GEI Consultants

Consulting Engineers and Scientists

2024 Aquatic Biological Monitoring Report for Gold Run Creek, South Dakota

March 2025

2024 Aquatic Biological Monitoring Report for Gold Run Creek, South Dakota

GEI Consultants

Consulting Engineers and Scientists

Submitted to:
Sanford Underground Research Facility
630 E. Summit Street
Lead, SD 57754

Submitted by:
GEI Consultants, Inc.
4601 DTC Boulevard, Suite 325
Denver, CO 80237

March 2025

Lee Bergstedt, Reviewer

Jenniffer Lynch, Project Manager

Table of Contents

List of Figures

List of Tables

List of Appendices

1. Introduction

Aquatic biological monitoring of Gold Run Creek and Whitewood Creek in the northern Black Hills, South Dakota began in 2009 for the Sanford Underground Research Facility (SURF). This site was formerly the Homestake underground gold mine and has been converted into an underground research laboratory. The SURF Wastewater Treatment Plant treats water from the dewatering of the underground laboratory and water from the historic Grizzly Gulch tailings impoundment. The treated water is discharged under National Pollutant Discharge Elimination System (NPDES) permit SD0000043 through Outfall 001 to Gold Run Creek.

Five sites were established in Gold Run and Whitewood creeks in 2009 by personnel from SURF and GEI Consultants, Inc. (GEI) to monitor the biological communities (Figure 1-1). Site locations are in accordance with the study plan developed for SURF (GEI 2009) and approved by the South Dakota Department of Agriculture and Natural Resources (SDDANR) and South Dakota Department of Game, Fish and Parks (SDDGFP). In 2009, data were collected at two control sites (sites WWC-A and GR-A) and the site furthest downstream from Outfall 001 (Site WWC-C) prior to initiation of discharge. These sites were selected to establish baseline data as they were the least likely to be affected by the discharge (Stan Michals, SDDGFP, personal communication). All five sites were sampled in 2010 through 2016.

In March 2017, SDDANR, along with SDDGFP, revised the biological monitoring sampling plan that had been used from 2009 through 2016. The revised changes were enacted for the 2017 sampling as a condition of the current NPDES permit. The revisions to the sampling plan required alterations to how certain data were analyzed; the habitat assessment method used; and the sites that continue to require monitoring. The revised sampling plan only requires monitoring at the two sites on Gold Run Creek. Until 2023, sampling continued at Site WWC-B on Whitewood Creek downstream of the confluence with Gold Run Creek at the discretion of SURF. In 2019 through 2023, control Site WWC-A on Whitewood Creek, upstream of the confluence with Gold Run Creek, was also sampled at the request of SURF. In 2024, SURF decided to not perform discretionary sampling on Whitewood Creek and only Gold Run Creek was sampled.

This report presents the sixteenth year of monitoring for Site GR-A, and the fifteenth year for Site GR-B. Habitat characterization and sampling of the fish, benthic invertebrate, and periphyton populations were conducted by GEI on August 19 - 20, 2024, at these two sites. The purpose of the continued monitoring on Gold Run Creek is to identify any potential effects on biological communities in Gold Run Creek resulting from discharge approved through the SURF NPDES permit. Specifically, biological data were collected and analyzed in the study areas to determine any potential short-term and/or long-term aquatic impairment.

In this report, data collected in 2024 are presented and compared to data collected since 2009 (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024).

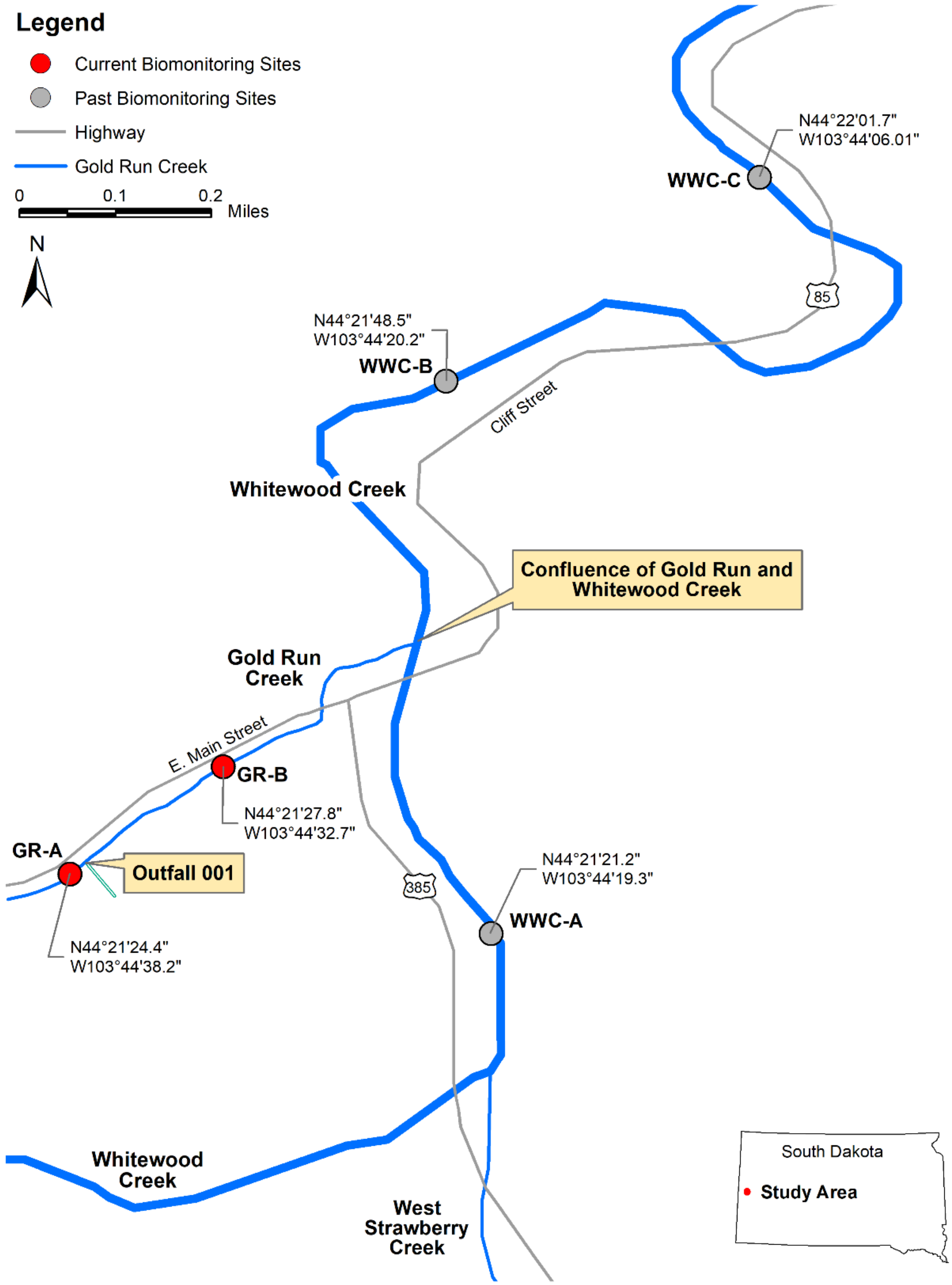

Figure 1-1: Current and past aquatic biological monitoring sites on Gold Run Creek and Whitewood Creek, respectively, near Lead and Deadwood, South Dakota. GPS coordinates were collected at downstream site boundaries.

2. Study Area

The study area is located in the northern Black Hills in the Middle Rockies Ecoregion (Omernik 1987; Omernik and Gallant 1987) near Lead and Deadwood, South Dakota. Five study sites were established in total on Gold Run and Whitewood creeks in 2009 as part of the aquatic biological monitoring program. (Figure 1-1). Two sites, located upstream and downstream of the SURF NPDES permitted Outfall 001, were established on Gold Run Creek. Three sites were established on Whitewood Creek: one upstream and two downstream of the confluence with Gold Run Creek. Specific sites on each stream were chosen in the field with consultation from SURF (John Scheetz, personal communication) and approved by SDDGFP. Individual sites were representative of the sampling reach with respect to habitat features and stream morphology.

In 2017, the study plan used from 2009 through 2016 was revised by the SDDANR and SDDGFP. The revised study plan directs sites GR-A and GR-B on Gold Run Creek to be monitored for potential effects from the Outfall 001 discharge. No biological monitoring is required on Whitewood Creek. However, SURF elected to perform biological monitoring at Site WWC-B on Whitewood Creek in 2017 and 2018 in addition to the two Gold Run sites. In 2019 through 2023, both Site WWC-A and Site WWC-B were monitored along with the two Gold Run sites to provide a more robust data set describing the aquatic biological community in Whitewood Creek.

2.1 Current Sites

2.1.1 Gold Run Creek

Gold Run Creek is a relatively steep, first order stream for most of its length. It flows northeast from the city of Lead to its confluence with Whitewood Creek at an elevation of approximately 1,430 m. The city of Lead and the former Homestake Mine mill area comprise the headwaters of Gold Run Creek and SURF's Outfall 001 discharges into Gold Run Creek below the reclaimed mill area. Locations of the study sites (Figure 1-1) are described below.

GR-A This site is located on Gold Run Creek at an elevation of 1,461 m, approximately 0.6 km upstream of the confluence with Whitewood Creek and acts as a control site for the downstream site. The bottom of this site is located approximately 10 m upstream of Outfall 001. GPS coordinates for the bottom and top of this site are N44° 21' 24.4", W103° 44' 38.2" and N44° 21' 21.8", W103° 44' 40.9", respectively.

GR-B This site is located on Gold Run Creek at an elevation of 1,453 m, approximately 0.4 km upstream of the confluence with Whitewood Creek and downstream of Outfall 001. The downstream end of this site is located adjacent to the

Deadwood/Custer road sign. Approximate GPS coordinates for the bottom and top of this site are N44° 21’ 27.8” and W103° 44’ 32.7”, respectively.

2.2 Past Sampling Sites

2.2.1 Whitewood Creek

Site WWC-C on Whitewood Creek (Figure 1-1) was discontinued from the biological monitoring plan in 2017, and sampling at sites WWC-A and WWC-B were discontinued in 2024. The past Whitewood Creek sites are described here for historical reference.

Whitewood Creek originates in the northern Black Hills of South Dakota and flows northeast into the Belle Fourche River. The confluence of Whitewood Creek with the Belle Fourche River is approximately 24 kilometers (km) northeast of Spearfish, South Dakota. Mean monthly discharge of Whitewood Creek (US Geological Survey [USGS] Gage 06436180) near the study sites is highest from April through June when average flows ranged from 52 to 91 cubic feet per second (cfs) from 2010 through 2024, and in the remaining months, average flow ranges between 8 and 26 cfs (USGS 2024). Within the study area, Whitewood Creek is a third order stream. The location of the three past study sites on this stream (Figure 1-1) are described below.

WWC-A This site is located on Whitewood Creek at an elevation of 1,446 meters (m), approximately 0.6 km upstream of Gold Run Creek. The bottom of this site is located just upstream of the foot bridge for the Mickelson Trail and the top of the site is located adjacent to an old United States Geological Survey (USGS) staff gage. GPS coordinates for the bottom and top of this site are N44° 21’21.2”, W103° 44’ 19.3” and N44° 21’ 18.2”, W103° 44’ 17.7”, respectively.

WWC-B This site is located on Whitewood Creek at an elevation of 1,425 m, approximately 0.6 km downstream of the confluence with Gold Run Creek and just below NPDES Monitoring Site MTL-2. This site is located across from the Thunder Cove Inn. Approximate GPS coordinates for the bottom and top of this site are N44° 21’ 48.2’, W103° 44’ 20.2’ and N44° 21’ 48.2’, W103° 44’ 25.4’, respectively.

WWC-C This site is located on Whitewood Creek at an elevation of 1,408 m, approximately 1.8 km downstream of the confluence with Gold Run Creek. The bottom of this site is located adjacent to Claim Jumper’s storage units and the top of the site is located adjacent to the corner of the Super 8 building. GPS coordinates for the bottom and top of this site are N44° 22’ 01.7”, W103° 44’ 06.1” and N44° 21’ 59.3”, W103° 44’ 03.1, respectively.

3. Methods

3.1 Habitat Assessment

Physical habitat data were collected at the study sites on August 19 and 20, 2024. Sites were surveyed with a standardized habitat measurement protocol that has been used during monitoring since 2009 and includes parameters measured by the U.S. Forest Service (Platts et al. 1983; Overton et al. 1997). Pursuant to the monitoring plan approved in 2017, the U.S. Environmental Protection Agency (EPA) Environmental Monitoring and Assessment Program (EMAP) habitat survey method (SDDANR 2005) performed in previous years was not performed in 2019 through 2024 and is not scheduled to be performed in the future.

Each habitat attribute was measured throughout the entire unit or at a representative transect within the habitat unit. Flow measurements were taken at each site by GEI. The following parameters were measured in each habitat unit over the entire length of the monitoring site.

1. **Habitat type** – type of riffle, run, or pool for each habitat unit.
2. **Channel width** – water width plus width of left and right banks at each transect.
3. **Water width** – width of the water surface measured at each transect.
4. **Average water depth** – measured at 25, 50, and 75 percent of the water width at each transect.
5. **Maximum water depth** – deepest point within each habitat unit.
6. **Water velocity** – measurements collected at 25, 50, and 75 percent of the water width along each transect.
7. **Eroding streambank** – percent of eroding streambank along each bank for entire length of each habitat unit.
8. **Streambank vegetation** – describes dominant streambank vegetation at the transect.
9. **Streambank cover** – visual estimate of percentage of streambank covered by different vegetation types, along entire length of each habitat unit.
10. **Streambank angle** – rating of whether streambank is sloping, vertical, or undercut at the transect.
11. **Streambank undercut** – depth of undercut bank for each bank at the transect.
12. **Vegetation overhang** – measurement taken along each transect of vegetation overhanging water column which provides fish cover.
13. **Percent surface fines** – substrate measurement based on a grid sampling device, as described in Overton et al. (1997). Measurements are collected at three or more individual locations in each habitat unit.
14. **Substrate composition** – visual estimate of the percent of the stream bottom covered by bedrock, boulder, cobble, gravel, and coarse or fine sediment substrate in each habitat unit.

