021. This publication will serve as the primary product of this investigation. At the same time, an abbreviated version of the findings will also be published as a 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.