Powell River Project 2023-2024 Annual Research Report

Continued Long-term Assessment of Water Quality and Macroinvertebrate Communities Following Surface Coal Mining in Central Appalachian Headwater Streams (2024-2025)

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Introduction

Surface coal mining in central Appalachia has resulted in persistent alterations to water chemistry and benthic macroinvertebrate communities of headwater streams, highlighting the need for long-term monitoring. Our ongoing13-year study has focused on 24 (now 23) headwater streams across a salinity gradient, where we have assessed benthic macroinvertebrate communities and water chemistry parameters in fall and spring and have measured in situ specific conductance (SC; surrogate for salinity) at 30-minute intervals. Over the period of 2019-2024, with support from the Powell River Project (PRP), we added to this study by monitoring sub-daily water levels at 14 of these streams and conducting streamflow measurements at six streams; these data are being used to both account for flow-driven variation in water chemistry in long-term trend analysis and to quantify downstream loads of water chemistry constituents. Notably, by leveraging our long-term sites and accumulated data, our team was awarded a three-year National Science Foundation (NSF) grant to assess how altered water chemistry and macroinvertebrate communities may impact ecosystem-scale carbon dynamics, including primary productivity, decomposition, and food web dynamics.

In this reporting period, we continued long-term monitoring of water chemistry and macroinvertebrate communities and our more recent water level and flow measurements to assess local and downstream influences of surface coal mining. Further, PRP support helped us conduct site visits, field data collection, instrumentation maintenance, and laboratory analysis necessary to support our recent NSF work (initiated in March 2023). PRP funds were critically important in supporting sites and data presented in our NSF proposal and in allowing us to actively pursue continued study of headwater stream recovery after mining.

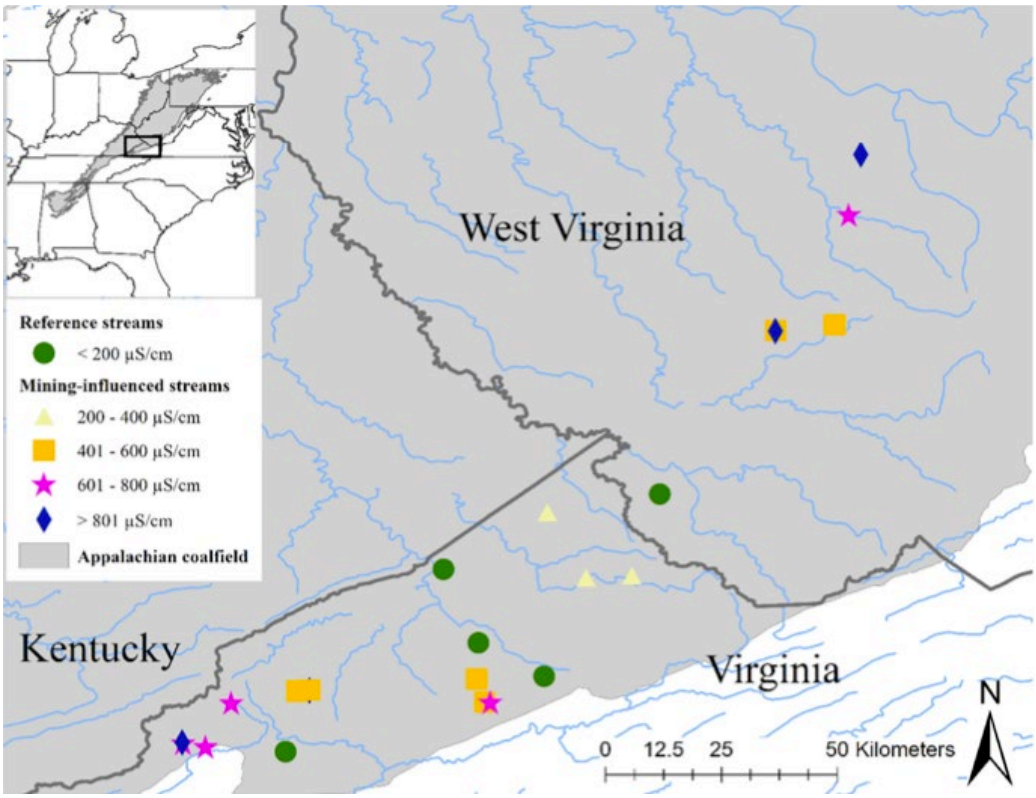

Figure 1. Location of 23 headwater streams used in this study (Cianciolo et al. 2020a).

Objectives

With continued PRP support, our interdisciplinary research group is assessing local and downstream water quality consequences of surface mining to headwater streams. During this reporting period, we addressed two objectives:

1. Expand temporal scope for high-frequency SC monitoring and seasonal sampling for benthic macroinvertebrates and synoptic water chemistry in 23 streams initiated in 2011.
2. Continue measurement of water level and streamflow to inform analyses of long-term trends in water quality and for quantification of downstream mass fluxes of major ions and trace elements.