The percent surface fines metric provides an accurate estimate of the amount of fine substrate in fast water portions of habitat units, such as pool tails and riffles and usually closer to the middle of the channel and away from the slower areas near the bank. The focus on these fast water areas provides an estimate of how much fine sediment is present in areas where fish might spawn and areas that provide the most suitable habitat for macroinvertebrates. The substrate composition metric focuses on substrate throughout the habitat unit, including slow-flow areas near the bank.

3.2 Fish Populations

Fish populations were sampled at both sites on August 19 and 20, 2024. At the two sites on Gold Run Creek, where fish have not historically been found, only a single electrofishing pass was conducted to confirm that these sites remain unpopulated by fish. Population estimates based on electrofishing depletion rates assume no immigration into or emigration out of the site during sampling. Therefore, the upper and lower boundaries at each sampling site were placed at natural barriers such as small waterfalls, steep riffles, or a block net was used at the upstream and/or downstream ends of the reach to prevent fish, if present, from moving into or out of the site until sampling was complete and the nets were removed. No fish have been present on Gold Run Creek during biological monitoring since sampling began in 2009. Fish have been present in Whitewood Creek. This report does not include fish population and fish tissue data and analyses from Whitewood Creek, these data are available from previous GEI reports (GEI 2009, 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024).

3.3 Benthic Macroinvertebrate Populations

Benthic invertebrate samples were collected at both sites on Gold Run Creek on August 19 and 20, 2024, using SDDANR (2017) sampling protocols (Peck et al 2006). Using this protocol, an area of 1 ft^2 (0.09 m^2) was sampled with a kick net (500 micrometer [µm] mesh size) at 11 transects, determined before other sampling or survey activities were conducted, as to eliminate disturbance to invertebrate sampling locations. At each transect, one sample was collected at 25, 50, or 75 percent of the wetted width from the bank on a rotating basis. In erosional habitat, loose rocks and large (large cobble) and finer substrates (small cobble, gravel, and smaller) were kicked vigorously for 30 seconds to dislodge organisms into the net. In depositional habitats, the same techniques were used, except that the net was dragged through the standing water within the 0.09 m^2 area to capture suspended benthic organisms. Samples from the eleven transects were combined into a single, composite sample of 11 square feet (ft^2; approximately 1.0 m^2) for each site.

Collected samples were transferred to individual sample containers and preserved in the field using 95 percent ethanol. Each labeled sample container was submitted to the GEI laboratory, where organisms were sorted from debris, identified, and counted. For quality assurance, all samples were checked by a quality assurance officer or macroinvertebrate lab manager to ensure completeness.

The sorted specimens were identified to the lowest practical taxonomic level (usually species), depending on the age and condition of each specimen (Lenat and Resh 2001) and counted. Quality assurance for identifications and counts (Whittaker 1975; Stribling et al. 2003) was conducted randomly on one of the four samples. The quality assessment target is 95 percent similarity, and taxonomic and count accuracy in 2024 was 97 percent.

Oligochaetes were mounted on glass slides prior to identification, and chironomids were identified under a dissecting microscope. Chironomid larvae and oligochaetes were identified and counted by GEI personnel. All organisms were identified in samples with small numbers of chironomids or oligochaetes (i.e., <30 individuals/sample). Samples with greater than 30 organisms/sample were randomly subsampled prior to identification (minimum of 30 individuals each, generally 50 to 60 individuals). Quality assurance checks for identification were not made on Chironomidae or Oligochaeta.

These analyses provided species lists, estimates of relative abundance (number of organisms/sample), and percent abundance of each taxon (as percent of total abundance). The data was used to calculate the invertebrate metrics described below.

3.3.1 Metric Calculations

Many metrics are available for evaluating benthic macroinvertebrate populations with most belonging to one of five categories: richness, composition, tolerance, trophic habits, and life history. In 2017, the SDDANR provided a revised list of requested metrics for reporting under the current NPDES permit (Table 3-1). In addition to the SDDANR requested metrics, the macroinvertebrate density and number of taxa are also provided for each site.

3.3.1.1 Richness Metrics

Four metrics were calculated for richness: density, total number of taxa, number of EPT taxa, and number of Plecoptera Taxa (Table 3-1). The total number of taxa is commonly used to represent invertebrate species richness at a site and higher richness usually indicates better water quality. In mountain streams, such as those in the northern Black Hills, the presence of mayfly (Ephemeroptera), stonefly (Plecoptera), and caddisfly (Trichoptera) taxa (collectively referred to as the EPT taxa) are generally an indicator of good water quality because these insect taxa are considered to be sensitive to a wide range of pollutants (Hynes 1970; Wiederholm 1984; Klemm et al. 1990; Barbour et al. 1999; Merritt et al. 2008). The number of taxa and the number of EPT taxa would be expected to be higher in unimpacted sites than in impacted sites. However, in some cases, the number of taxa can increase due to increases in the number of non-insect taxa or to tolerant insect taxa which indicate poor water quality. Therefore, changes in the number of taxa were also evaluated with respect to species composition. Plecoptera tolerate a narrow range of fluctuation in environmental conditions, and apparently minor changes may affect compensating alterations in species composition, abundance, and distribution (EPA 1978). The number of Plecoptera taxa are expected to be higher in unimpacted sites than in impacted sites.

Table 3-1: Summary of benthic macroinvertebrate metrics calculated for data from Gold Run Creek, South Dakota.

Metric	Type of Metric	Definition	Change Expected Following Environmental Disturbance
Density	Richness	Total abundance of invertebrates (#/sample)	Decrease
Number of Taxa	Richness	Number of distinct taxa	Usually Decrease
Number of EPT Taxa	Richness	Number of taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT)	Decrease
Number of Plecoptera Taxa	Richness	Number of the taxa in the order Plecoptera	Decrease
Percent Sensitive EPT Taxa	Composition	Percent taxa comprised of EPTs with tolerance values between 0 and 4	Decrease
Percent Dominant Taxon	Composition	Relative abundance of the most abundant taxon	Increase
Percent of non-*Baetis* Ephemeroptera	Composition	Proportion of Ephemeroptera density not in the genus *Baetis*	Decrease
Percent of Oligochaeta and Hirudinea	Composition	Relative abundance of Oligochaeta and Hirudinea	Increase
Hilsenhoff Biotic Index (HBI)	Tolerance	Abundance-weighted average of the tolerance values.	Increase
Percent Intolerant Taxa	Tolerance	Percent taxa comprised of taxa with tolerance values ranging from 0 to 4	Decrease
Number of Intolerant Taxa	Tolerance	Number of taxa with tolerance values ranging from 0 to 4	Decrease
Number of Shredder Taxa	Trophic Habit	Number of taxa belonging to this functional feeding group	Decrease
Percent Collector-Gatherers	Trophic Habit	Relative abundance belonging to this functional feeding group	Variable
Number of Semivoltine Taxa	Life History	Number of taxa classified as having a semivoltine (longer than 1 year) life history	Decrease
Percent of Semivoltine Taxa	Life History	Percent of taxa classified as having a semivoltine (longer than 1 year) life history	Decrease
Number of Univoltine Taxa	Life History	Number of taxa classified as having a univoltine (shorter than 1 year) life history	Increase

3.3.1.2 Composition Metrics

Four composition metrics were evaluated in this study: the percent of sensitive EPT taxa, dominant taxa, percent of non-*Baetis* Ephemeroptera, and percent of Oligochaeta and Hirudinea (Table 3-1). The percent of sensitive EPT taxa was calculated as the number of sensitive EPT taxa divided by the total number of taxa and multiplied by 100. Sensitive EPT taxa were defined as those with tolerance values of 0, 1, 2, 3, or 4. The derivation of tolerance values is discussed in the following section on Tolerance Metrics. The percent of sensitive EPT taxa is expected to be higher in unimpacted sites because these more sensitive organisms cannot survive in disturbed environments (Wiederholm 1984; Klemm et al. 1990; Barbour et al. 1999).

The percent of the dominant taxon metric is an indicator of the diversity of the macroinvertebrate community. A diverse community contains a well-distributed relative abundance of many taxa, where a single taxon does not comprise the majority of the abundance. Stable and healthy macroinvertebrate communities contain a diverse number of taxa and intolerant taxa. A high percentage of the dominant taxon reflects an unbalanced community and is likely to increase with an increase in environmental disturbance.

The percent of non-*Baetis* Ephemeroptera metric is calculated by dividing the density of all mayflies except for those in the genus *Baetis* by the total density of Ephemeroptera. The mayfly family Baetidae includes species with a wide range of tolerance values, but *Baetis* species in general are more tolerant than the non-*Baetis* Ephemeroptera species. The non-*Baetis* Ephemeroptera metric provides similar ecological assessment to the number of EPT taxa richness metric. The percent of non-*Baetis* Ephemeroptera is expected to decrease in environments with disturbance.

The percent of Oligochaeta and Hirudinea metric is an indicator of habitat and water quality. There is an increasing percentage of Oligochaeta and Hirudinea as habitat quality decreases (Wilkens et al. 2016). A high relative abundance of Oligochaeta and Hirudinea may be an indicator of the presence of organic pollution, sedimentation, and disturbed habitat.

3.3.1.3 Tolerance Metrics

Three metrics were calculated for tolerance: The Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), percent intolerant (or sensitive) taxa, and number of intolerant taxa (Table 3-1). The HBI was originally designed to gauge the effects of nutrient pollution. The Idaho Department of Environmental Quality compiled a set of updated values in the Northwest Regional Tolerance Value database (Appendix B of Barbour et al. 1999). These updated values measure sensitivities to general environmental stress (Grafe 2002). Although multiple tolerance databases are available (Barbour et al. 1999), benthic invertebrate communities in the northern Black Hills have the most taxa in common with the communities used to develop the Northwest Regional Tolerance Value database. The updated tolerance values range from 0 (sensitive, intolerant organisms) to 10 (highly tolerant organisms) and were assigned to each identified taxon by GEI. If an identified taxon was not listed in Appendix B of Barbour et al. (1999) or a tolerance value was not given for that taxon, best available literature was used by GEI to determine a tolerance value. The final HBI value is an abundance-weighted average of the tolerance values. The HBI is expected to be higher at impacted sites since the community would be comprised of more tolerant (higher scoring) organisms.

Hilsenhoff Biotic Index scores were also rated. Invertebrate communities with scores of 0.00 - 3.50 are considered “Excellent,” 3.51 - 4.50 are considered “Very Good,” 4.51 - 5.50 are considered “Good,” 5.51 - 6.50 are considered “Fair,” 6.51 - 7.50 are considered “Fairly Poor,” 7.51 - 8.50 are considered “Poor,” and 8.51 - 10.00 are considered “Very Poor” (Hilsenhoff 1987). HBI values and ratings were compared between sites to determine whether non-control sites showed indications of environmental stress absent at the control sites.

The proportion and number of taxa in the community composed of intolerant taxa were also used to evaluate community sensitivity to environmental stress. Tolerant taxa are defined as those which have been assigned tolerance values of 7, 8, 9, or 10. Intolerant taxa are those that have been assigned values of 0, 1, 2, 3, or 4. Stressed sites tend to support communities dominated by tolerant taxa (Barbour et al. 1999; Grafe 2002), so the percentage and number of intolerant taxa tend to decrease with increasing environmental stress. The percentage and number of intolerant taxa were evaluated at each site to determine whether individual sites showed signs of environmental stress.

3.3.1.4 Trophic Habit Metrics

Trophic habits and functional feeding groups (e.g., predators, collector-gatherers, shredders, etc.) were determined for each taxon based on Merritt et al. (2008). Number of shredder taxa is a measure of the trophic stability of a stream (Shearer 2006). Impacts to a stream’s riparian area that directly alter allochthonous inputs (e.g., leaves, twigs, grasses) would have a direct impact on the trophic structure of the associated macroinvertebrate community (Shearer 2006). A disturbed riparian habitat and an increase in environmental stress in the vicinity of and upstream of a site may decrease the allochthonous vegetative material available in the stream and result in a community with a diminished number of shredder taxa.

Fine particulate organic matter is the primary food source of collector-gatherers, and their relative abundance can indicate disturbances associated with sedimentation and/or nutrient enrichment (Hargett 2011). These species tolerate a wider range of conditions. They are generalist feeders and can adjust to a broader range of food materials than specialist feeders. Disturbances that increase organic matter in the stream, such as nutrient enrichment, may result in a community shift favoring high relative abundance of collector-gatherers (Hargett 2011). However, physical disturbances, such as increased sedimentation, can reduce these species.

3.3.1.5 Life History Metrics

The number of taxa and percent of taxa characterized as having a semivoltine life history, and number of taxa characterized as having a univoltine life history were calculated. Semivoltine taxa require more than one year to complete a generation, and short-term disruptions in suitable aquatic conditions, either chemical or physical, can reduce the number of taxa with this life history trait. For this metric, the number of merovoltine taxa which require three or more years to complete their life cycle were also included in the semivoltine calculation.

The number of univoltine taxa, taxa that complete one life history cycle in one year, can be expected to supplant semivoltine taxa as environmental disturbance increases. As anthropogenic stressors increase, a community shift towards taxa with short life histories that develop multiple generations in a year are favored. The presence of longer-lived macroinvertebrates indicates a permanence of suitable habitat (Shearer 2006).

3.4 Periphyton Populations

Periphyton samples were collected at both monitoring sites on August 19 and 20, 2024, using SDDANR (2005) protocols, following EMAP procedures described in Peck et al. (2006). Using this protocol, an area of 12 square centimeters (cm) was sampled at each of the 11 transects delineated during the habitat assessment. As with the macroinvertebrate samples, one sample was collected from each transect from a point 25, 50, or 75 percent of the wetted width from the bank, on a rotating basis determined by random assignment at the first transect, similar to that for macroinvertebrates. In erosional habitats, a piece of substrate was selected and scrubbed with a stiff-bristled toothbrush for 30 seconds, and the dislodged periphyton was washed into a 500 milliliter (mL) plastic collection bottle. In depositional habitats, the top 1 cm of sediment was collected with a 60-mL syringe and added to the 500-mL plastic collection bottle.

The 11 periphyton samples were combined to create a single “reach-wide” composite sample for the site, and this composite sample was brought up to a total of 500 ml. After thorough mixing, a 50-mL aliquot was removed for taxonomic identification and enumeration and preserved with Lugol’s solution. A second aliquot of 25 mL was filtered onto a Whatman GF/F filter for chlorophyll *a* determination and stored wrapped in foil in the dark on dry ice to prevent exposure to light. A third aliquot of 25 mL for biomass determination was filtered onto a pre-combusted Whatman GF/F filter for ash-free dry mass (AFDM) determination.

All samples were labeled with the site name, sample type, and date, and samples were submitted to the GEI laboratory. Samples for identification and enumeration were sent to Aquatic Analysts (White Salmon, WA) or similar laboratory for processing. Samples for chlorophyll-*a* and AFDW were processed by GEI. Filamentous algae are not targeted in sample analysis, but visual observations are recorded for comparison over time.

3.5 Metric Calculations

Similar to the benthic macroinvertebrate data, metrics that described species richness, community composition, and tolerance of individual taxa were calculated for periphyton data (Table 3-2).

Table 3-2: Summary of periphyton metrics calculated for data from Gold Run Creek, South Dakota.

Metric	Type of Metric	Definition	Change Expected Following Environmental Disturbance
Relative Density	Richness	Percent density of individual periphyton divisions (#/mm^2)	Decrease
Total Density	Richness	Total density of all periphyton divisions (#/mm^2)	Decrease
Number of Taxa	Richness	Total number of taxa	Decrease
Number of Diatom Taxa	Richness	Number of diatom taxa	Decrease
Number of Genera	Richness	Total number of genera	Decrease
Number of Divisions	Richness	Total number of divisions	Decrease
Shannon–Weaver Diversity Index for Diatoms	Composition	The extent that density is spread among a wide number of species.	Decrease
Autotrophic Index (AI)	Composition	Ash free dry weight / chlorophyll *a*	Increase
Autecological Classes of Diatoms • Eutrophic • Acidophilic • Alkaliphilic • Nitrogen Heterotrophs • High Oxygen • Motile • Saprobic	Composition	Percent density of the autecological classes of diatoms	Variable
Diatom Tolerance Values	Tolerance	Percent density of diatoms belonging to the three Classes: (1) tolerant, (2) less tolerant, and (3) sensitive	Increase in Class 1, decrease in Class 3
Lange-Bertalot Pollution Tolerance Index	Tolerance	Weighted average of the relative abundance of each taxon multiplied by its pollution tolerance value	Decrease

3.5.1.1 Richness Metrics

The richness metrics calculated were the relative density and total density of periphyton, total number of taxa and of diatom taxa, and the number of genera and divisions (Table 3-2). The relative and total density represents the overall abundance of the different periphyton divisions. The total number of taxa represents the biological diversity at a given site. This measure includes taxa from all algal divisions that are large enough to see or identify during routine identifications. Diatoms (Bacillariophyceae) are generally larger, have a more resilient physical structure, and have a more stable taxonomy (Patrick and Reimer 1966, 1975; Wehr and Sheath 2003). Therefore, the total number of taxa and the total number of diatom taxa were calculated separately. The number of genera and number of divisions was also calculated to further define the biological diversity at a given site. All richness metrics would be expected to decrease with increasing disturbance or stresses to the periphyton community.

3.5.1.2 Composition Metrics

The following three composition metrics were calculated: the Shannon-Weaver Diversity Index (H'), the Autotrophic Index (AI), and the Autecological Classes of Diatoms (Table 3-2). The Shannon-Weaver Diversity Index was calculated for diatom data using the same formula as for benthic invertebrates. This index is considered to be sensitive to changes in water quality (Barbour et al. 1999), but its utility is lessened if total number of diatom taxa is less than ten (Barbour et al. 1999). The Shannon-Weaver Diversity Index for diatoms was calculated for each site.

The Autotrophic Index (AI) is calculated by dividing the AFDW value by the Chlorophyll *a* value and is used to indicate proportions of the community composed of either heterotrophic (outside sources of organic matter, such as leaf litter) or autotrophic (in-stream sources such as periphyton) material. Communities less disturbed by organic pollution and dominated by algae usually contain AI values ranging from 50-100. Values greater than 400 indicate communities affected by organic pollution.

The autecology classes of diatoms are a classification system that groups diatom taxa into the classes as outlined by Fore and Grafe (2002). The percent of diatom density for each class at each site were classified into the following attribute categories: eutrophic, acidophilic, alkaliphilic, nitrogen heterotrophic, high oxygen, motile, and saprobic. The density of eutrophic, saprobic, and nitrogen heterotrophic diatoms is expected to increase with an increase in inorganic and organic nutrients (Fore and Grafe 2002). Acidophilic diatom density is expected to increase with an increase in acidity and are indicators of acid-mine waste. Alkaliphilic diatoms density is expected to increase with an increase in agricultural disturbances since agricultural practices tend to produce alkaline salts and residues (Fore and Grafe 2002). The density of the high oxygen autecology class is indicative of organic matter and decreases oxygen concentration in the stream (Fore and Grafe 2002).

Motile diatom density is expected to increase with an increase in anthropogenic disturbance that increases the siltation of a stream. Diatoms in the genera *Navicula*, *Nitzschia*, and *Surirella* can move upwards through sediment if they are covered by silt (Wehr and Sheath 2003). Because of this ability, the combined relative abundance of these three motile diatom taxa is generally expected to reflect the amount and frequency of siltation at a site (Barbour et al. 1999). Therefore, the percent of motile diatoms is a surrogate siltation index and was calculated from the data for each site as the sum of the relative abundances of the three motile genera. The percent motile diatoms metric is expected to be higher at sites with more silt.

3.5.1.3 Tolerance Metrics

Tolerance values are based on values in Bahls (1993), which incorporated previously published tolerance values (Lange-Bertalot 1979) with changes and additions based on ecological preferences in Lowe (1974). The scale ranges from 1 to 3, where a value of 1 is assigned to the most pollution-tolerant taxa, 2 to less tolerant taxa, and 3 to sensitive taxa. The diatom tolerance values metric calculated the relative abundance of periphyton in each of the three tolerance groups for each site and is especially important in smaller-order streams where primary productivity and periphyton density may be naturally low (Barbour et al. 1999). The Lange-Bertalot Pollution Tolerance Index is the weighted average of the relative abundance of the taxa in each tolerance group. This metric is expected to be lower in degraded streams with fewer sensitive taxa (tolerance value of 3) and more tolerant taxa (tolerance value of 1). The index scores are rated according to Bahls (1993) as No Organic Enrichment (>2.50), Minor Organic Enrichment (2.01 to 2.50), Moderate Organic Enrichment (1.50 to 2.00), and Severe Organic Enrichment (<1.50).

3.6 Water Quality Monitoring

Water quality samples were collected at both biological monitoring sites by SURF personnel on August 26, 2024. Results are included in Appendix C for reference.

3.7 Data Analyses

Habitat data were summarized, analyzed, and interpreted with regards to possible impacts from Outfall 001. When appropriate, fish, benthic macroinvertebrate, and periphyton community data were referenced with stream habitat and flow data to explain variations in the biotic community. Results from 2024 were compared to those from 2009 through 2023.

A single benthic macroinvertebrate sample was collected from each site in 2024. As statistical analysis cannot be conducted with a single value per site, metric values between the two sites in 2024 were compared qualitatively between the upstream control site, Site GR-A, and the site downstream of Outfall 001, Site GR-B.

Differences between sites over the study period in long-term mean values for macroinvertebrate abundance, total number of taxa, number of EPT taxa, percent sensitive EPT taxa, HBI, and percent intolerant taxa were compared and identified statistically using Analysis of Variance (ANOVA) comparisons. Within each site, these macroinvertebrate metrics were compared from 2009 (or 2010) through 2024 to identify any temporal patterns in the macroinvertebrate community. Linear regression analyses were utilized for this purpose to determine if metric values were increasing, decreasing, or remaining stable over time. If macroinvertebrate data did not meet the assumptions of parametric tests (i.e., normal distribution and equal variance), nonparametric statistical methods were used to analyze the data. The parametric and nonparametric tests produced p-values which were considered significant when compared to an $\alpha = 0.05$ level.

Similarly, periphyton samples consisted of one composite sample at each site, so statistical tests comparing 2024 data among sites are not feasible. Therefore, periphyton metrics calculated in 2024 were compared qualitatively among sites. Within each site, periphyton density and number of taxa metrics were compared from 2009 (or 2010) through 2024 to identify any temporal trends in the periphyton community. Long-term differences in means for periphyton density, number of taxa, and Shannon-Weaver Diversity values were identified statistically between sites using ANOVA comparisons. Linear regression analyses were also conducted for these metrics. The remaining metrics were not analyzed statistically as many were added recently using the revised study plan and long-term datasets are lacking.

4. Results and Discussion

4.1 Habitat Assessment

Low-gradient riffles and step runs were the most common habitat types among the Gold Run Creek sites in 2024 (Table 4-1). In addition, Site GR-A had two types of pools present and a single cascade, while Site GR-B had a step pool complex and a run during the 2024 surveys.

Table 4-1: Habitat characteristics for sites on Gold Run Creek, August 2024. LGR = low gradient riffle; RUN = run; SRN = step run; SPB = plunge pool formed by boulders, SPR = plunge pool formed by bedrock; STP = step pool complex; and CAS = cascade.

Site/Habitat Type	Number of Units	Total Length (m)	Average Water Width (m)	Average Depth (cm)
Site GR-A				
LGR	1	5.2	1.3	9
SRN	4	58.0	1.6	14
SPB	1	7.4	1.8	23
SPR	1	8.0	2.7	47
CAS	1	6.4	0.8	6
Site GR-B				
LGR	2	40.7	2.8	17
RUN	1	23.3	3.6	15
SRN	2	28.0	2.9	19
STP	1	23.3	3.6	15

Pools found at the study sites in 2024 were formed by bedrock and boulders. Diversity of habitat can increase the suitability of sites for both macroinvertebrates and fish, and pools function as valuable habitat during low flow periods when temperature extremes can occur, such as late summer and winter. Pools also provide shelter from terrestrial predators.

Habitat characteristics varied among the study sites (Table 4-1). The Gold Run Creek sites generally had narrow wetted widths, although widths at the downstream site were greater than at the upstream site. Gold Run Creek is a small first-order stream with a small volume of flow upstream of Outfall 001. Depths were also generally very shallow at both sites on Gold Run Creek, aside from the two relatively deep pools at Site GR-A.

The control site on Gold Run Creek, Site GR-A, flows adjacent to Highway 85. The streambank here is comprised primarily of rock gabions to prevent erosion of the base of the roadway. The opposite streambank is a steep wall of exposed bedrock. Almost no riparian vegetation exists at Site GR-A. The water at Site GR-A is turbid and rusty colored, and an orange (iron) precipitate is often found on the surface of the substrate throughout the reach (Figure 4-1). This precipitate was again present in 2024, as in almost all other years sampled.

Overhanging vegetation and undercut banks, which can serve as protective fish habitat, are not present at Site GR-A.

Figure 4-1: The bottom portion of Site GR-A as viewed from the shoulder of State Highway 85, looking upstream from the outfall location, August 2024.

Site GR-B has more riparian vegetation, particularly in the lower reaches of the site, but exposed rock is abundant. Gabions also border the stream adjacent to the roadway for the upstream half of this site, similar to Site GR-A. Vegetation was primarily grasses, sedges, forbs, and trees at Site GR-B. In contrast to Site GR-A, the water at Site GR-B is less turbid and has no visible precipitate accumulation, and streamflow at this site is much higher than at Site GR-A due to effluent from Outfall 001. The higher flow at Site GR-B results in the wider wetted widths than at the upstream control site.

Gravel, boulders, and bedrock were the most common substrate type at Site GR-A, while coarse sediment and gravel were common at Site GR-B (Table 4-2). The percentages of fine sediment were moderate at Site GR-A and low at GR-B. High amounts of surface fines and fine sediments can reduce habitat suitability for spawning trout and fill in interstitial spaces that are utilized by many types of benthic macroinvertebrates, particularly mayfly, stonefly, and caddisfly taxa (Waters 1995). This makes surface fines and fine sediments generally undesirable when they comprise a high proportion of the substrate within a given site. Substrate compositions among both sites showed a diversity of particle sizes.

Table 4-2: Substrate characteristics for sites on Whitewood and Gold Run creeks, August 2024. Values are combined results from all habitat types.

Site/Habitat Type	Average Percent Surface Fines	Average Percent Substrate Composition				
		Fine Sediment	Coarse Sediment	Gravel	Rubble	Boulder and Bedrock
Site GR-A	21	13	20	36	9	22
Site GR-B	2	5	43	25	18	9

Year-to-year variation in fine substrate metrics (percent surface fines and fine sediment) in Gold Run Creek is related to variations in the flows of these streams. High spring runoff in 2013 (Figure 4-2) removed small substrates, reducing the amount of surface fines observed during sampling. Moderate spring flows as indicated at the Whitewood Creek flow gage in 2014 and 2015 allowed suspended sediment to settle in the sampling reaches. Spring runoff flows from 2016 through 2018 were substantially less than those observed in 2013 through 2015, reflected in slightly higher values for both surface fines and percentages of fine substrate. Despite higher peak flows in 2022, percentages of surface fines and fine sediments were higher than during the previous two years at both sites. In 2023, multiple rain events led to numerous spikes in stream flow during the summer months and percentages of surface fines and fine sediments were lower at both sites than during the previous year.