Methods

Objective 1: Long-term Trends in Water Chemistry and Benthic Macroinvertebrate Communities

During this reporting period, we continued collection of water chemistry data and macroinvertebrate metrics at our 23 streams, which supports assessment of long-term stream recovery. In situ SC was recorded every 30 minutes using automated dataloggers (HOBO Freshwater Conductivity Data Logger, model U24-001, Onset Computer Corp., Bourne, Massachusetts) already installed within each stream. Grab samples of streamwater were collected in fall 2023 and spring 2024 to assess major ion and trace element concentrations. Vertically

mixed water was collected and immediately filtered through a 0.45-µm pore syringe filter into polyethylene sample bags for ion samples. The cation sample was preserved to pH < 2 with 50% ultrapure nitric acid (USEPA 1996). Samples were transported on ice to the laboratory, then stored at 4° C until analysis. Samples were analyzed for total dissolved solids (TDS) by evaporating streamwater to constant weight in a drying oven at 180° C (USEPA 1971). Total alkalinity was measured by titration of stream water samples with a prepared standard acid using a potentiometric auto-titrator (EasyPlus Titrator Easy pH, Mettler Toledo, Columbus, Ohio) (APHA 2005). Calculations of HCO_3^- were made from total alkalinity and pH measurements (APHA 2005). Samples were analyzed for major cations/trace elements by ICP-MS (Thermo iCAP-RQ) (UESPA 1996) and for SO_4^{2-} and Cl^- by ion chromatography (Dionex ICS 3000).

As we have done since 2011, benthic macroinvertebrates were sampled in fall 2023 and spring 2024 in 23 study streams using the semi-quantitative, single habitat (riffle-run) method established by the Virginia Department of Environmental Quality (VDEQ 2008), which is adapted from U.S. EPA Rapid Bioassessment Protocols (RBP; Barbour et al. 1999). Using a 0.3-m D-frame kicknet with 500-µm mesh, a single composite sample (approximately 2 m^2) composed of six approximately 1×0.3-m kicks was collected from separate riffles along a 100-m reach upstream of the SC datalogger. Samples were preserved in 95% ethanol and returned to the lab for sorting and identification. Macroinvertebrate samples were sub-sampled randomly to obtain a 200 (±10%) organism count following VDEQ biomonitoring protocols (VDEQ 2008). Specimens were identified to genus using standard keys (e.g., Merritt et al. 2008), except individuals in family Chironomidae and subclass Oligochaeta, which were identified at those levels.

Objective 2: Water Level and Streamflow Monitoring

During fall 2019, HOBO U20 water level dataloggers (6 matched by VWRRC, 8 purchased with previous PRP support) were installed across 14 of our 23 study streams to measure stream stage. Dataloggers were placed inside screened wells within each stream to record stage every 30 minutes. Additional dataloggers were installed in streamside areas to collect and account for local barometric pressure variation. During this project period, these streams were visited on two occasions to download data and maintain dataloggers.

Flow was measured multiple times (4-6 per site) at a subset of nine streams. Collectively, flow measurements (via salt tracer methods) at these nine sites will yield rating curves (relationships between flow and stage) and thus high-frequency (30-min) flow estimates. Such flow data will inform daily mass loading rates for major ions and trace elements, as well as support our NSF-focused measurements of stream metabolism.

Results and Discussion

In this reporting period, we continued our long-term monitoring of in situ SC and seasonal water chemistry and macroinvertebrate communities (Objective 1) and more recent water level monitoring and streamflow measurements (Objective 2). We collected and analyzed chemistry and macroinvertebrate samples across 23 study streams in fall 2023 and spring 2024. In addition, we downloaded and processed data from SC loggers at 23 streams and water level recorders at

14 streams. We also conducted 4-6 discharge measurements across nine streams; those data are now being used to construct rating curves to relate flow to water level time series data. All data have been processed and added to our long-term database to support ongoing long-term trend analyses. Further, these data are fundamental to our NSF project focused on nine sites, where SC, water level and flow patterns are predicted drivers of carbon processing. As such, the efforts from this reporting period efforts are critical to our continued assessment of long-term effects of mining on water quality, biota, and (now more recently) ecosystem processes.

Conclusions

With this PRP funding support, we i) conducted seasonal macroinvertebrate and water quality sampling to add to our long-term dataset and enable future long-term recovery assessments; ii) continued monitoring of SC, stage, and flow; and iii) complimented our recent NSF-funded project focused on effects to ecosystem carbon processing. Contributions of this work include:

- Using deployed instrumentation and two synoptic sampling events, we added to our long-term dataset for continued analysis of potential stream recovery following mining.
- We maintained stage recorders and conducted flow measurements; these resources will be leveraged for future funding and work to assess downstream mass export rates.
- Continued SC, stage, and flow monitoring will allow us to account for flow controls in future assessment of stream water chemistry recovery.
- We collected data and maintained equipment necessary for our NSF-funded project and to inform future proposals.
- We disseminated findings via a MS thesis, four presentations at the Society for Freshwater Science Annual Meeting, two publications in preparation, and a workshop at the UVA Wise Governor's School: From the Tree Tops to Groundwater.

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