Similarly in 2024, there were a couple spikes in stream flow during the summer months prior to sampling. The percentage of surface fines was very low at Site GR-B and moderately low at Site GR-A and comparable to percentages at this site in 2023 and 2021. There was a spike in the flow at the Whitewood Creek gage on August 19-20, 2024, just after sampling on Gold Run Creek. The flow on Whitewood Creek during this period increased from a baseflow of about 8 cubic feet per second (cfs) to close to 1,000 cfs over a period of 2 to 3 hours. Notably elevated flow was not present on Gold Run Creek during sampling on August 19, 2024, but there were indications in the channel of a recent high flow event at both sites, especially Site GR-B (Figure 4-3). This high flow event in addition to the flow contributed by Outfall 001 likely attributed to the very low percentages of surface fines and fine sediment at Site GR-B in 2024 and the high flow event upstream of the outfall reduced the percentage of fine sediments at Site GR-A.

Year to year variations in fine sediment percentages may be influenced by inputs from the roadway adjacent to Gold Run Creek as well as the flow regime during a given year. Site GR-A has much lower discharge than Site GR-B. Due to the much lower discharge at Site GR-A for much of the year, a higher proportion of surface fines and fine sediments are often found at Site GR-A.

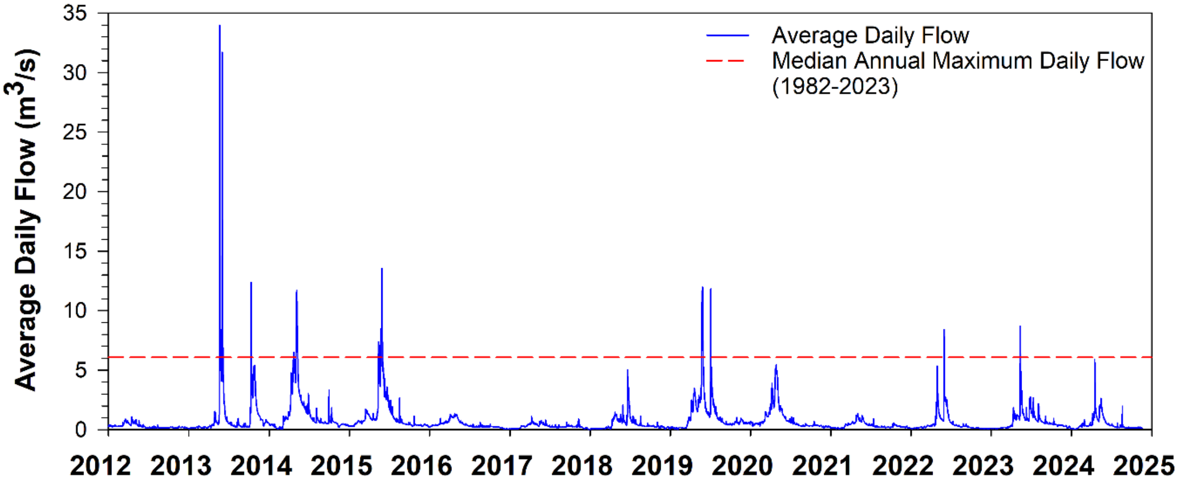

Figure 4-2: Average daily flow (in m^3/s) on Whitewood Creek from January 2012 through December 2024 (USGS 2024). Data are from USGS Gage 06436180 upstream of Whitewood, South Dakota. Median annual maximum flow from 1982 through 2023 is also presented for comparison.

Figure 4-3: Evidence of a recent high flow event on Gold Run Creek as shown at the downstream portion of Site GR-B on August 19, 2024. Vegetation along the banks was submerged above the bankfull width just prior to sampling.

Overall, the habitat at sites on Gold Run Creek are not very suitable for abundant and varied macroinvertebrate populations and fish habitat. The low flows, abundance of bedrock, and higher proportions of surface fines are particularly limiting to aquatic communities at Site GR-A. Site GR-B has higher flows and more substrate diversity than Site GR-A. Despite improved habitat at Site GR-B, this site remains inaccessible to fish from downstream due to the low flow barrier where the stream passes under the roadway. The general habitat features at each site on Gold Run Creek have been mostly consistent over time since monitoring began and do not indicate negative impacts due to Outfall 001.

4.2 Benthic Macroinvertebrate Populations

4.2.1 Community Composition and Abundance

4.2.1.1 2024 Data

In 2024, both sites supported macroinvertebrate communities that included springtails (Collembola), mayflies, beetles (Coleoptera), caddisflies, true flies (Diptera), and segmented worms (Oligochaeta) (Table 4-3 and Appendix A). Site GR-A also contained stoneflies, water mites (Hydracarina), and snails (Gastropoda), and Site GR-B also contained damselflies (Odonata) and moths (Lepidoptera).

Table 4-3: Benthic macroinvertebrate abundances on Gold Run Creek from August 2024.

TAXA	Site GR-A	Site GR-B
INSECTA		
Collembola (Springtails)	1	1
Ephemeroptera (Mayflies)	102	14
Odonata (Dragonflies & Damselflies)	--	3
Plecoptera (Stoneflies)	2	--
Coleoptera (Beetles)	6	4
Lepidoptera (Moths)	--	2
Trichoptera (Caddisflies)	5	18
Diptera (True flies)	39	38
HYDRACARINA (Water mites)	1	--
ANNELIDA		
Oligochaeta (Segmented worms)	60	9
MOLLUSCA		
Gastropoda (Snails)	5	--

Site GR-A in 2024 was dominated by mayflies which represented 46 percent of the total density at this site (Table 4-3 and Appendix A). Site GR-B had low abundance of all taxonomic groups, but true flies were the most numerous. The somewhat tolerant and cosmopolitan mayfly species, *Baetis tricaudatus* cx., was the most abundant species at Site GR-A, comprising 41 percent of the total abundance at this site (Appendix A). This species also had a relatively high abundance at Site GR-B in comparison to the proportions of all groups at this site, but the tolerant true fly species *Simulium sp.* was more numerous at Site GR-B in 2024. The proportions for the remaining species at Site GR-A were well distributed among all taxa except for greater proportions for two segmented worm species. Similarly, proportions of the remaining groups at Site GR-B were comparable except for greater proportions for the caddisfly *Hydropsyche sp*., the true fly *Psychodini sp*., and the segmented worm taxon Enchytraeidae (Appendix A). Some of the groups present, such as springtails, damselflies, stoneflies, moths, water mites, and snails were represented by only a few individuals where collected (Table 4-3).

Richness Metrics

4.2.1.2 2024 Data

Both sites on Gold Run Creek contain relatively sparse benthic macroinvertebrate communities in 2024. All richness metrics, including density, number of taxa, number of EPT taxa, and number of Plecoptera taxa, were greater and more favorable at Site GR-A (Table 4-4). The high flow scouring event discussed in Section 4.1 appeared to have affected the invertebrate populations at both sites in 2024, most notably at Site GR-B. The density at Site GR-B was very low in 2024, but this site contained 17 taxa including three EPT taxa (Table 4-4). The density was also low at Site GR-A but more than twice as high as at GR-B, with greater numbers of total and EPT taxa. Two plecopteran taxa were collected at Site GR-A; none were collected at Site GR-B (Table 4-4).

Table 4-4: Benthic macroinvertebrate summary metrics on Gold Run Creek from August 2024.

METRIC	Site GR-A	Site GR-B
RICHNESS METRICS		
Density (# per sample)	221	89
Number of Taxa	32	17
Number of EPT Taxa	7	3
Number of Plecoptera Taxa	2	0
COMPOSITION METRICS		
Percent Sensitive EPT Taxa	12.5	11.8
Percent Dominant Taxon	41.2	16.9
Percent of non-Baetis Ephemeroptera	0	0
Percent of Oligochaeta and Hirudinea	27.2	10.1
TOLERANCE METRICS		
Hilsenhoff Biotic Index	6.39	6.13
Percent Intolerant Taxa	25.0	29.4
Number of Intolerant Taxa	8	5
TROPHIC HABIT METRICS		
Number of Shredder Taxa	6	1
Percent Collector-Gatherers	81.4	55.1
VOLTINISM METRICS		
Number of Semivoltine Taxa	4	2
Percent Semivoltine Taxa	12.5	11.8
Number of Univoltine Taxa	10	5

Long-Term Data

Density at Site GR-A in 2024 was below the long-term average for the site while the numbers of total taxa, EPT taxa, and Plecoptera taxa in 2024 were greater than respective long-term averages (Appendix D). At Site GR-B in 2024, data values for all richness metrics were below their respective long-term averages. The density and number of EPT taxa at Site GR-B were both lower than in all previous years sampled. The number of total taxa at this site in 2024 was the third lowest value that has occurred at this site over the study (Figure 4-4; Appendix D).

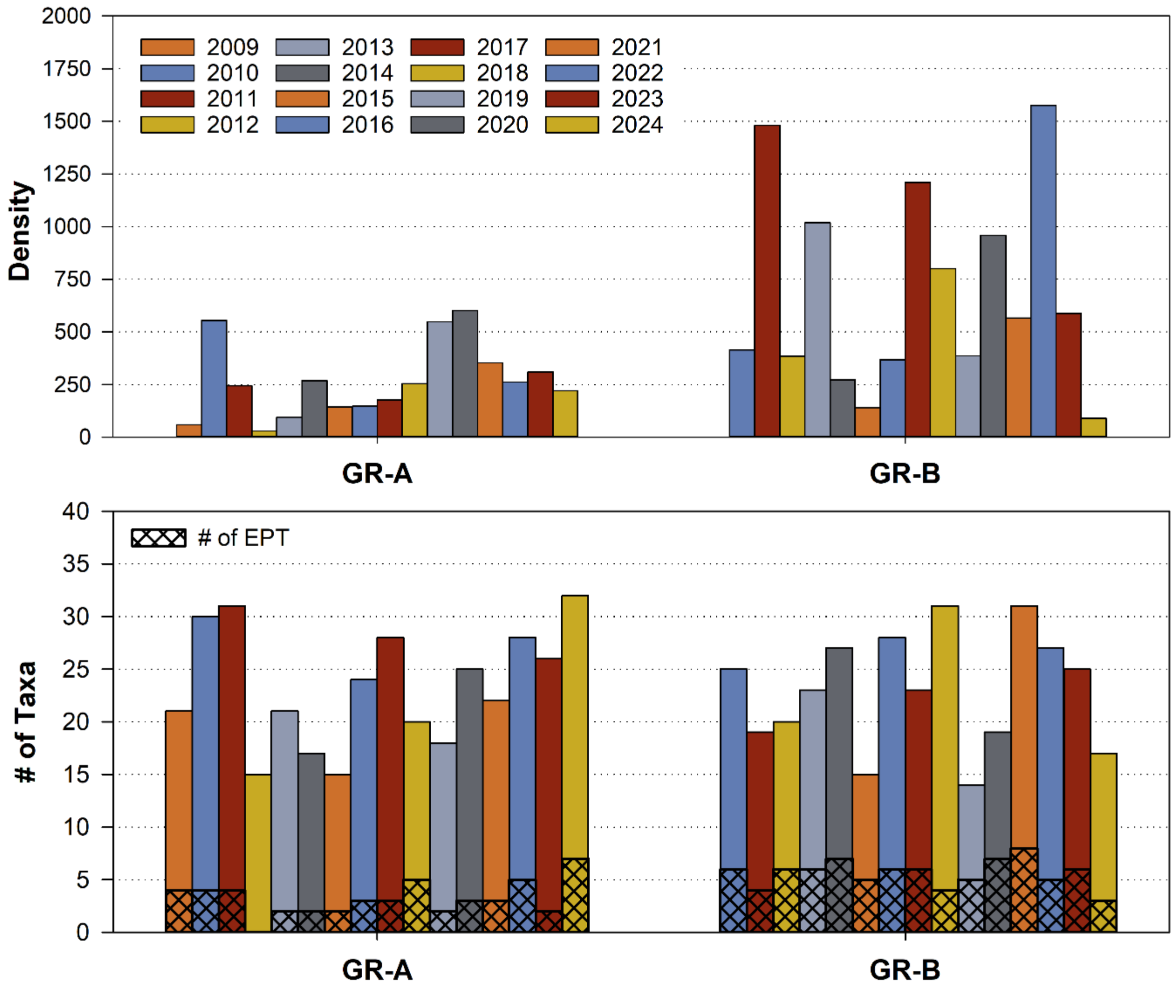

Figure 4-4: Total macroinvertebrate density and number of taxa and EPT taxa from Gold Run Creek, 2009 through 2024. Site GR-B was not sampled in 2009.

ANOVA analyses indicate that density and number of EPT taxa have been significantly greater at Site GR-B than Site GR-A over the study period ($p < 0.05$ for all), while values for total taxa were not significantly different between the two sites ($p > 0.05$). Linear regression analyses for data within each site indicated values have been stable, with no increasing or decreasing trends for the richness metrics over time.

Stoneflies have been rare or absent at both Gold Run Creek sites during many years of sampling, including in 2024 when sites GR-A and GR-B contained 2 and 0 stonefly taxa, respectively. Stonefly taxa have been absent from Site GR-A in 12 of the 16 years sampled and absent from Site GR-B in 10 of the 15 years sampled. Inadequate flow appears to be the most important limiting factor in Gold Run Creek for this group (and for other groups reflected in other metrics). Other limiting factors to stoneflies in some years may include occasional high temperatures, nutrient enrichment, or some other regional water quality constituent.

Over time, the effluent from Outfall 001 appears to be improving the conditions in Gold Run Creek below the outfall, likely due to the increased flows. While richness metrics were lower at Site GR-B compared to Site GR-A in 2024, likely this resulted from the effect of the storm event that affected the downstream site more substantially with the additional flow from the outfall. The data on density, number of taxa, and number of EPT taxa indicate overall conditions since 2009 have been stable at both sites on Gold Run Creek.

4.2.2 Composition Metrics

4.2.2.1 2024 Data

Percent sensitive EPT taxa values were moderate and similar at both Gold Run Creek sites in 2024 (Table 4-4 and Figure 4-5). Values for this metric are often lower at Site GR-A in comparison to Site GR-B due to limited flows, sedimentation, and the precipitates often observed within Site GR-A. EPT species were present at both sites and in lower abundance at Site GR-B (Appendix A). Site GR-A contained at least two taxa from each of the EPT groups while of the EPT groups Site GR-B only contained one mayfly taxa and two caddisfly taxa. As noted previously, the mayfly taxon, *B. tricaudatus* cx., was the dominant taxon at Site GR-A, while the black fly taxon, *Simulium* sp., was dominant at Site GR-B in 2024 (Table 4-4). Non-*Baetis* mayflies were absent at both sites in 2024; the percent of non-*Baetis* Ephemeroptera capture the relative abundance of other mayfly genera which are usually more sensitive than *Baetis*.

The percent of Oligochaeta and Hirudinea (leeches) metric was relatively high at Site GR-A due to the presence of six oligochaete taxa that comprised a total of 27 percent of the total density at the site. The value for this metric was lower at Site GR-B with three total taxa that comprised 10 percent of the total taxa at this site in 2024. No leeches were collected at the Gold Run Creek sites in 2024.

4.2.2.2 Long-Term Data

Values for the percent sensitive EPT taxa metric have been variable at both sites on Gold Run Creek, ranging from 0 to 15 percent at Site GR-A and from 7 to 26 percent at Site GR-B (Figure 4-5; Appendix D). The percent sensitive EPT taxa metric value at Site GR-A has been lower in most years when compared to Site GR-B, and values for this metric have been 5 percent or less in seven of the 16 years sampled (Appendix D). Fluctuation in the percent sensitive EPT taxa metric at the study sites appears to be related to natural variations in flows, water quality conditions, and sediment input.

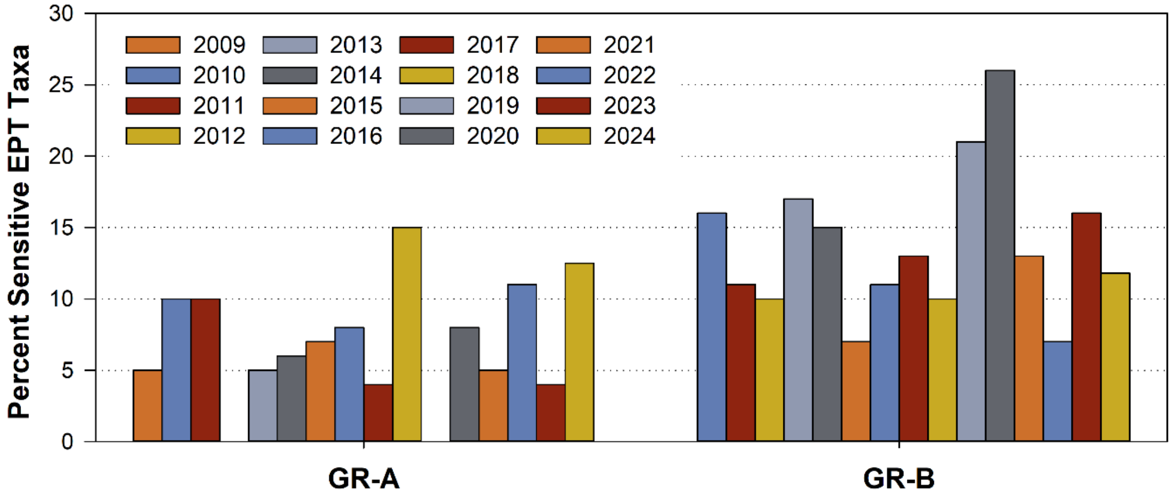

Figure 4-5: Percent sensitive EPT taxa from Gold Run Creek, 2009 through 2024. Site GR-B was not sampled in 2009.

The percentage of sensitive EPT taxa has been significantly greater at Site GR-B than Site GR-A over the study period ($p < 0.05$), indicating that conditions at Site GR-B have been more conducive to this group since 2010. There were no significant increasing or decreasing trends for percent sensitive EPT taxa over the study period within both Gold Run Creek sites ($p > 0.05$), indicating percentages have been stable at both sites since the beginning of the study.

4.2.3 Tolerance Metrics

4.2.3.1 2024 Data

The HBI scores in 2024 on both Gold Run Creek sites were similar between the two sites, categorizing both sites as "Fair" (Table 4-4). High relative total abundances of tolerant true flies and segmented worm species at both sites resulted in the less than favorable HBI scores. The slightly higher (less favorable) HBI score at Site GR-A illustrate that the benthic macroinvertebrate community at Site GR-A in 2024 was comprised of slightly more tolerant benthic macroinvertebrates than Site GR-B. In addition to the HBI, values for the percent intolerant taxa metric were also greater at Site GR-B, although the number of intolerant taxa was slightly lower at the downstream site. These three metrics indicated that despite a notably smaller invertebrate community at site GR-B, sensitive taxa were present at both sites, comprising a quarter or more of the total abundance at each site in 2024.

4.2.3.2 Long-Term Data

HBI ratings have been variable at both sites on Gold Run Creek over the study period, ranging from 5.08 to 8.03 at Site GR-A and from 4.87 to 6.35 at Site GR-B (Appendix D).

Both sites were rated as “Good” in 2013, 2016, and 2019, as was Site GR-B in 2021 – 2023 and Site GR-A in 2015 and 2020. Site GR-B in all other years sampled was rated as “Fair”. Values at Site GR-A have been more variable in the other years, having ratings of “Poor,” “Fairly Poor,” and “Fair.” HBI scores were less favorable in some years at Site GR-A due to a relatively high proportion of a tolerant or moderately tolerant species, such as *B. tricaudatus* cx. ANOVA analysis of HBI scores indicated no significant differences were apparent between the Gold Run Creek sites over time, and regression analyses indicate no significant trends for HBI scores at either site over the study period. These data suggest conditions for less tolerant taxa have been comparable and stable at both sites and have not significantly changed with time at both sites.

The percent intolerant taxa metric has also varied over the study period, although more variability has been observed at the upstream control site. Values for this metric at Site GR-A ranged from 0 to 36 percent in 2012 and 2022, respectively, while values at Site GR-B ranged from 20 to 37 percent in 2015 and 2020, respectively. Mean percent intolerant taxa values were significantly higher at Site GR-B compared to Site GR-A over the study period ($p < 0.05$). While values for both sites for this metric have generally increased over time, this increase was not statistically significant.

4.2.4 Trophic Habit Metrics

4.2.4.1 2024 Data

The number of shredder taxa and percent collector-gatherers were notably greater at Site GR-A in 2024 (Table 4-4). Factors such as riparian trees and shrubs can influence the availability of leaf and woody material utilized by shredders. Vegetated riparian areas along Gold Run Creek are limited, particularly at Site GR-A, which has a steep bedrock hillside on one bank and rock gabions along the other bank. More vegetation is found in the vicinity of Site GR-B than at Site GR-A; however, this was not reflected in the number of shredder taxa present, which was low for both sites but lower downstream. Larger values for the percent collector-gatherer metric can indicate disturbance, and both sites contained relatively high percentages of collector-gatherers, with values of 81.4 and 55.1 percent at sites GR-A and GR-B, respectively (Table 4-4). The lower number of shredder taxa at Site GR-B and the percent collector-gatherer percentages at both sites indicate the scouring event discussed in Section 4.1 disturbed the invertebrate communities at both sites and notably reduced the number of shredder taxa at Site GR-B in 2024.

4.2.5 Voltinism Metrics

4.2.5.1 2024 Data

Semivoltine taxa require more than one year to complete a generation, and short-term disruptions in aquatic conditions, either chemical or physical, can reduce the number of taxa with this life history following a disturbance. Therefore, as anthropogenic stressors increase, taxa with shorter life histories, capable of producing one generation (univoltine) or multiple generations in a year (multivoltine) are favored.

Sites GR-A and GR-B in 2024 contained four and two semivoltine taxa, respectively, comprising about 13 and 12 percent of all taxa at that site (Table 4-4). Univoltine taxa were more common at both sites than semivoltine taxa, indicating conditions continue to favor invertebrates with shorter life cycles on Gold Run Creek. As with most other invertebrate metrics, the scouring event prior to sampling likely greatly influenced the assemblages at both sites on Gold Run Creek and favored taxa with shorter life cycles in August 2024.

Even with the scouring event in 2024, some of the data from Gold Run Creek in 2024 and data over the entire study period suggest that the added water from Outfall 001 benefits the benthic macroinvertebrate community at Site GR-B, likely due to better water quality and increased water volume during low flow periods at Site GR-B when compared to Site GR-A. Inflows from Outfall 001 provide more physical habitat for benthic macroinvertebrate colonization, sustain streamflow during dry periods, and increase dissolved oxygen, all of which would favorably impact the benthic macroinvertebrate community. In contrast, Site GR-A often has very little flowing water and substrate is covered with an orange (iron) precipitate (Figure 4-6). Long-term benthic macroinvertebrate metrics at both Gold Run Creek sites continue to show that a more limited community is present upstream of Outfall 001 on Gold Run Creek, while healthier communities are found at Site GR-B.

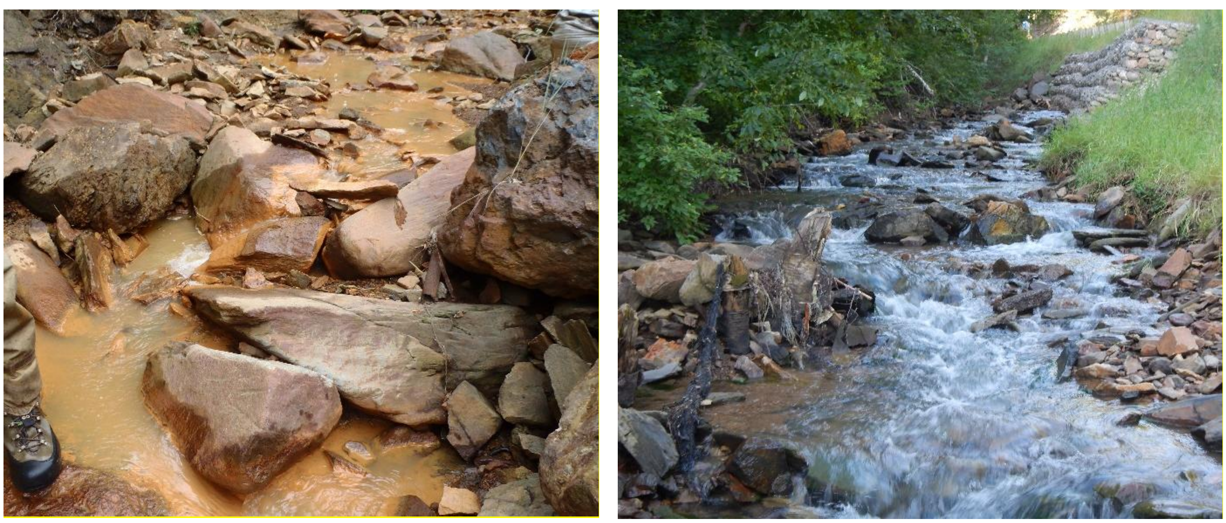

Figure 4-6: Photos of conditions during sampling at sites GR-A (left) and GR-B (right) on Gold Run Creek.

4.3 Periphyton Populations

4.3.1 Community Composition and Density

4.3.1.1 2024 Data

Pennate diatoms were the only taxonomic group found at both Gold Run Creek sites in 2024 (Table 4-5). The species *Achnanthes minutissima* was the most abundant species at Site GR-A and the only species present at Site GR-B (Appendix B). Relative abundance of *A. minutissima* greater than 25 percent can suggest recent disturbances in the form of scouring events or exposure to toxic pollution, with severity of disturbance proportional to higher abundances, and as well as the time elapsed since these events (Barbour et al. 1999). This species comprised 27.5 percent of the density at Site GR-A and 100 percent of the density at Site GR-B in 2024 (Appendix B). As discussed in Section 4.1 there was evidence of a high flow event at both sites on Gold Run Creek just prior to sampling on August 19, 2024, most notable at Site GR-B, which likely caused scouring in the channel at this site. The presence of a single taxa with very low density at Site GR-B is likely due to the channel scouring during the high flow event which resulted in very limited periphyton at the site. This species is often the first to become established at a scoured site, sometimes to the exclusion of all other algae (Barbour et al. 1999).

4.3.2 Richness Metrics

4.3.2.1 2024 Data

In 2024, total densities and diatom densities were low at both Gold Run Creek sites when compared to previous years at respective sites (Table 4-5; Appendix E). The density at Site GR-A in 2024 was substantially lower than the long-term average from 2009 to 2023 but was within the range of values observed in previous years (Figure 4-7). This site had no periphyton observed in 2019. The density at Site GR-B in 2024 was substantially lower than in all previous years at this site since sampling began at this site in 2010.

Despite the low density, the number of taxa and diatom taxa at Site GR-A in 2024 were equal to the largest values for both metrics at this site over the monitoring period (Appendix E). Site GR-B in 2024 contained only one taxon which was lower than the previous minimum in 2021 when nine total taxa were collected. Site GR-A has contained fewer taxa and diatom taxa than Site GR-B in all years except 2021 and 2024. The limited periphyton population at Site GR-B was attributed to the high flow event and scouring that occurred a short period prior to sampling in 2024. Site GR-A usually has fewer algal taxa present compared to Site GR-B because Site GR-A usually contains lower flows, higher percentages of fine sediment, and an orange-colored precipitate that covers the substrate and settles into interstitial spaces. This poor habitat impacts both the periphyton and benthic macroinvertebrate communities (See 4.1 Habitat Assessment).

4.3.2.2 Long-Term Data

Periphyton density has been highly variable at both Gold Run Creek sites over time (Figure 4-7; Appendix E). Densities at both sites were highest in 2017. Low densities in some other years appeared to be related to the thick mats of filamentous algae that are periodically observed that may have limited the abundance of diatoms. The moderately low density measured in 2019 at Site GR-B, and the lack of diatoms at Site GR-A are all likely related to high flows during 2019.

Table 4-5: Periphyton density and community metrics for both sites on Gold Run Creek, August 2024.

Taxa	Site GR-A	Site GR-B
BACILLARIOPHYTA		
Pennales (Pennate diatoms; cells/cm²)	1,560	46
Summary		
RICHNESS METRICS		
Total Density (cells/cm²)	1,560	46
Number of Taxa	14	1
Number of Diatom Taxa	14	1
Number of Divisions	1	1
Number of Genera	8	1
COMPOSITION METRICS		
Shannon-Weaver Diatom Diversity (H')	3.08	0.00
Autotrophic Index	2,755	8,955
Autecological Classes of Diatoms*(percent of diatom density)		
Eutrophic	30	0
Acidophilic	0	0
Alkaliphilic	30	0
Nitrogen Heterotrophs	3	0
High Oxygen	35	100
Motile	20	0
Saprobic	0	0
TOLERANCE METRICS		
Diatom Tolerance Values (percent of diatom density)		
(1) Tolerant	0	0
(2) Less Tolerant	35	0
(3) Sensitive	65	100
Lange-Bertalot Pollution Tolerance Index	2.65	3.00
Ash-Free Dry Weight (mg/m²)	2,204	1,791
Chlorophyll a (mg/m²)	0.8	0.2

* = Some taxa are categorized into multiple autecological classes; displayed as percent of total density.

Since Site GR-A is upstream of Outfall 001, changes at this site are due to background conditions and are unrelated to discharge from Outfall 001, indicating that regional factors were more important than site-specific factors in 2019. In 2021, densities were somewhat low at both Gold Run Creek sites. The August 19, 2021, high flow event on Gold Run Creek may have reduced periphyton densities at both sites in 2021. In 2022, density notably increased at both sites and the number of total taxa increased notably at Site GR-B from 2021 values. High flow events occurred in the summer of 2023 and 2024 prior to sampling, and this likely caused scouring of the substrate and reduced diatom densities at both sites in both years when compared to long-term averages. No significant increasing or decreasing trends over time in density at these sites were observed, and mean densities at the two sites were not statistically significant ($p \geq 0.05$).

Numbers of taxa supported at both sites have generally shown less annual variability than densities within each site over the monitoring period. The mean number of taxa was statistically greater at Site GR-B compared to Site GR-A ($p < 0.05$). No long-term increasing or decreasing trends for mean number of taxa was observed over time ($p > 0.05$ for both sites).

The periphyton communities collected by KNK in 1998 through 2000 were comparable to the periphyton communities observed in 2010 through 2024 by GEI (Knudson 2001, GEI 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024). Species varied between KNK and GEI samples, but the genera collected from 1998 through 2000 were similar to the genera observed from 2010 through 2024.

4.3.3 Composition Metrics

4.3.3.1 2024 Data

At Site GR-A in 2024, the relatively high number of taxa and well distributed densities among the taxa resulted in the largest diversity index value at the site over the monitoring period and indicated that the community was well-balanced. Conversely, the diversity index value at Site GR-B in 2024 was 0.00, due to only the single taxon being present, and this value was the lowest at this site over the monitoring period. In all years except 2010 and 2024 the diversity index values were greater at Site GR-B than Site GR-A, as related to the increased flows below the outfall and more favorable water quality. Diversity index values have indicated that a disturbed periphyton community has been present at Site GR-A in almost all previous years, likely due to low flows, poor water quality, and the iron precipitate on the bottom substrate (Figure 4-1).

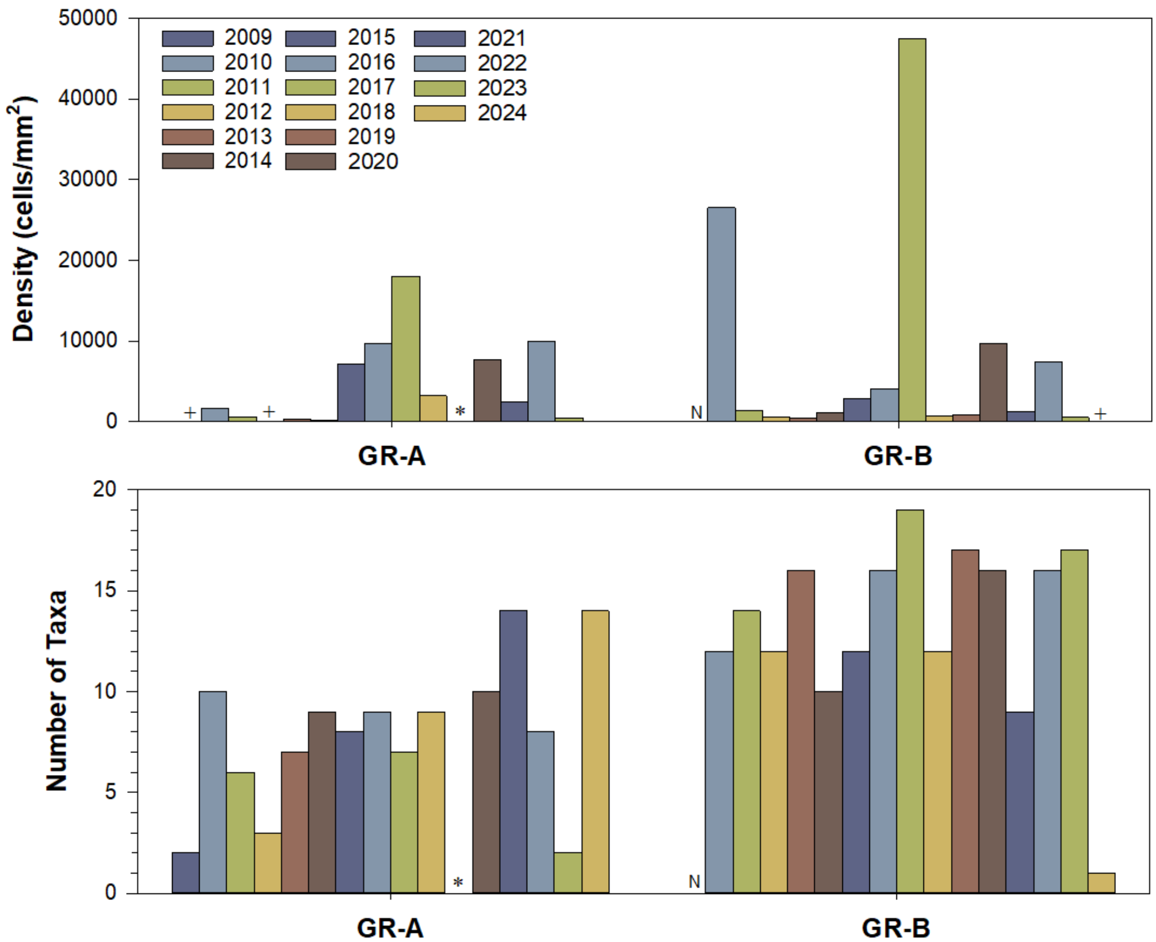

Figure 4-7: Total periphyton density (cells/mm²) and number of taxa from all sites on Gold Run Creek, 2009 through 2024. Of note, periphyton densities were reported in cells/cm² but are shown as cells/mm² on graph for a more clearly viewable scale. N=not sampled. += Periphyton present at low density. *= No periphyton cells found in sample.

Autotrophic Index (AI) values were 2,755 at Site GR-A and 8,955 at Site GR-B in 2024 (Table 4-5). Communities less disturbed by organic pollution usually contain AI values ranging from 50 to 100 and values greater than 400 indicate communities affected by organic pollution. In 2024, these high values may have been more related to the low amount of chlorophyll-α at both sites because of the low periphyton abundance combined with a relatively high amount of AFDW/ Due to this storm event influencing these values, it is difficult to discern if organic pollution was also affecting the periphyton communities in 2024. In prior years there has sometimes been indication of organic pollution impacts at both sites on Gold Run Creek. Runoff from lawns in residential developments or along roadways may be affecting these sites in some years.

The most abundant autecological groups collected from Site GR-A in 2024 were high oxygen diatoms, followed by eutrophic and alkaliphilic diatoms (Table 4-5). Motile diatoms also comprised a substantial percentage of the diatom density, and there was also a small percentage of nitrogen heterotrophs present at this site in 2024. The single taxon collected from Site GR-B was categorized as a high oxygen diatom. These abundances at both sites indicates that dissolved oxygen concentrations are suitable to support such diatoms in Gold Run Creek. The presence of a relatively abundant eutrophic and alkaliphilic diatoms combined with less abundant but present nitrogen heterotrophs indicate that organic or inorganic nutrient inputs and/or the presence of alkaline salts from agricultural disturbance was present at Site GR-A in 2024.

Motile diatoms were present at Site GR-A, but the single taxon present at Site GR-B is not a motile diatom species. The presence of motile diatoms at Site GR-A indicates some sedimentation was present at this site. Acidophilic diatoms and saprobic diatoms were absent at both Gold Run Creek sites in 2024 (Table 4-5). The absence of acidophilic diatoms these two sites suggests these sites are not impacted by acid mine drainage, but the high flow event prior to sampling in 2024 that resulted in greatly reduced densities at both sites obfuscates autecological group analyses.

4.3.3.2 Long-Term Data

Shannon-Weaver Diversity Index values have generally been low and frequently very low at Site GR-A (Appendix E), with values less than 1.00 in 11 of the 16 years of sampling. From 2009 to 2023, the maximum diversity value observed was 1.09 in 2012. The value in 2024 was substantially higher at 3.08, suggesting that the scouring event may have benefitted the periphyton community temporarily by allowing recolonization by multiple taxa rather than dominance by one or two taxa. Diversity values at Site GR-B have varied less, ranging from 0.92 in 2014 to 3.40 in 2019 until 2024, when the single species present resulted in a diversity value of 0. Values have consistently been greater than 1.00 and often greater than 2.00 at this site. Over time, the mean diversity value at Site GR-B was significantly greater than at Site GR-A ($p < 0.05$). No significant long -term increasing or decreasing trends were observed.

4.3.4 Tolerance Metrics

4.3.4.1 2024 Data

There were no tolerant diatoms at either of the Gold Run sites in 2024 (Table 4-5). Sensitive diatoms comprised 65 percent of the density at Site GR-A in 2024, with less tolerant diatoms comprising the remainder of the population. The high abundance of *A. minutissima*, a sensitive diatom species, has influenced the composition of the assemblage in terms of tolerance throughout the study period at Site GR-A and in many years at Site GR-B. The absence of tolerant diatoms in 2024 and most previous years at both sites suggest that both sites on Gold Run Creek support sensitive periphyton communities even if the communities at both sites are sometimes unbalanced and dominated by one or two species. The Lange-Bertalot pollution tolerance index values were greater than 2.50 at both sites, indicating an absence of organic enrichment. These pollution tolerance index values contradict the AI values discussed above, further suggesting that the AI values were unduly influenced by the low densities resulting in low chlorophyll-α values in 2024.

High percentages of *A. minutissima* found in 2024 and every other year of the study in Gold Run Creek result in metrics highly influenced by this single species. In 2024, this species accounted for 27.5 percent and 100 percent of the density at sites GR-A and GR-B, respectively. This dominance of the community by a small number of diatom taxa results in in lower richness, diversity, and percent tolerant and motile diatom values in 2024 and other years. Since *A. minutissima* is classified as a sensitive species, this skews some of the autecological and tolerance metrics to indicate a healthy community when diversity values often suggest otherwise. Additionally, as with the composition metrics, the high flow event prior to sampling in 2024 greatly reduced densities at both sites and obfuscates tolerance metric analyses.

5. Conclusions

Two sites on Gold Run Creek were sampled in August 2024 to continue monitoring activities upstream and downstream of SURF's permitted Outfall 001. Whitewood Creek was not sampled in 2024. Habitat surveys were conducted and fish, benthic macroinvertebrate, and periphyton population sampling was performed at both Gold Run Creek sites. The 2024 sampling event was the sixteenth consecutive year of sampling conducted since 2009 at Site GR-A, and the fifteenth consecutive year of sampling at Site GR-B since 2010.

5.1 Habitat

Gold Run Creek at Site GR-A contains very low base flows when there is no recent precipitation or surface water runoff, and the water in this site is turbid and rusty colored. Overhanging vegetation, which can function as fish habitat, is not found at Site GR-A, and depths are generally shallow. The riparian area at this site is mostly comprised of bedrock and rock gabions, and habitat is significantly influenced by the roadway adjacent to the stream. An orange precipitate is often found on the surface of rocks at Site GR-A and was present in 2024 as well. In 2024, most of the site reach at Site GR-A was comprised of step runs, with a riffle, cascade, and two pools observed also. Gravel was the dominant substrate type observed, and percent surface fines were moderately high.

Site GR-B contains much greater flows than the upstream site due to inflows from Outfall 001. Riparian vegetation is also more abundant, particularly in the lower sections of the site, although exposed rock is also common. A small amount of overhanging vegetation is present along the site. In contrast to Site GR-A, the water at Site GR-B is much less turbid and has no orange coloration. Low gradient riffle habitat comprised much of the site reach in 2024, and coarse and gravel substrates were the most common substrate sizes. In 2021, scour and bank erosion from an August high flow event that year was evident; some areas of exposed banks due to this storm event remained evident in the years following. Similarly, there was a high flow event in 2024 that caused scouring and exposed banks on Gold Run Creek and was most notable at Site GR-B.

The suitability of Gold Run Creek to support aquatic communities is limited due to the culvert through which the stream flows through before its confluence with Whitewood Creek. This section is likely too shallow to be passable to fish and Gold Run Creek remains isolated from the fish populations in Whitewood Creek.

5.2 Fish Populations

No fish have been collected in Gold Run Creek over the study period, including in 2024. Upstream of Outfall 001 the stream has very low flows and poor water quality and cannot support fish. Downstream of Outfall 001, the stream is larger with higher flow, but fish are not present. The section of stream below Outfall 001 at Site GR-B is likely too short to support a self-sustaining fish population, and a culvert that runs under the road near the mouth of Gold Run Creek acts as a barrier to migration and prevents colonization of fish into this reach from Whitewood Creek.

5.3 Benthic Macroinvertebrate Populations

In 2024, both sites on Gold Run Creek supported benthic macroinvertebrate communities that were diverse but limited in abundance. Historically Site GR-B has supported a more abundant assemblage with more favorable metrics than Site GR-A. However, Site GR-B had a notably less abundant community with some less favorable metrics compared to Site GR-A. The high flow scouring event prior to sampling in 2024 reduced invertebrate density at both sites compared to long-term averages but disproportionately appeared to affect communities at Site GR-B, potentially because flows are already higher at this site. Despite the low density and low values for some metrics at Site GR-B in 2024, this site still contained numerous taxa including EPT taxa. All composition metrics and most of the tolerance and voltinism metrics scored similarly between the two sites or more favorably at the downstream site.

Site GR-A has limited flows and less favorable aquatic habitat compared to Site GR-B. Consistently higher community metrics during most years at Site GR-B downstream of Outfall 001 indicate that Outfall 001 is generally beneficial to the benthic macroinvertebrate community downstream by increasing flows, expanding aquatic habitat, and improving water quality. Mean density, number of EPT taxa, percentage of sensitive EPT taxa, and percent intolerant taxa values over the study period were significantly higher at Site GR-B compared to GR-A. The larger volume of water at Site GR-B from Outfall 001 is likely the main reason for generally better community metrics at Site GR-B compared to Site GR-A in almost all years. Dilution from Outfall 001 also improves water quality in Gold Run Creek through reduction of turbidity and the concentration of metals, particularly iron.

The low densities mixed with diverse assemblages that included sensitive taxa at both sites in 2024 indicate that the scouring event resulted in populations that were undergoing fluctuations following the disturbance at the time of sampling. The 2024 data indicate that the populations at both sites were experiencing transient dynamics as the population were still in the process of stabilizing following a disturbance, and colonization of newly available habitat and niches were still occurring. The diversity of the macroinvertebrate assemblages at both sites at the time of sampling suggests that the communities in Gold Run Creek were resilient to this disturbance, with sensitive taxa still present at both sites.

5.4 Periphyton Populations

Both sites on Gold Run Creek supported limited periphyton communities in 2024, due to scouring from the high flow event which occurred a short period prior to sampling. Only one algal taxon was present at Site GR-B, and, while there were a robust number of taxa at Site GR-A, the densities at both sites were low. As with the macroinvertebrate assemblages, the periphyton community appeared to have been destabilized following the scouring event, and recolonization of newly available habitat and niches were still occurring at the time of sampling in August 2024.

High percentages of *A. minutissima* found in 2024 and other years of study at these sites result in metrics dominated by the presence of this single species. Since *A. minutissima* is classified as a sensitive species, this skews some of the autecological and tolerance metrics. While these sites have conditions that support such a sensitive species, including sufficient dissolved oxygen levels, the communities at both sites are sometimes not balanced, as they are strongly dominated by a one or two species in many years, particularly at Site GR-A. The assemblage at Site GR-A was more balanced in 2024 than in most years, as *A. minutissima*, while still the most abundant species, only comprised 28 percent of the density rather than the much higher percentages that have occurred in some past years.

Low flow, turbid water, and poor water quality are especially limiting to the periphyton community at Site GR-A. Past data indicate Outfall 001 has a positive effect on the periphyton communities downstream. The long-term data indicate that Site GR-B has maintained a more robust periphyton community over time than at Site GR-A, even if this was not reflected in the 2024 data based on the impact of the scouring event. The low densities of periphyton at both sites in addition to a diverse assemblage at Site GR-A in 2024 indicate that the periphyton populations were undergoing fluctuations following the disturbance at the time of sampling.

5.5 Overall

Fish were absent from both sites on Gold Run Creek in 2024, as has been observed throughout the study period. The benthic macroinvertebrate and periphyton populations were notably affected by a high flow event prior to sampling in 2024 which caused disturbances to the aquatic communities at both sites on Gold Run Creek. While the communities at Site GR-B were more affected than at Site GR-A, communities are expected to rebound over time, and many of the macroinvertebrate metric values remained favorable at the downstream site compared to the upstream site.

Site GR-B directly downstream of Outfall 001 has historically supported more robust macroinvertebrate and periphyton communities relative to Site GR-A. Long-term data analyses do not indicate any unfavorable trends in the benthic macroinvertebrate and periphyton population metrics over time at both sites. Low-flow, poor water quality, and less suitable habitat conditions limit aquatic life at Site GR-A, upstream of Outfall 001. Data collected over the study period indicate that the continuous discharge of water from Outfall 001 benefits macroinvertebrate and periphyton communities at Site GR-B when compared to communities at Site GR-A.

6. References

Bahls, L. L. 1993. Periphyton Bioassessment Methods for Montana Streams. Water Quality Bureau, Montana Department of Health and Environmental Sciences, Helena, MT.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Invertebrates and Fish, 2nd Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Washington, DC.

Fore, L. and C. Grafe. 2002. Using diatoms to assess the biological condition of large rivers in Idaho (U.S.A.). *Freshwater Biology* 47:2015-2037.

GEI Consultants, Inc. (GEI). 2009. Study Plan for Aquatic Biological Monitoring of Gold Run and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2010. Aquatic Biological Monitoring of Gold Run and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2011. Aquatic Biological Monitoring of Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2012. Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2013a. Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2013b. Aquatic Biological Monitoring Report for Whitewood Creek, South Dakota, 2012. Report prepared for Homestake Mining Company, Lead, SD.

GEI Consultants, Inc. (GEI). 2014. Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2015. Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2016. Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2017. 2016 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2018. 2017 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2019. 2018 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2020. 2019 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2021. 2020 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2022. 2021 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2023. 2022 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

GEI Consultants, Inc. (GEI). 2024. 2023 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota. Report prepared for South Dakota Science and Technology Authority, Lead, SD.

Grafe, C.S. (ed.). 2002. Idaho Small Stream Ecological Assessment Framework: An Integrated Approach. Idaho Department of Environmental Quality, Boise, ID.

Hargett, E. G. 2011. The Wyoming Stream Integrity Index (WSII)- Multimetric Indices for Assessment of Wadeable Streams and Large Rivers in Wyoming. Document #11-0787, Water Quality Division, Cheyenne, Wyoming.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. *Great Lakes Entomologist* 20(1): 31-40.

Hynes, H. B. N. 1970. The Ecology of Running Waters. University of Toronto Press, Toronto, Canada.

Klemm, D. J., P. A. Lewis, F. Fulk, and J. M. Lazorchak. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. EPA/600/4-90/030. U.S. Environmental Protection Agency.

Knudson, K. 2001. An Evaluation of the Biological Communities of Whitewood Creek near Deadwood, South Dakota. Report prepared for Homestake Mining Company, Lead, SD.

Lange-Bertalot, H. 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. *Nova Hedwigia* 64:285-304.

Lenat, D. R., and V. H. Resh. 2001. Taxonomy and stream ecology: the benefits of genus- and species-level identifications. *Journal of the North American Benthological Society* 20:287-298.

Lowe, R. L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. EPA 670/4-74-005. U.S. Environmental Protection Agency, Cincinnati, OH.

Merritt, R. W., Cummins, K. W., and M. B. Berg. 2008. An Introduction to the Aquatic Invertebrates of North America, 4th ed. Kendall-Hunt Publishing Company, Dubuque, IA.

NCSS 12 Statistical Software. 2021. Version 12.0.18.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers* 77:118-125.

Omernik, J. M., and A. L. Gallant. 1987. Ecoregions of the West Central United States. EPA/600/D-87/317. U.S. Environmental Protection Agency.

Overton, C. K., S. P. Wollrab, B. C. Roberts, and M. A. Radko. 1997. R1/R4 (Northern/Intermountain Regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. General Technical Report INT-GTR-346. U.S. Forest Service Intermountain Research Station.

Patrick, R., and C. W. Reimer. 1966. The Diatoms of the United States, Exclusive of Alaska and Hawaii. Monograph 13. Academy of Natural Sciences, Philadelphia, PA.

Patrick, R., and C. W. Reimer. 1975. The Diatoms of the United States, Volume 2, Part 1, Monograph 13. Academy of Natural Sciences, Philadelphia, PA.

Peck, D.V., A.T. Herlihy, B.H. Hill, R. M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M.R. Cappaert. 2006. *Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams*. U.S. EPA Report EPA/620/R-06/003. U.S. Environmental Protection Agency, Washington, D.C.

Platts, W. S., W. F. Megahan, and G. W. Minshall. 1983. Methods for Evaluating Stream, Riparian, and Biotic Conditions. General Technical Report INT-138. U.S. Forest Service.

Shearer, J. 2006. Macroinvertebrate Bioassessment of Black Hills Streams, South Dakota. SD GFP Report 2006-09. June 2006. South Dakota Game, Fish and Parks, Rapid City, South Dakota.

South Dakota Department of Agriculture and Natural Resources (SDDANR). 2005. Standard Operating Procedures for Field Samplers, Volume II: Biological and Habitat Sampling. Version 1.2, Water Resources Monitoring Team, February 2005.

Stribling, J. B., S. R. Moulton, II, and G. T. Lester. 2003. Determining the quality of taxonomic data. *Journal of the North American Benthological Society* 22:621-631.

U.S. Environmental Protection Agency (EPA). 1978. Environmental Requirements and Pollution Tolerance of Plecoptera. EPA-600/4-78-062. October 1978. Environmental Monitoring and Support Laboratory, Cincinnati, OH.

U.S. Geological Survey (USGS). 2024. USGS 06436180 Whitewood Creek Above Whitewood, SD. Available online: http://waterdata.usgs.gov/sd/nwis/uv?site_no=06436180, accessed 1/2025.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7.

Wehr, J. D., and R. G. Sheath (eds.). 2003. Freshwater Algae of North America. Academic Press, San Diego, CA.

Whittaker, R. H. 1975. Communities and Ecosystems, 2nd edition. Macmillan Publishing Company, New York, NY.

Wiederholm, T. 1984. Responses of aquatic insects to environmental pollution. Pp. 508-557 *in* Resh, V.H., and D.M. Rosenberg (eds.). *The Ecology of Aquatic Insects*. Praeger Scientific, New York, NY.

Wilkens, J., Rosse, A., and Dozark, K. 2016. A Macroinvertebrate Index of Biotic Integrity for Monitoring Mining Impacts in Black Hills Streams. March 2016. South Dakota Department of Environment and Natural Resources, Pierre, South Dakota.

Appendix A 2024 Benthic Invertebrate Data

DATA: MACROINVERTEBRATE DENSITY
Client: SDSTA
Sampled: 8/19/2024
Site: GOLD RUN, GR-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
COLLEMBOLA	**1**	
Unid. Collembola	1	0.5
EPHEMEROPTERA	**102**	
Baetis flavistriga cx.	11	5.0
Baetis tricaudatus cx.	91	41.2
PLECOPTERA	**2**	
Perlidae	1	0.5
Zapada cinctipes	1	0.5
COLEOPTERA	**6**	
Agabus cx.	4	1.8
Hydrophilidae	1	0.5
Optioservus divergens	1	0.5
TRICHOPTERA	**5**	
Hydroptila sp.	3	1.4
Limnephilus sp.	1	0.5
Rhyacophila brunnea/vao	1	0.5
DIPTERA	**39**	
Brillia sp.	5	2.3
Caloparyphus/Euparyphus sp.	2	0.9
Ceratopogonidae	1	0.5
Chironomus sp.	1	0.5
Geranomyia sp.	1	0.5
Microtendipes sp.	1	0.5
Orthocladius/Cricotopus gr.	2	0.9
Pagastia sp.	6	2.7
Parametriocnemus sp.	1	0.5
Paraphaenocladius sp.	1	0.5
Psychodini sp.	6	2.7
Simulium sp.	9	4.1
Tipula (Sinotipula)	3	1.4
HYDRACARINA	**1**	
Oribatida sp.	1	0.5

DATA: MACROINVERTEBRATE DENSITY
Client: SDSTA
Sampled: 8/19/2024
Site: GOLD RUN, GR-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
ANNELIDA		
OLIGOCHAETA	**60**	
Eiseniella tetraedra	2	0.9
Enchytraeidae	24	10.9
Limnodrilus sp.	2	0.9
Nais sp.	24	10.9
Unid. Immature Tubificidae w/ Capilliform Chaetae	4	1.8
Unid. Immature Tubificidae w/o Capilliform Chaetae	4	1.8
MOLLUSCA		
GASTROPODA	**5**	
Physa sp.	5	2.3
TOTAL (#/sample)	221	
NUMBER OF TAXA	32	
SHANNON-WEAVER (H')	3.38	
TOTAL EPT TAXA	7	
EPT INDEX (% of Total Taxa)	22	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	46	

DATA: MACROINVERTEBRATE DENSITY
Client: SDSTA
Sampled: 8/20/2024
Site: GOLD RUN, GR-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
COLLEMBOLA	**1**	
Unid. Collembola	1	1.1
EPHEMEROPTERA	**14**	
Baetis tricaudatus cx.	14	15.7
ODONATA	**3**	
Argia sp.	3	3.4
COLEOPTERA	**4**	
Microcylloepus pusillus	3	3.4
Optioservus divergens	1	1.1
LEPIDOPTERA	**2**	
Petrophila sp.	2	2.2
TRICHOPTERA	**18**	
Chimarra utahensis	5	5.6
Hydropsyche sp.	13	14.6
DIPTERA	**38**	
Caloparyphus/Euparyphus sp.	1	1.1
Eukiefferiella sp.	4	4.5
Parametriocnemus sp.	6	6.7
Psychodini sp.	11	12.4
Simulium sp.	15	17.0
Tipula (Beringotipula)	1	1.1

DATA: MACROINVERTEBRATE DENSITY
Client: SDSTA
Sampled: 8/20/2024
Site: GOLD RUN, GR-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
ANNELIDA		
OLIGOCHAETA	**9**	
Eiseniella tetraedra	1	1.1
Enchytraeidae	7	7.9
Nais sp.	1	1.1
TOTAL (#/sample)	89	
NUMBER OF TAXA	17	
SHANNON-WEAVER (H')	3.51	
TOTAL EPT TAXA	3	
EPT INDEX (% of Total Taxa)	18	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	16	

Appendix B 2024 Periphyton Data

DATA: PERIPHYTON ANALYSES
Client: SDSTA
Sampled: 8/19/2024
Site: GOLD RUN, GR-A

TOTAL CELLS/cm²	1,560
NUMBER OF TAXA	14
SHANNON-WEAVER DIVERSITY (H')	3.08
TROPHIC STATE INDEX	44.3

Organisms	Cells/cm²	Rel % Conc.
BACILLARIOPHYTA		
Order Pennales		
Achnanthes linearis	39	2.5
Achnanthes minutissima	429	27.5
Cocconeis placentula	273	17.5
Cymbella affinis	39	2.5
Cymbella minuta	312	20.0
Gomphonema angustatum	39	2.5
Gomphonema clevei	39	2.5
Navicula cryptocephala	156	10.0
Navicula gregaria	39	2.5
Navicula sp.	39	2.5
Nitzschia frustulum	39	2.5
Nitzschia linearis	39	2.5
Rhoicosphenia curvata	39	2.5
Synedra rumpens	39	2.5

DATA: PERIPHYTON ANALYSES
Client: SDSTA
Sampled: 8/20/2024
Site: GOLD RUN, GR-B

TOTAL CELLS/cm^2	46
NUMBER OF TAXA	1
SHANNON-WEAVER DIVERSITY (H')	0.00[1]
TROPHIC STATE INDEX	8.6

Organisms	Cells/cm^2	Rel % Conc.
BACILLARIOPHYTA		
Order Pennales		
Achnanthes minutissima	46	100.0

[1]Not enough organisms present in sample to calculate diversity index.

Appendix C 2024 Water Quality Data

MIDCONTINENT
TESTING LABORATORIES, INC.

Page 1 of 1

2381 South Plaza Drive P.O. Box 3388 Rapid City, SD 57709
(605) 348-0111 – www.thechemistrylab.com

Sample Site: GR - A
Sampled: 08/26/24 at 11:19 AM
by Zachary Adam
Sample Matrix: Water

Lab ID#: 20240828202
Received: 08/27/24 at 11:50 AM
by Bobbie Laurenz
Account: W1433 - South Dakota Science & Technology Authority

JULIE EWING
SOUTH DAKOTA SCIENCE & TECHNOLOGY AUTHORITY
630 EAST SUMMIT STREET
LEAD, SD 57754

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst/Date	
Physical Properties								
Electrical Conductivity	1100	µmhos/cm	1	0.363	5.00	SM 2510B	JAM	08/28/24
Hardness	486	mg/L	1			SM 2340 B	TMN	09/09/24
pH	8.00	S.U.	1			SM 4500-H+ B	JAM	08/29/24
Total Dissolved Solids	773	mg/L	100ml	13.8	50.0	SM 2540 C	TMN	08/28/24
Total Suspended Solids	< 2.00	mg/L	500ml	0.475	2.00	SM 2540 D	TMN	08/28/24
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	09/03/24
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	IBS	08/28/24
Nitrogen, Nitrate (NO3)	1.57	mg/L	1	0.009	0.050	SM 4500-NO3 F	BLL	08/28/24
Phosphorus (P) Dissolved	< 0.010	mg/L	1			SM 4500-P E	GRR	09/09/24
Metals - Dissolved								
Calcium (Ca)	136	mg/L	4	0.379	4.00	SM 3111 B	GRT	08/30/24
Magnesium (Mg)	35.6	mg/L	1	0.090	0.500	SM 3111 B	GRT	08/30/24
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000038	0.0002	EPA 245.1	GRT	08/28/24
Metals - Total Recoverable								
Arsenic (As)	0.007	mg/L	10	0.00036	0.005	EPA 200.8	TNA	08/30/24
Cadmium (Cd)	< 0.001	mg/L	10	0.000099	0.001	EPA 200.8	TNA	08/30/24
Chromium (Cr)	< 0.0010	mg/L	10	0.00016	0.0010	EPA 200.8 DRC	TNA	08/30/24
Copper (Cu)	< 0.005	mg/L	10	0.00014	0.005	EPA 200.8	TNA	08/30/24
Iron (Fe)	0.335	mg/L	10	0.004	0.050	EPA 200.8	TNA	08/30/24
Lead (Pb)	< 0.0010	mg/L	10	0.000022	0.0010	EPA 200.8	TNA	08/30/24
Nickel (Ni)	0.028	mg/L	10	0.00035	0.005	EPA 200.8	TNA	08/30/24
Selenium (Se)	< 0.005	mg/L	10	0.001	0.005	EPA 200.8	TNA	08/30/24
Silver (Ag)	< 0.0010	mg/L	10	0.00014	0.0010	EPA 200.8	TNA	08/30/24
Zinc (Zn)	< 0.050	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/24
Metals - Speciation								
Selenium (IV) Speciation	< 0.002	mg/L	1			Selenium (IV) Speciation	TNA	09/20/24
Selenium (VI) Speciation	0.002	mg/L	1			Selenium (VI) Speciation	TNA	09/20/24

Report Approved By:
Tanya Nelson

Report Approved On: 9/23/2024 9:50:24 AM

Page 1 of 1

MIDCONTINENT
TESTING LABORATORIES, INC.

2381 South Plaza Drive P.O. Box 3388 Rapid City, SD 57709
(605) 348-0111 – www.thechemistrylab.com

Sample Site: GR - B
Sampled: 08/26/24 at 11:26 AM
by Zachary Adam
Sample Matrix: Water

Lab ID#: 20240828203
Received: 08/27/24 at 11:50 AM
by Bobbie Laurenz
Account: W1433 - South Dakota Science & Technology Authority

JULIE EWING
SOUTH DAKOTA SCIENCE & TECHNOLOGY AUTHORITY
630 EAST SUMMIT STREET
LEAD, SD 57754

Parameter	Result	Units	DF	MDL	PQL	Method	Analyst	Date
Physical Properties								
Electrical Conductivity	2230	µmhos/cm	1	0.363	5.00	SM 2510B	JAM	08/28/24
Hardness	1200	mg/L	1			SM 2340 B	TMN	09/09/24
pH	8.02	S.U.	1			SM 4500-H+ B	JAM	08/29/24
Total Dissolved Solids	2080	mg/L	100ml	13.8	50.0	SM 2540 C	TMN	08/28/24
Total Suspended Solids	10.4	mg/L	500ml	0.475	2.00	SM 2540 D	TMN	08/28/24
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	09/03/24
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	IBS	08/28/24
Nitrogen, Nitrate (NO3)	2.93	mg/L	2	0.018	0.100	SM 4500-NO3 F	BLL	08/28/24
Phosphorus (P) Dissolved	< 0.010	mg/L	1			SM 4500-P E	GRR	09/09/24
Metals - Dissolved								
Calcium (Ca)	205	mg/L	5	0.474	5.00	SM 3111 B	GRT	08/30/24
Magnesium (Mg)	167	mg/L	7	0.633	3.50	SM 3111 B	GRT	08/30/24
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000038	0.0002	EPA 245.1	GRT	08/28/24
Metals - Total Recoverable								
Arsenic (As)	0.017	mg/L	10	0.00036	0.005	EPA 200.8	TNA	08/30/24
Cadmium (Cd)	< 0.001	mg/L	10	0.000099	0.001	EPA 200.8	TNA	08/30/24
Chromium (Cr)	< 0.0010	mg/L	10	0.00016	0.0010	EPA 200.8 DRC	TNA	08/30/24
Copper (Cu)	< 0.005	mg/L	10	0.00014	0.005	EPA 200.8	TNA	08/30/24
Iron (Fe)	0.267	mg/L	10	0.004	0.050	EPA 200.8	TNA	08/30/24
Lead (Pb)	0.0015	mg/L	10	0.000022	0.0010	EPA 200.8	TNA	08/30/24
Nickel (Ni)	0.012	mg/L	10	0.00035	0.005	EPA 200.8	TNA	08/30/24
Selenium (Se)	< 0.005	mg/L	10	0.001	0.005	EPA 200.8	TNA	08/30/24
Silver (Ag)	< 0.0010	mg/L	10	0.00014	0.0010	EPA 200.8	TNA	08/30/24
Zinc (Zn)	< 0.050	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/24
Metals - Speciation								
Selenium (IV) Speciation	< 0.002	mg/L	1			Selenium (IV) Speciation	TNA	09/20/24
Selenium (VI) Speciation	< 0.002	mg/L	1			Selenium (VI) Speciation	TNA	09/20/24

Report Approved By:

Tanya Nelson

Appendix D Long-Term Benthic Macroinvertebrate Data

Table D-1: Long-term benthic macroinvertebrate data on Gold Run Creek from 2002 – 2024.

Year	Abundance (#/sample)	Number of Total Taxa	Number of EPT Taxa	Number of Plecoptera Taxa	Shannon-Weaver Diversity	Percentage of Sensitive EPT Taxa	Hilsenhoff Biotic Index
Site GR-A							
2009	59	21	4	0	3.93	5.0	6.75
2010	555	30	4	1	3.46	10.0	8.03
2011	244	31	4	0	4.32	10.0	6.25
2012	29	15	0	0	3.41	0.0	6.59
2013	95	21	2	0	2.94	5.0	5.08
2014	269	17	2	0	3.09	12.0	7.28
2015	143	15	2	1	2.11	7.0	5.29
2016	147	24	3	0	3.11	8.0	5.39
2017	177	28	3	0	3.96	4.0	6.39
2018	255	20	5	0	1.99	15.0	5.53
2019	548	18	2	0	1.41	0.0	5.36
2020	602	25	3	0	2.49	8.0	5.20
2021	353	22	3	0	2.88	5.0	6.24
2022	263	28	5	1	3.09	11.0	7.79
2023	310	26	2	0	3.51	4.0	5.80
2024	221	32	7	2	3.38	12.5	6.39
2009 – 2023 Averages	**270**	**23**	**3**	**0.20**	**3.05**	**6.9**	**6.20**
Site GR-B							
2010	415	25	6	1	3.56	16.0	5.71
2011	1480	19	4	0	2.41	11.0	6.03
2012	385	20	6	0	2.56	10.0	6.35
2013	1018	23	6	0	2.71	17.0	5.33
2014	273	27	7	1	3.57	26.0	6.18
2015	141	15	5	0	2.96	7.0	5.70
2016	368	28	6	0	3.49	11.0	5.43

Year	Abundance (#/sample)	Number of Total Taxa	Number of EPT Taxa	Number of Plecoptera Taxa	Shannon-Weaver Diversity	Percentage of Sensitive EPT Taxa	Hilsenhoff Biotic Index
2017	1210	23	6	0	3.14	13.0	6.15
2018	800	31	4	0	2.73	10.0	5.58
2019	386	14	5	1	1.26	21.0	5.16
2020	958	19	7	0	3.00	26.0	6.04
2021	565	31	8	1	2.50	13.0	5.07
2022	1576	27	5	0	2.46	7.0	4.87
2023	588	25	6	2	3.24	16.0	5.50
2024	89	17	3	0	3.51	11.8	6.13
2010 – 2023 Averages	**726**	**23**	**6**	**0.43**	**2.83**	**15**	**5.65**

Appendix E Long-Term Periphyton Data

Table E-1: Long-term periphyton data on Gold Run Creek from 2002 – 2024

Year	Density (cells/cm^2)	Total Number of Taxa	Total Number of Diatom Taxa	Shannon-Weaver Diversity	Percentage of Tolerant Diatoms	Percentage of Motile Diatoms
Site GR-A						
2009	1,200	2	2	0.81	0	0
2010	164,400	10	10	1.06	0.9	10.9
2011	61,300	6	6	0.26	1.5	1.95
2012	1,400	3	3	1.09	0	28.6
2013	30,700	7	7	0.38	0	0.7
2014	14,059	9	9	0.82	1.8	9.7
2015	712,471	8	8	0.26	0.6	1.4
2016	969,632	9	9	0.29	2	1
2017	1,807,889	7	7	0.20	1.1	0.5
2018	321,295	9	9	0.40	0.8	0.8
2019	0	0	0	--	--	--
2020	769,050	10	10	0.44	0	1
2021	248,173	14	14	1.04	0.7	8.9
2022	999,705	8	8	0.48	0	2
2023	46,315	2	2	0.02	0.2	0
2024	1,560	14	14	3.08	0	20
2009 – 2023 Averages	**409,839**	**6.9**	**6.9**	**0.5**	**0.7**	**4.8**
Site GR-B						
2010	265,700	12	12	1.03	5.3	97.9
2011	136,800	14	14	1.66	77.9	88
2012	54,400	12	12	1.31	81.3	89
2013	38,700	16	16	3.04	34.6	91.7
2014	115,692	10	10	0.92	87.3	95.3
2015	286,189	12	12	1.78	10.5	85.3
2016	413,801	16	16	2.77	48	45

Year	Density (cells/cm^2)	Total Number of Taxa	Total Number of Diatom Taxa	Shannon-Weaver Diversity	Percentage of Tolerant Diatoms	Percentage of Motile Diatoms
2017	4,743,276	19	19	3.40	57.4	53.3
2018	72,557	12	12	2.76	15.1	20.8
2019	89,726	17	17	2.96	3.4	20.5
2020	968,487	16	16	1.23	0.2	4
2021	128,914	9	9	1.85	1.5	4.4
2022	743,441	16	16	2.43	1.6	9
2023	52,931	17	17	2.78	8.7	24.6
2024	46	1	1	0	0	0
2010 – 2023 Averages	579,330	14.1	14.1	2.1	30.9	52.1